A Medium of Cultural Critique and a Framework for Interpretation:

Religion in Werner Heisenberg's Popular Writings

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Abstract

In 1969, the physicist Werner Heisenberg published his memoir, titled *The Part and the One: Conversations in the Area of Particle Physics*. Up until today, the memoir is Heisenberg's most prominent text addressed to a lay audience. Like most of his popular writings, the memoir discusses epistemological and ontological interpretations of modern physics along with social and cultural problems. Part of these discussions include the role of religion in modern society and in particular the relationship between science and religion. With the premise that Heisenberg refers to religion in these texts, my thesis focuses on how religion (including related aspects of Romanticism and *Naturphilosophie*) shapes the understanding of science and how, in turn, popular science communication serves as a mechanism of meaning-making in the 20th century.

Starting from the observation that popular science communication is an important mechanism of meaning-making, I first discuss the conceptual and analytical framework within which I study the dynamics between the social and cultural systems of science and religion. Second, I use a multimethod approach, combining a historical semantic analysis with an aesthetic analysis, to study three different layers of religion in Heisenberg's texts. Starting with the explicit discussion of religion, I continue with an analysis of the implicit use of religion (including traditions such as pantheism and Neo-Platonism) for the interpretation of modern physics, and end with the study of the aesthetic repertoire (i.e. experience of nature) in the descriptions of knowledge production. Third, I propose an empirically-founded interpretation of the different interference patterns of the dynamics between science and religion. This thesis argues that religion plays a central role in shaping the understanding and response to the social role of science by serving as a medium of cultural critique [*Kulturkritik*] and a framework of interpretation.

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Note on Translations

All translations of Heisenberg's texts are those of the author unless otherwise noted. Wherever possible, existing translations have been consulted, as acknowledged in the Bibliography. To recognise the ambivalence of certain terms or the analysis renders a literal translation rather than a poetic one necessary, the German original is included.

Abbreviation

AMPG – Archive der Max Planck Gesellschaft

Chapter 1 Introduction

The work of the German physicist Werner Heisenberg includes along with his research texts that were directed to a public audience. The word 'religion' appears for the first time in his speech "The Unity of the Scientific *Weltbild*[1] [*Die Einheit des naturwissenschaftlichen Weltbildes*]," [2] from 1941. Religion features prominently in the speech, the core argument of which is structured around the consequences of the social transformations—the differentiation of society, as described by sociologists—that gave rise to modern science.[3] Reflecting on a scientific *Weltbild* in the context of this transformation, Heisenberg claims that the differentiation of intellectual and cultural realms like science, religion, and art builds on a segregation of the world into material and *geistige*[4] components. It is this separation of religion from science that informs Heisenberg's critique of modern science and society.

> After all, in this *Weltbild* there was no appropriate place to be found for the vast area [*grossen Bereich*] of reality that encompasses the *geistige* processes. This circumstance was partly to be blamed for the often-lamented split [*Spaltung*] of the *geistige* life into the realm [*Reich*] of science and the realms of art and of religion.[5]

This demarcation of the *geistige* world from the *Weltbild* of modern science is at the centre of Heisenberg's critique of the ideals and practices that constitute modern

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[1] The literal translation of *weltbild* is 'world image' or 'world picture;' I will nevertheless use the German term following Cathryn Carson's study titled *Werner Heisenberg in the Atomic Age* (Cambridge: Cambridge University Press, 2009), 58. See Section 1.5 on the difficulty of translating Heisenberg's texts.

[2] Werner Heisenberg, 'Die Einheit des naturwissenschaftlichen Weltbildes,' In *Heisenberg, Werner Gesammelte Werke. Abteilung C: Allgemeinverständliche Schriften. Physik und Erkenntnis (1927-1955)*, edited by Walter Dürr, Hans–Peter Blum, and Helmut Rechenberg (München: Piper 1984), 161–192.

[3] Weber, Max, 'Wissenschaft als Beruf: 1917/1919,' In *Wissenschaft als Beruf: 1917/1919 und Politik als Beruf, 1919,* edited by Wolfgang J. Mommsen et al, Max Weber Gesamtausgabe, Abt. I, Schriften und Reden, (Tübingen: J.C.B. Mohr 1992), 71–111; Luhmann, Niklas 'Die Ausdifferenzierung der Religion', In Gesellschaftsstruktur und Semantik 3, (Frankfurt/Main: Suhrkamp 1989), 259–357; Luhmann, Niklas, Die Wissenschaft der Gesellschaft (Frankfurt/Main: Suhrkamp 1992); Bourdieu, Pierre, Homo Academicus, translated by Bernd Schwibs, (Stanford: Stanford University Press 2018); Bourdieu, Pierre, Religion, edited by Franz Schultheis and Stephan Egger, translated by Andreas Pfeuffer, Hella Beister, and Bernd Schwibs, (Berlin: Suhrkamp 2011).

[4] The German term *geistig* can be translated as 'mental,' 'spiritual,' or 'intellectual.' See Section 1.5 for an explanation on why I use the German *geistig* to convey the ambivalence of the term.

[5] Heisenberg, 'Die Einheit des naturwissenschaftlichen Weltbildes,' 172.

science. Alongside an explicit critique of modern science, Heisenberg identifies the potential for developing a different kind of science that focuses on "the creative forces" of nature as opposed to the material aspect of nature, the latter of which is central to modern science. Heisenberg distinction of an active aspect of the universe builds on the coincidence of the active aspect with God in the pantheistic tradition. The active component of the universe and/or nature has been described by Spinoza as *natura naturans [*naturing nature], as opposed to a passive component of nature, a biproduct of the active component, *natura naturata* [*natured nature*]. Since Spinoza's explicit distinction of the two components of nature in his *Short Treatise: On God, Man and His Well-Being,* written around 1661,[6] the distinction of the two components of nature can been found in many traditions, including the works of German *Naturphilosophen* [Nature Philosophers],[7] like Johann Wolfgang von Goethe and Romanticists. In their works, *Naturphilosophen* and Romantics defended and pursued the study of the *natura naturans* in opposition to a materialist science, which they associated to the focus of the natured nature.[8]

In his speech, Heisenberg draws explicitly on this idea of the *natura naturans*, largely through the work of the German *Naturphilosopher* and poet von Goethe. This is visible, for example, in his proposition of alternative approaches to conducting research and, as Heisenberg further develops in his texts, in imagining a science that challenges the split between the *geistige* and the material world. The opportunity to renegotiate scientific ideals and practices in a way that would overcome that split is

[6] Baruch Spinoza, *A Short Treatise on God, Man and His Well-Being*, translated by A. Wolf. London (London: Adam and Charles Black 1910) was first published in 1864 by Johannes van Vloten.
[7] I use the German terms of *Naturphilosoph* and *Naturpholsophie* [Nature Philosophy] to describe the Germanic tradition of the study of Nature around 1800, which holds a strong link with Romanticism and distinguishes it from the English one. In doing so I follow Nicholas Jardine 'Preface' in Romanticism and the Sciences, edited by Andrew Cunningham and Nicholas Jardine, (Cambridge: Cambridge University Press 1990), xix.
[8] Cunningham and Jardine, *Romanticism and the Science.*

repeatedly bound back to the formulation of quantum mechanics. While initial research on the reference of central ideas and actors of *Naturphilosophie* in Heisenberg's texts exists,[9] their ties to the wider history of religion have yet to be studied.

Three decades later, in 1973, Heisenberg still ponders the distinction between modern science and religion in the speech "Scientific and Religious Truth [*Wissenschaftliche und Religiöse Wahrheit*],"[10] held at the Catholic Academy in Bavaria upon receiving the Romano Guardini Prize. Now, the social differentiation and decline of religion in light of modern science is no longer a development to "lament," but rather the starting point for a critique of modern society. The cultural critique is led by an invitation to renegotiate the role of religion within modern society at large and, in particular, its relation to science.

> In the last hundred years, science has made great progress. The wider spheres of life, about which we speak in the language of our religion, may have been neglected in the process. Whether we will succeed in expressing the *geistige* form of our future community [*Gemeinschaft*] in the old religious language, we do not know.[11]

Here, the social transformation is led by the advancement of science coupled with the negligence of religion. While Heisenberg suggests in his speech from 1941 that religion is under pressure because of the success of modern science, by 1973 he hints at a potential inflection point for the role of religion in a society shaped by science. Over the

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[9] Maren Partenheimer, Goethes Tragweite in der Naturwissenschaft. Hermann von Helmholtz, Ernst Haeckel, Werner Heisenberg, Carl Friedrich von Weizsäcker, (Berlin: Duncker & Humblot 1989); Helmut Rechenberg '"Goethe hat ihn durch sein ganzes Leben begleitet:" Werner Heisenberg's Auseinandersetzung mit Goethes Naturbild,' In Goethe-Jahrbuch edited by Werner Fricker, Jochen Golz, and Edith Zem (Stuttgart: J.B. Metzler 2004), 277-291; Stefano Furlan and Rocco Gaudenzi 'Looking Stereoscopically at Goethe vs. Newton. Heisenberg and Pauli on the Future of Physics,' In Società italiana degli storici della fisica e dell'astronomia: atti del XLI Convegno annuale (2022), 190–196.

[10] Heisenberg, 'Naturwissenschaftliche und Religiöse Wahrheit', In *Werner Heisenberg Gesammelte Werke. Abteilung C: Allgemeinverständliche Schriften. Physik und Erkenntnis (1969 - 1976)*, edited by Walter Dürr, Hans–Peter Blum, and Helmut Rechenberg (München: Piper 1985), 422–439.

[11] Ibid., 438.

course of three decades, then, religion and the relationship between religion and science remain an important topic in Heisenberg's popular texts.

Prior research on religion in Heisenberg's texts focused primarily on the biographical contexts and his motivations to write about religion[12] rather than the role 'religion' plays in his popular writings. As a result of this focus, the link between Heisenberg's discussion of religion and his critique of both modern society and modern science, visible in the two examples above, has largely gone unnoticed by the existing literature. By focusing explicitly on the role of religion in Heisenberg's popular texts, this thesis unpacks how religion shapes his texts and arguments in multiple ways, from the explicit discussion of religion in regard to social problems to the use of a Romantic conception of nature.

Starting from the observation that Heisenberg discusses religion in relation to modern science in the two aforementioned speeches, the aim of this study is to analyse the role religion plays in his popular science writings. The relationship between science and religion is perhaps the most prominent way by which religion structures much of Heisenberg's reflections on the problems of his time. Moreover, questions about this relationship have guided much of the literature in the research field of science-and-religion.

1.1 The Field of Science-and-Religion: A Literature Review

Heisenberg's explicit reference to religion in the above 1941 and 1973 speeches engages in an ongoing debate about the relationship between science and religion. In

[12] Cassidy, David C., *Uncertainty: The Life and Science of Werner Heisenberg* (New York: W. H. Freemann 1992); Cassidy, *Beyond Uncertainty: Heisenberg, Quantum Physics, and the Bomb* (New York: Bellevue Literary Press 2009); Carson, *Heisenberg in the Atomic Age*.

the late 19th century, this relationship was discussed by different actors who defended various positions on that relationship, from an inherent conflict[13] to a natural harmony between science and religion. Much like these early studies, the research field of science-and-religion focused for a long time on the identification and rejection of various positions on the relationship by drawing on historical examples. However, in recent years, historical studies on the relationship between science and religion demonstrated that the debate on the (true) relationship was and remains an important topic for the definition of science at large and, in particular, for the differentiation of the history of science as a discipline.

In a recent article, the historians Kostas Tampakis and Jaume Navarro showed that debates on the relationship prompted academics and historians of science alike to reflect on science as a social system.[14] The self-fashioning of scientists, especially as representatives of modernity, was coupled with the negotiation of the relationship between science and religion. As a result of this negotiation, science was presented as modern, religion demarcated as traditional. At the same time that Tampakis and Navarro focus on the role of that relationship for the self-fashioning and formation of science, they highlight the plethora of positions on the relationship along with the dynamics between these two knowledge cultures.

While this recent scholarship is concerned with the development of grand narratives and their role in shaping the understanding of science, past scholars from various disciplines sought to explore, classify, and define the complex interplay between science and religion. Many philosophically motivated studies, most prominent

[13] The conflict position was most prominently defended in two books: *History of the Conflict between Religion and Science* from 1874 by John William Draper and *A History of the Warfare of Science with Theology in Christendom* from 1896 by Andrew Dickson White.
[14] Jaume Navarro and Kostas Tampakis, 'Science, Religion, and the Creation of Historiographical Categories', In *Handbook for the Historiography of Science*, edited by Mauro L. Condé and Marlon Salomon, (Cham: Springer 2023), 503–521.

among them those of Ian Barbour, ask essentialist questions about the nature of this relationship. In his survey of the extensive literature on the relationship, Ian Barbour presented a four-fold model. The four positions he identified are: conflict, independence, dialogue, and integration.[15] Following the identification of the four positions in the literature, Barbour goes on to plead for a dialogue between science and religion in the third part of his monograph, *Religion in an Age of Science*, thus engaging in the debate on the relationship.

Barbour, like many other scholars, does not specify what his subject is or whether he conceptualises religion and science as practices, concepts, institutions, or other such possible categories. Building on Barbour's model, the philosopher of religion Mikael Stenmark develops a 'multidimensional' model. With this model he seeks to capture the different concepts of science and religion (e.g., cultural, social, or institutional) as well as the possible dimension of a relationship (e.g., practical, teleological, or epistemological) between the two may be observed. Like many of the studies on the relationship, Barbour and Stenmark draw normative conclusions from their modelling to be able to discuss desirable connections and what should count as religion. In Stenmark's case, the discussion of the relationship becomes the foundation for defending the ideals of value-neutral science, in which he demarcates feminist approaches as "ideological" and thus as non-scientific.[16]

While these two studies examine the conceptual premises of possible relationships between science and religion, historical studies have highlighted the empirical diversity of relationships between science and religion. Exemplary for these historical studies is the 2014 work *Science and Religion: Some Historical Perspectives*

[15] Ian G. Barbour, *Religion in an Age of Science,* (London: SCM Press 1990).
[16] Michael Stenmark, *How to Relate Science and Religion: A Multidimensional Model*, (Grand Rapids, MI: William B. Eerdmans 2004), 175.

by the historian Hedley Brook. Brook illustrated the historical plurality of the relationship of science and religion as 'complex.'[17] Furthermore, the study presents an alternative to the essentialist research by taking the historical context into account and highlighting the potential of investigating particularities for the field of science-and-religion. While his historical work offers thorough insight, Brook does not situate the observed dynamic between science and religion within the concurring social transformations. Nevertheless, the case studies illustrate how structural factors, such as institutions and agents in history, shape the relationships between science and religion. Furthermore, in their efforts to recognise the different aspects of science, religion, and their possible relationships, these historical and philosophical studies investigated mainly the institutions of religion and science – mostly "the church" and "academia" – rather than the plurality of aspects that characterise religion or science as two competing systems of relating to and understanding the world.

In the 1990s, a research program gained prominence in the German-speaking study of religion that takes its vantage point from the historical and conceptual plurality of religion and science. Coined in 1993 by the classicist and scholar of religion Burkhard Gladigow, the program of the European History of Religion (EHR) provides a framework for a cultural study of religion that goes beyond the discourse of "religion" or institutionalised religion. Rather, Gladigow opens up the research field of religion to what he calls a "double pluralism" of religion that further includes the systems of meaning (e.g., religion and "concomitant alternatives" to it, in particular Neo-Platonism and *Naturphilosophie*) that compete with the established Christian monotheism.[18] The attention paid to the alternatives, in particular their conceptualisations of nature, shifts

[17] John Hedley Brooke*, Science and Religion: Some Historical Perspectives*, (Cambridge: Cambridge University Press 2014).
[18] Gladigow, 'Europäische Religionsgeschichte,' 296; Gladigow 'Gegenstände und wissenschaftlicher Kontext von Religionswissenschaft.'

the focus of the research field of science-and-religion to the dynamics between science and religion. As a result, the framework invites and facilitates investigations about religion and science that go beyond the debate of their relationship or institutional structures.[19] Rather it enables, for example, the study of a changing role of religion under social differentiation from a system of interpretation that encompasses one's whole social life to a medium of cultural critique or a framework of interpretation, as we have seen above.

The novelty of EHR stems from the combination of theories, concepts, and models that takes into account the interactions of religion with other societal sub-systems like science, rather than contributing to the self-reflection of religion (e.g., conducted by theologies or phenomenological research interested in the essence of 'the religious experience'). This is made possible because of insights offered by concepts like interference. Borrowed from physics, where it is unencumbered by the negative connotation of obstruction, Gladigow uses "interference" to analyse different levels and patterns that emerge from interactions between the social systems of science and religion.[20] Relying on social systems theory, interference provides a model for identifying the levels at which interactions can be observed and for reflecting on the understanding of religion and science as social systems maintained through autopoietic communication that is engaged in discourses, practices, and aesthetic regimes. In the tradition of Gladigow, interference serves as the model for a fine-grained study of the points where science and religion meet, as well as the patterns

[19] Burkhard Gladigow, 'Europäische Religionsgeschichte', In *Religionswissenschaft als Kulturwissenschaft*, edited by Christof Auffarth and Jörg Rüpke (Stuttgart: W Kohlhammer 2005), 289–301; Grieser, Alexandra, ''European History of Religion« Revisited'; Grieser and Anne Koch, 'Religion in Culture—Culture in Religion: Burkhard Gladigow's Contribution to the Paradigm Shift in the Study of Religion', In *Religion in Culture - Culture in Religion,* edited by Auffrath, Koch, and Grieser, (Tübingen: Tübingen University Press 2021), 11–52.
[20] Gladigow, 'Europäische Religionsgeschichte'

demonstrated by these points, through, for example, the popularisation of science in Heisenberg's texts.

An example for the application of interference in the field of science-and-religion is the work from the cultural scholar of religion Kocku von Stuckrad on the discourses shared by the two in German *Naturphilosophie* and esoteric discourse.[21] Here, interference serves as a model for studying the dynamics between science and religion during the process of functional differentiation and within a functionally differentiated society. These dynamics may include the processes of disenchantment[22] and re-enchantment,[23] subtraction,[24] and compensation that have been captured by grand narratives such as modernisation[25] or secularisation.[26] These cultural approaches and structural perspectives redirect questions about the relationship between religion and science to the dynamics between these two social systems and the pluralism of systems of meaning-making, symbols, and interpretations in modern society.

1.2 Religion and Heisenberg's Texts: A Literature Review

The reference to and mobilisation of religion in Heisenberg's texts has received little attention by the science-and-religion and Heisenberg scholarship. While biographers and Heisenberg scholars recognise two of his texts (a manuscript from 1942 and the above speech from 1973) in their books, their interpretations of the texts are largely guided by biographical interest about Heisenberg's motivations to discuss religion. As

[21] Von Stuckrad, 'Naturwissenschaft und Religion'; von Stuckrad, *Locations of Knowledge in Medieval and Early Modern Europe: Esoteric Discourse and Western Identities*, (Leiden: Brill 2010).
[22] Max Weber, 'Wissenschaft als Beruf. 1917/1919' In Max Weber Gesamtausgabe, Abt. I, Schriften und Reden, Wissenschaft als Beruf: 1917/1919 und Politik als Beruf, 1919, edited by Wolfgang J Mommsen et al (Tübingen: J.C.B. Mohr 1992), 71–111.
[23] Egil Asprem, *The Problem of Disenchantment*, (Albany: SUNY Press 2018).
[24] Charles Taylor, *A Secular Age,* (Cambridge: The Belknap Press of Harvard University Press 2007).
[25] Bruno Latour, *We Have Never Been Modern*, (Cambridge: Harvard University Press 1994).
[26] For example, research group "Multiple Secularities - Beyond the West, Beyond Modernities" at the University of Leipzig 2016–2024.

a consequence, there is a clear lacuna in the scholarship regarding the role religion plays in Heisenberg's popular science writings.

The first text discussed in biographies and scholarship on Heisenberg is the manuscript *Philosophy* from the early 1940s, posthumously titled by the editors "Order of Reality [*Ordnung der Wirklichkeit*] (1942)"[27] that includes a designated section on "Religion [*Die Religion*]." In his biographies of Heisenberg, the historian David Cassidy presents the manuscript and a subsequent discussion of religion as a response to Heisenberg's political context and his age.[28] Written during the Third Reich and in the middle of the Second World War, Cassidy suggests that the manuscript is a sign of a midlife crisis, a search for order and "harmony" during the "chaos and confusion" of the war.[29] The French translation of the manuscript by Catherine Chevalley, however, is accompanied by its most extensive analysis. In her introduction, Chevalley discusses the political context, such as Heisenberg's role in the German nuclear project (*Uranverein*), but is most interested in the philosophical influence in connection with the text's arguments. With her focus laid on the epistemological arguments of the texts, in particular the philosophy of language inspired by Kant, Chevalley pays little attention to the manuscript's section on religion.[30] Chevalley discusses Heisenberg's references to *Naturphilosophie*, German idealism, and Romanticism in the manuscript. Yet even after discussing the idea of the immediate experience of nature presented in the texts, she does not draw a link to the history of religion within which these traditions are also embedded.[31]

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[27] Heisenberg, 'Ordnung der Wirklichkeit (1942),' In *Gesammelte Werke. Abteilung C Allgemeinverständliche Schriften. Vol 1 Physik und Erkenntnis (1927-1955)*, edited by Walter Blum, Hans–Peter Dürr, and Helmut Rechenberg, (München: Piper 1984), 217–306.
[28] Cassidy, *Uncertainty*; Cassidy, *Beyond Uncertainty*.
[29] Cassidy, *Uncertainty*, 325f.
[30] Catherine Chevalley, 'Introduction', In *Philosophie: Le manuscrit de 1942*, translated by Catherine Chevalley (Paris: Editoins du Seuil 1998), 17–245.
[31] Von Stuckrad, 'Naturwissenschaft und Religion'.

The historian Cathryn Carson offers similar psychological and political interpretations of the manuscript but goes even further in interpreting Heisenberg's writings on religion as an integral part of his scientific persona and public engagement after the second World War. In her analysis of a second manuscript, "Scientific and Religious Truth," Carson reduces the speech to intra-Catholic politics in West-Germany without paying attention to Heisenberg's arguments on the importance of religion.[32] With the focus on the philosophical merit of Heisenberg's texts and the political circumstances surrounding them, these three studies reveal little about the concepts of religion used by Heisenberg or the role religion plays in his texts.

The shared history of religion, literature, philosophy, and the study of nature, as peripherally addressed by Chevalley, has yet to become a centrepiece in a philosophical or historical study of Heisenberg's texts. The scholar Maren Partenheimer presents an overview of the different ways Goethe appears in Heisenberg's texts, establishing a reference point for an intuitive approach to knowledge production or the use of aesthetic judgments as epistemic values.[33] In a comparative study, the philosopher Cornelia Liesenfeld goes further in highlighting the junctions of physics and philosophy in the texts of Max Planck and Heisenberg and shows how the two physicists contribute to the creation of worldviews. Liesenfeld suggests that these worldviews emerge in the interference of new academic knowledge and meaning systems, including Eastern philosophy that facilitated their integration into New Age Movement.[34] Moreover, Liesenfeld observes how the references to Neo-Platonic concepts, often through the lens of Christian ideas, presents an important junction in the development of interpretations of quantum physics beyond physics,

[32] Carson, *Heisenberg in the Atomic Age*, 55, 129–133.
[33] Partenheimer, *Goethes Tragweite in der Naturwissenschaft*.
[34] Cornelia Liesenfeld, *Philosophische Weltbilder des 20. Jahrhunderts: Eine Interdisziplinäre Studie zu Max Planck und Werner Heisenberg*, (Würzburg: Königshausen & Neumann 1992), 283.

which we will encounter in Chapter 6.[35] Together, biographical and philosophical studies on Heisenberg indicate important aspects of the role of religion in Heisenberg's popular writings, including the presence of Romanticism or Goethe's *Naturphilosophie;*[36] however, these studies stop short of relating them to the role of religion in Heisenberg's texts or even modern society.

1.3 What is the Role of Religion in Heisenberg's Texts?

The broader understanding of and the cultural approach to religion presented by the EHR offers a framework to revisit the question about the role of religion in Heisenberg's popular writings as a case study of the social dynamics between science and religion. This thesis aims to analyse, through Heisenberg's texts, first, the multiple ways religion shapes the social, epistemological, cultural, and ontological interpretations of quantum mechanics and modern physics in Heisenberg's texts, and second the influence of scientific knowledge on the development of meaning-making and cultural commentary in the 20th century. In order to study these aspects, I use the model of interference to distinguish and analyse three different layers of religion in Heisenberg's writings: the explicit discussion of religion, the religion mobilised in the reflection on science, and the religion used in the presentation of knowledge production. The analysis of these intertwined layers offers an in-depth insight into the role of religion by paying attention to different interference patterns, in particular religion as a medium of cultural critique, religion as a framework for interpretation, and the transfer of scientific concepts into the debate on the relationship between science and religion.

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[35] Liesenfeld, *Philosophische Weltbilder des 20. Jahrhunderts,* 153, 262–267; Partenheimer, Chevalley

[36] Patrick Heelan, *The Observable: Heisenberg's Philosophy of Quantum Mechanics,* (New York: Peter Lang 2016); Arkady Plotnitsky, '"In Principle Observable": Werner Heisenberg's Discovery of Quantum Mechanics and Romantic Imagination,' *Parallax*, 10(3), (2004), 20–35.

The analysis of the explicit reference to religion in Heisenberg's texts is the most apparent way religion appears in his texts and is thus the only layer that has been heretofore studied. The two examples of Heisenberg's writing, introduced in above, illustrate how Heisenberg invokes religion in response to questions on social changes, for example the growing presence of science in society. In focusing on the layer of the explicit reflection on religion, I show how different concepts of religion are used and often combined to critique modern science or modern society.

Religion as a medium of cultural critique became a prominent form of religion around 1900 in response to the rise of a materialist science and technology along with the functional differentiation of society and a growing cultural pluralism.[37] The perception of crisis in the *bildungsbürgerliche* (the educated bourgeoisie) society around 1900, spurred by the progress and growing visibility of science and technology, shaped the way religion was invoked in the cultural critique at the time.[38] Reiterations of a Christian Europe that stands in tension with a simultaneous revitalisation of past religious traditions (e.g., paganism)[39] were instrumental for the consolidation of religion as a medium of critique which was often entwined with nationalist sentiments.[40] The historian Andreas Daum showed that the cultural critique voiced in popular science outlets around 1900 mobilised Romantic and *naturphilosophische* ideals in arguments that opposed mechanistic research. Daum already highlighted the junction between religion as a medium of cultural critique and the sacralisation of

[37] Thomas M. Schmidt and Matthias Lutz-Bachman, *Religion and Cultural Critique,* (Darmstadt: Wissenschaftliche Buch Gesellschaft 2006).
[38] Drehsen, Volker and Walter Sparn, *Vom Weltbildwandel zur Weltanschauungsanalyse. Krisenwahrnehmung und Krisenbegwältigung um 1900*, (Berlin: Akademie Verlag 1996).
[39] Stefanie Schnurbein, *Religion als Kulturkritik: Neugermanisches Heidentum im 20. Jahrhundert*, (Heidelberg: Winter 1992).
[40] Schnurbein, *Religion als Kulturkritik*; Ulrike Peters, *Esoterik als moderne Religionsform* (Nordhausen: Bautz 2012).

nature in the practices and texts of science popularisation, a junction that comes to the forefront of my thesis on Heisenberg's popular science texts.

Until now, the focus on how Heisenberg's personal convictions and political motivations permeated his communication of religion has eclipsed the mobilisation of "concomitant alternatives"[41] to institutionalised Christianity and established monotheisms—chief among them pantheism, Neo-Platonism, Romantism, or *Naturphilosophie*—in his epistemological and ontological interpretations of quantum mechanics. This second layer of religion is part of the explicit reflection on science. While Heisenberg, much like many of his colleagues, rejects the idea that quantum mechanics can serve as a foundation for a new theology, it is the newly formulated quantum mechanics that presents the opportunity to renegotiate the concept of nature and with it its scientific study. As seen earlier, Heisenberg invokes the concept of a *natura naturans* in his proposals of an alternative to a materialist science. While these concomitant alternatives serve as frameworks for interpretation for new scientific knowledge, the aesthetisation of nature, knowledge, and knowledge production draws on Romanticism and *Naturphilosophie*.[42] Daum suggests that this aesthetisation of nature in popular science texts is key in the sacralisation of nature as a response to a growing influence of rationalisation around 1900.[43]

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[41] Burkhardt Gladigow introduced the term 'concomitant alternatives' to described the plurality of meaning-making systems, like Neo-Platonism or Buddism, that co-exist and compete with religion throughout the European History of Religion (see Alexandra Grieser's article on discussion of the term 'concomitant alternatives' in English, '"European History of Religion" Revisited: Modelling a Pluralist Approach,' in *Religion in culture - culture in religion: Burkhard Gladigow's contribution to shifting paradigms in the study of religion* [*Religion in der Kultur - Kultur in der Religion: Burkhard Gladigows Beitrag zum Paradigmenwechsel in der Religionswissenschaft*], edited by Christoph Auffarth, Anne Koch, and Alexandra Grieser (Tübingen: Tübingen University Press 2021), 191–220.

[42] Kocku von Stuckrad, 'Naturwissenschaft und Religion: Interferenzen und diskursive Transfers,' In *Europäische Religionsgeschichte: ein mehrfacher Pluralismus*, edited by Hans Gerhard Kippenberg, Jörg Rüpke, and Kocku von Stuckrad, (Göttingen: Vandenhoeck & Ruprecht 2009), 441–467; Grieser, 'Imaginationen des Nichtwissens: Zur Hubble Space Imagery und den Figurationen des schönen Universums zwischen Wissenschaft, Kunst und Religion', In *Religion – Imagination – Ästhetik: Vorstellungs- und Sinneswelten in Religion und Kultur*, edited by Lucia Traut and Annette Wilke (Göttingen: Vandenhoeck & Ruprecht 2015), 451–486.

[43] Andreas Daum, 'Das versöhnende Element in der neuen Weltanschauung: Entwicklungsoptimismus, Naturästhetik und Harmoniedenken im populärwissenschaftlichen Diskurs der Naturkunde um 1900,'

The aesthetisation of knowledge features prominently in the third layer of my investigation: the role of religion in the aesthetic repertoire of Heisenberg's texts. The aesthetic repertoire, including allegories, narratives, sceneries, or topoi are central aspects of the justification of knowledge and the narration of knowledge production, which Heisenberg used, for example, in the description of his breakthrough in matrix mechanics during a stay in Helgoland (see Section 7.2.3). The broader understanding of religion as a cultural study and the insight of recent research in the aesthetics of knowledge[44] draws attention to the analysis of the aesthetic repertoire as crucial in further understanding religion in Heisenberg's texts and modern society. Similar to von Stuckrad's and Daum's findings on the sacralisation of nature, the scholar of religion Alexandra Grieser showed how contemporary images and the *imaginaire* of scientific knowledge activates the repertoire of the early Romantics.[45] In particular, the aesthetisation of religion by early Romantics, like the German theologian Friedrich Schleiermacher, shaped the idea of one single and particular form of a religious experience as an overwhelming encounter with God through the medium of nature.[46]

The aesthetic repertoire of Heisenberg's texts gains further importance in shaping the *imaginaire* of the physicist when combined with the analytical category of

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In *Vom Weltbildwandel zur Weltanschauungsanalyse: Krisenwahrnehmung und Krisenbewältigung um 1900* edited by Volker Drehsen and Walter Sparn, (Berlin: Akademie Verlag 1996), 203–216, 214f.; von Stuckrad, 'Naturwissenschaft und Religion,' 452.

[44] Arianna Borrelli and Alexandra Grieser, 'Recent Research on the Aesthetics of Knowledge in Science and in Religion,' In Approaching Religion, 7(2), (2017), 4–16; Borrelli, 'Symmetry, Beauty and Belief in High-Energy Physics,' In *Approaching Religion*, 7(2), (2017), 22–35; Arianna Borrelli, 'Poetic Imagination in Scientific Practice: Grand Unification as Narrative Worldmaking', In *Narrative Cultures and the Aesthetics of Religion*, edited by Dirk Johannsen, Anja Kirsch, and Jens Kreinath, (Leiden: BRILL 2020), 314–344.

[45] Alexandra Grieser, 'Blue Brains: Aesthetic Ideologies and the Formation of Knowledge Between Religion and Science', In *Aesthetics of Religion: A Connective Concept*, edited by Alexandra Grieser and Jay Johnston (Berlin: De Gruyter 2017), 237-270.

[46] Jochen Schmidt, *Die Geschichte des Genie–Gedankens in der deutschen Literatur, Philosophie und Politik 1750–1945,* (Darmstadt: Wissenschaftliche Buchgesellschaft 1985); von Stuckrad 'Naturwissenschaft und Religion,' 452.

'scientific masculinity.'[47] In particular, the mobilisation of the early Romantic aesthetics of experience in Heisenberg's writings shapes his scientific persona built around a sensitivity towards nature. This sensitivity towards nature, combining the aesthetic repertoire of Romanticism and *Naturphilosophie,* are central in creating Heisenberg's masculinity as a Romantic genius that sets him apart from the masculinity of the 'men of science and rationality.' While prior studies examined the masculinity of the engineer,[48] the scholar and the gentlemen of science,[49] or the professional scientist,[50] the aesthetic approach to religion and knowledge production supports the analysis of the scientific masculinity of the genius. As such, the cultural study of religion can offer insight into an important cultural *imaginaire* of the genius against which other scientists and masculinities are compared. Combined with a focus on masculinity,[51] the analysis of the aesthetic repertoire offers an opportunity to show how the experience of nature contributes to the ideal of the scientist as a genius as well as a public figure.

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[47] Erika Milam and Robert Nye 'An Introduction to Scientific Masculinities', In *OSIRIS*, 30(1) Scientific Masculinities, (2015), 1–14, coined the concept of scientific masculinity in the tradition of Joan Wallace Scott's article on 'Gender: A Useful Category of Historical Analysis' from 1986 published in *The American Historical Review*, 91(5), (1986), 1053-1075. Other research on science and masculinity have offered insight into the many ways masculinity and institutional structures, research practices, vocabulary, or ideals produce, manifest, and negotiate ideals of science, knowledge production, and masculinity. See Jan Golinski, 'Humphry Davy's Sexual Chemistry', In *Configurations* 7(1), (1999) 15–41 and Falko Schnicke, 'Fünf Analyseachsen für eine kritische Geschlechtergeschichte'.

[48] Tanja Paulitz, *Mann und Maschine: Eine Genealogische Wissenssoziologie des Ingenieurs und der modernen Technikwissenschaften 1850-1930*, (Bielefeld: transcript 2012).

[49] Heather Ellis, *Masculinity and Science in Britain, 1831-1918:* Genders and Sexualities in History, (London: Palgrave Macmillan 2017); Steven Shapin, 'The Man of Science', In *The Cambridge History of Science: Early Modern Scienc*e, edited by Lorraine Daston and Katharine Park, (Cambridge: Cambridge University Press 2006), 179-191.

[50] Paul Lucier, 'The Professional and the Scientist in Nineteenth-Century America', In *Isis* 100(4), (2009), 699–732; Furthermore, the handbooks edited by Julia Barbara Köhne, *Exzellenz, Brillanz, Genie: Historie und Aktualität erfolgreicher Wissensfiguren*, (Berlin: Neofelis Verlag 2020) illustrating the plurality of figures and ideals of the "genius" and Köhne, Julia Barbara, and Barbara Ventarola *Weibliche Genieentwürfe: Eine Alternative Geschichte des schöpferischen Subjekts,* (Würzburg: Königshausen & Neumann 2022) that showed how the masculinity of the genius has been contested by women, both researchers and historical actors.

[51] Falko Schnicke, 'Fünf Analyseachsen für eine kritische Geschlechtergeschichte der Geisteswissenschaften: Aufriss eines Forschungsfeldes', In *Jahrbuch für Universitätsgeschichte*, (Stuttgart: Franz Steiner Verlag 2017), 43–68.

1.4 Heisenberg's Popular Science Writings in the Context of his Academic Biography

In Heisenberg's case, his persona is constructed in and through the practice of popular science writings. For the analysis of the roles of religion in Heisenberg's writings, I selected seven texts he had written for a lay audience between 1931 and 1976. These popular science texts are largely accessible to a lay audience with little to no knowledge or training in physics, as the technical details of the groundbreaking changes are kept to a minimum. Rather, these texts embed the new knowledge of modern physics and their consequences in epistemological, social, and ethical discussions about the limits of knowing the world or using science for political gains. As we have seen above, the explicit references to religion and the mobilisation of religion in these popular texts make the texts a relevant medium of transporting religion as well as a nexus to produce meaning based on scientific knowledge. A further characteristic of his texts is the presentation of histories of modern physics, particularly the use of grand narratives leading to the formulation of quantum mechanics in the late 1920s and the presentation of personal anecdotes related to Heisenberg's role in the formulation of quantum mechanics. Together, the topics and style set the popularising texts apart from Heisenberg's more technical work, published in academic journals or presented for an audience of trained physicists, in which he engages in the academic discussions of contemporary physics and uses a specialised language centred around mathematical formulae.

This large corpus of texts spanning four crucial decades in modern physics and European History holds the potential to recognise changes and continuities in Heisenberg's texts. Over the decades, the scope and the form of these writings change.

While Heisenberg gave a few speeches and wrote around five newspaper articles between 1926 and 1937, much of his popular texts with a focus on Goethe were written in the early 1940s. By the late 1940s, the popular writings outnumbered his academic output of technical publications, the rate of publication of which remained stable until his death in 1976.[52] After the Second World War, his public engagement grew in prominence and resonated with the social and cultural climate at the time.[53]

To analyse and understand Heisenberg's texts and their wide reception, we have to consider the cultural context of the German *Bildungsbürgertum* (the educated bourgeoisie) within which they were written. At the core of the *Bildungsbürgertum*, the concept of *Bildung* involves a knowledge- and practice-based 'active self-formation' and 'self-realisation' which is guided by the study of texts, music-making, or physical activities.[54] With the specialisation of science the popularisation of academic knowledge became an integral part of the *bildungsbürgerliche* culture in the 19th century.[55] The traditions of German Romanticism and *Naturphilosophie* are an integral part of the *bildungsbürgerliche* culture, which as we will see feature prominently in Heisenberg's writings.

The role of the *Bildungsbürgertum* in Heisenberg's biography and the efficacy of writings and scientific persona has already been highlighted by the biographical work on Heisenberg. In her study on Heisenberg and the public sphere of West Germany, Carson showed for example, that Heisenberg's texts and public engagement resonated with the ? and the counter-culture.[56] Another example is Cassidy's study of

[52] David C. Cassidy and Mara Baker, *Werner Heisenberg: A Bibliography of his Writings*, (Berkeley: University of California 1984).
[53] Carson, *Heisenberg in the Atomic Age*.
[54] Ursula Klein, 'Science, Industry, and the German Bildungsbürgertum*',* In *Annals of Science,* 77(3), (2020), 366–376.
[55] Daum, *Wissenschaftspopularisierung*.
[56] Carson, *Heisenberg in the Atomic Age*.

Heisenberg's upbringing in the wider *bildungsbürgerliche* culture around 1900.[57] Cassidy highlighted how the ideals of neo-humanistic education manifested themselves in Heisenberg's early study of Greek and Latin, philosophy, German literature, and music, and later continues to shape his later writings. The various biographical studies embed Heisenberg's academic and public success in the *bildungsbürgerliche* culture of the early 20th century and highlight several turning points in his career. Heisenberg was born 1901 in Würzburg to a Protestant family and baptised Werner Karl. When his father became a professor of Classics at the Ludwig Maximilian University in 1910, the family moved to Munich. In Munich he attended the humanistic Maximilian's Gymnasium, of which his maternal-grandfather August Wecklein a philologist, was the headteacher until 1913. As a result, Heisenberg grew up in a *bildungsbürgerliche* milieu with a particularly strong presence of Classics.

Towards the end of his school years, Heisenberg became a member of a group of boy scouts with whom he spent time hiking in the surrounding areas of Munich. Nine of the 13 men went on to study theology or become members of clergy, many of whom Heisenberg remained friends with throughout his life. These early years in Munich were formative for his social network and professionalisation while also remaining a reference point in his memoir from 1969.

Following school, Heisenberg went on to study physics at the Ludwig Maximilian University under Arnold Sommerfeld in Munich in 1919. Three years later, in 1922, he graduated from his doctoral studies with a major in physics and minors in mathematics and astronomy.[58] In 1925, he went on to publish important papers in quantum mechanics, one of which[59] earned him the 1932 Nobel Prize of Physics for "the

[57] Cassidy, *Uncertainty*.
[58] The professors present at the doctoral exam were Arnold Sommerfeld and Wilhelm Wien for physics, Oskar Perron for mathematics, and Hugo von Seeliger for astronomy.
[59] The single-authored paper 'Quantum-Theoretical Re-interpretation of Kinematic and Mechanical Relations [*Über quantentheoretische Umdeutung kinematischer und mechanischer Beziehungen*]'

formulation of quantum mechanics" in 1933.[60] Two years later, in 1927, Heisenberg introduced the uncertainty principle, which is today widely known by the general public.[61] Despite being only 26 years old, he became a full professor at the University of Leipzig in 1927. It is in the late 1920s that he published his first newspaper articles and held presentations for wider audiences. Starting in the early 1930s, Heisenberg published several short articles in various media outlets, like the newspaper *Berliner Tageblatt,* or the weekly magazine for opticians *Deutsche optische Wochenschrift*. The focus of these early publications are the consequences of quantum mechanics for the structure of academic disciplines and academic work.

Unlike many of his colleagues, Heisenberg stayed in Germany throughout his life. Between the early 1930s and his retirement in 1970, he continued to conduct influential research on the S-Matrix (around 1940), the German Nuclear Weapons program (1939–45),[62] or unified field theory (1958).[63] While these research projects never matched his pioneering work of the 1920s in terms of the foundational change brought to physics as a field, they influenced future theories and research avenues (e.g., string theory). It is in the early 1940s that Heisenberg begins to focus in his popular writings on Johann Wolfgang von Goethe's treaties on the study of nature.[64]

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was followed by two more papers, one published by his colleagues Pasqual Jordan and Max Born called 'On Quantum Mechanics [*Zur Quantenmechanik*]' and another published by all three, titled 'On Quantum Mechanics II [*Zur Quantenmechanik II*].' Today, the work is known as the *Dreimännerarbeit* [Three men work], which has sparked discussions about Heisenberg winning a full Nobel Prize for the formulation of quantum mechanics, while Born went on win half a share in 1954 (the other half going to Walter Bothe) and Pasqual Jordan received no recognition at all.

[60] 'The Nobel Prize in Physics 1932. Werner Heisenberg', https://www.nobelprize.org/prizes/physics/1932/summary/>, [Accessed November 16th, 2019].

[61] 'On the descriptive content of quantum-theoretical kinematics and mechanics [*Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik*].'

[62] See for example Cassidy, *Beyond Uncertainty: Heisenberg, Quantum Physics, and the Bomb* and Carson, *Heisenberg in the Atomic Age* for the impact of Heisenberg's decision to remain in Germany and work on the *Uraniumverein* on his career and public persona in West Germany.

[63] See for an analysis of Heisenberg's attempt of an unified field theory Alexander Blum, *Heisenberg's 1958 Weltformel and the Roots of Post-Empirical Physics*, (Cham: Springer International Publishing 2019).

[64] The most prominent example being Heisenberg, Werner, 'Die Goethe'sche und die Newton'sche Farbenlehre im Lichte der Modern Physik,' In *Heisenberg, Werner Gesammelte Werke. Series C:*

After the Second World War, Heisenberg took on more political roles. Following the foundation of CERN (*Conseil Européen pour la Recherche Nucléaire*), the European Organisation for Nuclear Research near Geneva in 1954, Heisenberg was part of West-German representation for several years. His more active roles at CERN included the first chair of the Scientific Policy Committee (1954–1957) and the Vice President of the council (1958–1960). Around the same time, he served as the first president (1953–1975) of the Alexander von Humboldt Stiftung, a foundation promoting international cooperation among academics. Next to these more formal roles, Heisenberg voiced his opposition of the West-German nuclear armament by formulating and signing two open letters, the *Göttinger Manifesto* in 1957[65] and the *Tübinger Memorandum* in 1962.[66]

Together, these popularisation practices and political engagement were central to the creation and manifestation of Heisenberg' scientific persona in addition to the reception of his writings. This activation of the *bürgerliche* ideal of the educated and integrated individual in Heisenberg's public presence after the second World War in West-Germany stands at the centre of Carson's analysis.[67] Within this cultural context, Heisenberg's popular science communication and public presence succeed in establishing him as a "scientific intellectual"[68] or "philosopher-physicist."[69] Moreover, Carson highlights how his mannerisms, his voice, and actions appealed to the post-

Allgemeinverständliche Schriften Vol. 1 Physik und Erkenntnis (1927-1955), ed Walter Dürr, Hans–Peter Blum, and Helmut Rechenberg, (München: Piper 1984d), 146–160.

[65] Signed by 18 physicists, the memorandum was published in April by the three newspapers *FAZ*, *Süddeutsche Zeitung*, and *Die Welt*. I consulted the version made available by the University of Göttingen, Fritz Bopp *et al*. Text des Göttinger Manifests der Göttinger 18 https://www.uni-goettingen.de/de/text+des+g%c3%b6ttinger+manifests/54320.html [Accessed July 31st, 2024].

[66] 'Das Memorandum der Acht' In *Die Zeit*, March 2nd, 09/1962 along with Heisenberg, Helmut Becker D. Joachim Beckmann, Klaus von Bismarck, Günter Howe, Georg Picht, Ludwig Raiser and Carl Friedrich von Weizsäcker signed the memorandum.

[67] Carson, *Heisenberg in the Atomic Age*.

[68] Carson, *Heisenberg in the Atomic Age*, 27.

[69] Kristian Camilleri, *Heisenberg and the Interpretation of Quantum Mechanics: The Physicist as Philosopher*, (New York: Cambridge University Press 2009), 8.

War audience of West-Germany. His ability to balance the subjective angles of sensitive and self-restrained corporality with a professorial voice that vouched for the objectivity of science[70] shaped his persona, which presented an alternative to the ideal of the "inhuman scientists"[71] and "the aristocratic ideal of masculinity."[72] While his achievements in physics had granted him the authority to speak and be heard on matters beyond his profession, the resonance of his writings and persona with the West-German culture warranted the success of his writings.

The entanglement of Heisenberg's texts, the *bürgerliche* culture, and the political context is particularly relevant when we consider Heisenberg's memoir. Written in the late 1960s, the memoir tells the history of modern physics through the perspective of the protagonist, Werner Heisenberg, who engages in fictional discussions with different characters from his life, including friends and colleagues. These auto-fictional discussions are set in different years of Heisenberg's academic career starting with his studies in physics in 1919. The memoir goes on to discuss research problems as well as social and epistemological consequences of modern physics for the wider public. However, once we take into account the political context within which the memoir was written, it becomes a commentary on contemporary cultural, such as the German student movement of the 1960s as well as a story of Heisenberg's career. With the publication of his memoir, Heisenberg established his scientific persona as a Romantic genius and one of *bildungsbürgerliche* citizenship.

[70] Carson, *Heisenberg in the Atomic Age, 142;* Coen, *Vienna in the Age of Uncertainty*, 352.
[71] Carson, *Heisenberg in the Atomic Age*, 143.
[72] George L Mosse, *The Image of Man: The Creation of Modern Masculinity*, (New York: Oxford University Press 1996), 7.

1.5 Translation of Heisenberg's Texts

While presenting rich material for historical and cultural studies, Heisenberg's popular writings were mainly written in German and rarely include citations. This makes it difficult to identify the inspiration of and influences on his arguments. Additionally, the fact that the bulk of Heisenberg's texts have yet to be translated into English presented a large challenge to this thesis. Only a few of the texts investigated in this study were initially written in English. These include a lecture series published under the title *Physics and Philosophy,*[73] an interview "Double Dialogue,"[74] and one unnamed lecture. All the other texts, such as Heisenberg's memoir, the Romano Guardini Speech, and a collection of lectures called "Across Frontiers" have either been translated or only exist in German.

However, even those translations did not satisfy the demands posed by my inquiries into the role of religion in Heisenberg's writing and speeches. In the case of the memoir, the official translation from 1971 by Arnold Pomerans often omits the descriptions of aesthetic qualities or sensory experiences included in the German original, aspects that are crucial to the effectiveness of the texts and for the study of aesthetic repertoire.[75] As a result, in the arguments that follow, I translate relevant passages or complement existing translations as needed. An example of the sometimes inadequate translation of vital terms in the memoir is the translation of "interconnection [*Zusammenhang*]" as "relationship [*Beziehung*]." The "great interconnection", in Heisenberg's diction, suggests the idea of a harmonious holistic

[73] Werner Heisenberg, *Physics and Philosophy* (London: Penguin 1958).
[74] Werner Heisenberg, Horia Vintila, and X, 'Double Dialogue with Werner Heisenberg', In *Heisenberg, Werner Gesammelte Werke. Abteilung C: Allgemeinverständliche Schriften. Physik und Erkenntnis (1969 - 1976)*, edited by Walter Dürr, Hans–Peter Blum, and Helmut Rechenberg (München: Piper 1985), 464–486.
[75] Werner Heisenberg, *Physics and Beyond. Encounters and Conversations*, translated by Arnold Pomerans (New York: Harper and Row 1971).

unity and thus is not represented by the more functional and binary term "relationship." From his letters, we learn that the translation of his work was a nuisance to Heisenberg. The translation of his memoir, specifically, resulted in a few letters between him and his translator, Jan Pomerans. On March 16th, 1970, Heisenberg shares his discontent with the translation of the concept "interconnection [*Zusammenhang*];" however, he does not suggest an alternative:

> The word 'connection [*Zusammenhang*]' is always difficult to translate. I am not entirely satisfied with the word 'relationship' at this point, but I don't know what could be better here either.[76]

Another example of the challenges related to the translation of vocabulary is even part of one of the selected texts. In 1974, two interviews Heisenberg gave were published together under the title "The Double Dialogue." The interviews revolve around the wider implications of quantum mechanics as well as Heisenberg's interests in literature. In the second interview, held in English, he voices his discontent with the translation of the term *geistige*: "I mean the spiritual form of the society. (I can't really translate Geistige Form)."[77]

While Pomerans had translated *geistige* mostly as spiritual, awarding religious connotations in places where it might not be the case, I decided to follow Gentry and Pollak by using the German term *geistige*.[78] A central term in the intellectual history of the German-speaking world, *geistige* can mean mental, spiritual, intellectual, or all three together. By using the German original, the ambiguity of the term and its longue durée are recognised without falling into the trap of developing connections that do not exist. I likewise choose to use the German original on other occasions, for example,

[76] 16.03.1970 Heisenberg to Pomerans, AMPG III_093_1814.
[77] Werner Heisenberg, Horia Vintila, and X, 'Double Dialogue with Werner Heisenberg', 474.
[78] Gerad Gentry and Konstantin Pollak, *The Imagination in German Idealism and Romanticism,* (Cambridge: Cambridge University Press 2019).

in the case of *Weltanschauung* (worldview) and *Weltbild* (world-picture)[79] to recognise the distinction Heisenberg draws.

Lastly, prior translations rarely pay attention to the aesthetic repertoire of Heisenberg's texts. I have found that Pomerans' translation of Heisenberg's memoir condenses descriptions of spatial layouts, colours, sensory changes, or allegories, which play an essential role in Heisenberg's writing, as will become clear through the following analysis. As such, existing translations often make it impossible to recognise the resemblance of the aesthetic repertoire of Heisenberg's texts and the influence of aesthetic regimes, such as the romanticised experience of nature. To address this, I have mostly used my own translations, which are nonetheless informed by those of Pomerans.

1.6 Thesis Structure

The current study seeks to make three contributions to the scholarship on Heisenberg and the field of science-and-religion: first, to unpack the role of religion in Heisenberg's popular writings; second, to further the understanding of the mobilisation of concomitant alternatives in the interpretation of new scientific knowledge, i.e., modern physics.; and thirdly, to yield a new understanding of the dynamics between science and religion in the 20th century by using the model of interference.

The study is structured in three parts. Part I, which bundles Chapters 2 through 4, presents the analytical framework of the thesis. In Chapter 2, I discuss the model of interference for the study of the dynamics between the religion and science. Grounded in EHR, the introduction of interference is accompanied by an elaboration on science

[79] Carson, *Heisenberg in the Atomic Age*, 44–59.

and religion as two social systems of modern society. Against the background of functional differentiation, I proceed to introduce popularisation as a central mechanism of meaning-making. The popularisation of scientific knowledge may involve explicit references to religion as well as the mobilisation of concomitant alternatives. To study the interference patterns between science and religion developed by the mobilisation of religion (in particular concomitant alternatives), I then present the research lens of the 'aesthetics of knowledge' to analyse the aesthetic repertoires of Heisenberg's texts.[80] Lastly, I complement the assembled theoretical toolkit with the analytical concept of 'scientific masculinity'[81] to investigate the construction and reinforcement of hierarchies among men as well as between men and women.

Next, in Chapter 3, I present the multimethod approach, which I employ for the study of the role of religion in Heisenberg's texts. I combine a historical semantic analysis in the tradition of Reinhard Koselleck and systems theory[82] with an aesthetics analysis in the tradition of the aesthetics of religion[83] and the aesthetics of knowledge.[84] Combining the semantic analysis with the methods available for an aesthetic analysis, the multimethod approach enables the three-layered study of religion in the texts, letters, and archival material introduced in Chapter 4. While

[80] Grieser, 'Religion als Fascinans? Der Faszinationsbegriff in der Religionswissenschaft und die Interferenz von Faszinations- und Wissenschaftsgeschichte', In *Faszination. Historische Konjunkturen und Heuristische Tragweite eines Begriffs*, edited by Andy Hahnemann and Björn Weyand, (Frankfurt/Main: Peter Land 2009), 129–148; Grieser, 'Aesthetics', In *Vocabulary for the Study of Religion*, Vol 1, edited by Hocku von Stuckrad and R Segal, (Leiden: Brill 2015), 14–23; Borrelli and Grieser, 'Aesthetics of Knowledge', In *The Bloomsbury Handbook of the Cultural and Cognitive Aesthetics of Religion*, edited by Anne Koch and Katharina Wilkens, (London: Bloomsbury 2019), 33–46.
[81] Milam and Nye, 'An Introduction to Scientific Masculinities.'
[82] Niklas Luhmann, 'Die Ausdifferenzierung der Religion', In *Gesellschaftsstruktur und Semantik Vol 3,* (Frankfurt/Main: Suhrkamp 1989), 259–357; Reinhart Koselleck, *Futures Past: On the Semantics of Historical Time*, translated by Keith Tribe, (New York: Columbia University Press 2004).
[83] Grieser, 'Imaginationen des Nichtwissens'; Laura Feldt, *Wilderness in Mythology and Religion*: Approaching Religious Spatialities, Cosmologies, and Ideas of Wild Nature, (Boston: De Gruyter 2012).
[84] Borrelli and Grieser, 'Aesthetics of Knowledge'; Arianna Borrelli, 'Poetic Imagination in Scientific Practice.'

Heisenberg published popular writings as early as the late 1920s, I mostly rely on seven texts from the years 1931 to 1974. To present the texts, I situate them in Heisenberg's career and trace the "biography"[85] of the individual texts to show their reception by the Germanic and English markets. With texts spanning a period of over 30 years and three different media (speeches, memoir, and interviews), the study demonstrates how some arguments and aesthetics are context dependant while others remain stable over time.

Once the research framework and the historical background are established, I analyse three layers of religion in Heisenberg's texts in Part II, which includes Chapters 5 through 7. Focusing on the explicit discussion, Chapter 5 opens with a section on the phenomenological concept of religion present in Heisenberg's extensive discussion of experience as the foundation for and core principle of religion. I then continue the chapter with the analysis of the distinction Heisenberg's draws between religion and "immanent" alternatives like "national socialism" or "bolshevism." Already here, it becomes clear that Heisenberg's references to religion are entwined with a cultural critique of modern society and modern science. The critique of modern science is prominent in the discussion of different positions about the relationship between science and religion, analysed in the chapter's third section. The chapter as a whole shows that the explicit reference to religion in the semantic apparat of Heisenberg's texts reiterates the idea of religion as experience. Moreover, it draws on *bürgerliche* ethics. In both cases, religion serves as a medium of cultural critique.

Chapter 6 investigates the second layer of religion that can be identified in the explicit reflection on science, which includes the discussion of the structure of science, the structure of reality, and the evaluation of new theories. This layer of religion is

[85] Inspired by the concept developed in *Biographies of Scientific Objects*, edited by Lorraine Daston, (Chicago: University of Chicago Press 2000).

characterised by the mobilisation of *Naturphilosophie*, pantheism, Neo-Platonism, and Romanticism in the epistemological and ontological interpretations of modern physics. In the first section, I tease out the monism in Heisenberg's texts, which can be found in four strains of arguments: the unity of science, a structure of reality, the goal of a scientific theory, and cultural harmony. In Section 6.2, I focus on use of aesthetic values—like beauty and qualities of language used to communicate such as poetry—to show how the texts mobilise aspects of Neo-Platonism, *Naturphilosophie,* and Romanticism, contributing to the sacralisation of nature.

In Chapter 7, I analyse the third layer of religion, which is characterised by the mobilisation of *naturphilosophischen* ideals and the aesthetic repertoire of Romanticism. In this layer, religion shapes the ideal and presentation of the practices of knowledge production. Following the first section on the distinction between understanding and predicting as two practices of physics in Heisenberg's texts, I analyse in Section 2 the activation of topoi of encountering nature, including mountaineering or the experience of nature in histories and assessments of knowledge production. Here, the analytical concept of 'scientific masculinity' advances the analysis of the topoi by highlighting how these topoi, especial of exhaustion and caring contribute to a gendering of practices and labour associated with knowledge production. In the last section, I investigate two roles that history plays in the narration of the advancement of modern physics: genealogies of physicists and conversations with contemporaries. Both forms legitimise modern physics and Heisenberg's scientific persona as an outstanding physicist, a Romantic genius, and a model citizen of a *bildungsbürgerliche* society.

Part IV, encompassing Chapter 8 alone, brings the findings of its two predecessors into dialogue to discuss the findings of the study. In Chapter 8, I discuss the particular interference patterns developed between science and religion through

Heisenberg's texts. This includes the three roles religion plays in the texts: first, religion as a medium for cultural critique of modern society and modern science; second, religion as a framework for the interpretation of the epistemological and ontological questions posed by modern physics; and third, religion as a framework for interpreting and present practices of knowledge production. In the last section, I discuss four examples of the reception of Heisenberg's texts from the late 20th century, which illustrate the efficacy of Heisenberg's texts (e.g., news reports) as well as meaning-making on the basis of the texts by third parties (e.g., a Catholic Magazine and the new age movement). This last section demonstrates further, how the scientific persona of Heisenberg—created by his popular science writings—became part of the cultural *imaginaire* of the physicist as a genius and a model citizen.

To conclude the study, I embed in Chapter 9 the role of religion in Heisenberg's writings in the social dynamics between science and religion in modern society. The analysis shows how, in light of the advancement and social prominence of physics in the 20th century, religion serves as a medium of cultural critique and framework of interpreting as well as imaging new knowledge and its production.

Part I: Research Framework

The first part lays the theoretical, material, and methodological foundations for the analysis of the role of religion in Heisenberg's popular science writings conducted in Part II. In Chapter 2 I trace the conceptual framework of the thesis, in Chapter 3 I present the material I used, and in Chapter 4 I introduce the methodologies employed for the analysis.

Chapter 2 Theories, Concepts, and a Research Lens

The research field of science-and-religion has long been characterised by two complementary routes: theorising the relationship between science and religion investigating historical case studies. By the late 20th century, cultural approaches in the study of religion and the history of science redefined the foundation of the field by broadening the scope of the research object and incorporating new methodologies. This development has significant implications for this thesis, which pursues historical questions about the role of religion in Heisenberg's popular writings as well as theoretical questions about our understanding of the dynamic between science and religion. Cultural approaches redefined the framework within which religion can be studied, and in doing so, they opened the field to new sources and perspectives. As a result, science-and-religion research has become more versatile and offers a more comprehensive understanding of the different aspects of the dynamics between science and religion.

In this chapter, I outline the theoretical and conceptual framework along with the analytical category and lens that guide this study. In the first section, I introduce the model of interference which I use to dissect and analyse the dynamics between science and religion. Relying on the framework of functional differentiation, interference serve as a model to describe and analyse the many ways science and

religion interact, from texts and institutions to aesthetic repertoires. I continue, in Section 2.2, to narrow the research object down to popularisation of scientific knowledge as an important mechanism of meaning-making in the 20th century. In the third section, I introduce the analytical concept of 'scientific masculinity,' which is used to pay attention to and analyse how the presentation of knowledge production is gendered and contributes to the construction of Heisenberg's masculinity as a genius and physics as an androcentric discipline. Lastly, in Section 2.4, I introduce the aesthetics of knowledge as a research lens through which I study Heisenberg's references to the senses, practices, or aesthetic judgments as important aspects of knowledge production and the dynamics between science and religion. Together, the theoretical and conceptual framework developed in this chapter aid the two-folded study: a historical case-study on the role of religion in Heisenberg's popular writings and a structural analysis of the dynamics between science and religion.

2.1 A Study of the Dynamics between Science and Religion: Interference Patterns

The study of the dynamics between science and religion is embedded in theories of society. While historians in the tradition of Peter Harrison and John Hedley Brooke shed light on the negotiation and consolidation of the of "science" and "religion," the social structures and cultural contexts within which these intellectual debates take place remain largely invisible.[86] Social theorists provide alternative approaches that capture and conceptualise case studies as part of wider political contexts and structural changes of society.[87] This thesis brings the two traditions together when

[86] Harrison, *Territories of Science and Religion*; Brooke, *Science and Religion*.
[87] von Stuckrad, *The Scientification of Religion;* Grieser, 'Imaginationen des Nichtwissens'.

studying the role of religion in Heisenberg's texts and using these historical cases to discuss the social dynamics between science and religion.

The dynamics of social structures, and in particular those concerning religion, are at the centre of the EHR. Since the early 1990s, the program has been shaping the German scholarship of the academic study of religion. In order to study the diverse and changing roles of religion in society, the program employs the framework of a functionally differentiated society. Within the framework of functional differentiation, different levels of the dynamics between science and religion can be studied, including communication, the habitus of actors or groups, or institutions.[88] On the structural level, these dynamics include processes of social differentiation and integration,[89] or on an communicative level, processes of disenchantment and re-enchantment.[90] To study these dynamics between science and religion on a more fine-grained level, Gladigow introduced the model of interference. A physical concept itself, interference does not carry the negative connotations of obstruction or third-party meddling as in colloquial English.[91]

The model of interference holds a heuristic moment as it asks the researcher to take the different levels of the dynamics between science and religion into focus. The use of interference—a phenomenon and model from physics[92]—for historical and

[88] Weber, '*Wissenschaft als Beruf*'; Niklas Luhmann, *Theory of Society Vol. 1*, translated by Rhodes Barrett (Stanford: Stanford University Press 2012); Luhmann, *Theory of Society, Vol. 2*, translated by Rhodes Barrett (Stanford: Stanford University Press 2013); Pierre Bourdieu, *Homo academicus*, translated by Bernd Schwibs, (Stanford: Stanford University Press 2018); Pierre Bourdieu, *Religion*, edited by Franz Schultheis and Stephan Egger, translated by Andreas Pfeuffer, Hella Beister, and Bernd Schwibs (Berlin: Suhrkamp 2011).
[89] Weber, 'Wissenschaft als Beruf'; Luhmann, *Die Wissenschaft der Gesellschaft* (Frankfurt/Main: Suhrkamp 1992).
[90] Asprem, *The Problem of Disenchantment*.
[91] https://www.merriam-webster.com/dictionary/interference [Accessed April 18th, 2024].
[92] In *History of the Principle of Interference of Light*, Nahu Kipnis (Basel: Birkhauser Verlag 1991) tells the history of interference in physics. Proposed around 1800, the concept of interference in physics is intertwined with the development of the wave hypothesis of light. While interference was quickly accepted in acoustics, the idea of intersecting waves challenged the main hypothesis in optics at the time, which argued that light is made of particles, currently known as photons. These complementary properties of light remain central in modern physics. To use interference in research, scientists use mathematical formulations to describe the phenomenon, to model research objects and to analyse

cultural the studies of religion[93] exemplifies to the objects analysed with the model: the dynamics between the social systems of religion and science. Similarly, interference may serve as a method of describing and a model for manipulating dynamics between science and religion to gain a deeper understanding of the role of religion in modern society and, more specifically, society's interpretation of science. In physics, interference is embedded in wave theory, where it is used to study light and sound as waves emitted by a source with a distinct velocity, period, and frequency. In this context, interference describes the interactions of waves with either the same or different frequencies and energies. The results of these interactions can be observed as patterns of interference, for example, by human eyes in the case of the bright colours of a dragonfly, or heard by an orchestra. Additionally, interference allows physicists to calculate unknown variables, such as the frequency, the period, or the phase of an acoustic wave. Physicists speak of constructive interference when the interaction of two waves results in a greater amplitude, leading, for example, to increased volume in an orchestra, and of destructive interference when the waves cancel each other out. Between these two extrema, different interference patterns like stationary waves can be observed.

In the case of the study of science-and-religion, we can also observe and model different forms of interactions that can be described in forms of interference patterns. The potential of interference as a phenomenon has been illustrated by von Stuckrad,

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them or to make predictions. As a model, interference is intertwined with mathematical operations, which, like the Fourier transformations, are used to translate a function of one set of coordinates, like space or time, into a function of another set of coordinates, those of spatial or temporal frequency. Within this transformation, priorly obscured properties or phenomena, such as repetitions or dominant frequencies, are more visible. Furthermore, transformations are used to economise on data volume, for further operations, or to simplify calculations. Using interference in research is always accompanied with a reduction of complexity, such as focusing on light of a certain frequency and thus idealising research conditions.

93 See specifically 'Part Three: Interferences,' In von Stuckrad, *Locations of Knowledge*, 137–194 and von Stuckrad, 'Naturwissenschaft und Religion;' Grieser, '"European History of Religion" Revisited,' 206.

who combines it with a discursive approach to work out the dynamics between science and religion condensed as esoteric practices and texts.[94] Similarly, the physicist and philosopher of science Lukas Maierhofer proposes the use interference as a "methodological metaphor" to study the dynamics between science and literature. However, Mairhofer uses interference without elaborating on his reasoning for characterising inference as a metaphor instead of a model.[95]

Both Maierhofer and von Stuckrad attest to the potential interference holds when studying the dynamics between functionally differentiated systems like science, religion, or literature. Here the social systems are characterised by a function, like knowledge production in the case of science, or providing meaning in the case of religion. These functions are contentiously negotiated and sustained through autopoietic communication and the communicative delineation from other systems, like politics or art. The communicative systems of science or religion are entwined with institutions (e.g., university or church), practices (e.g., research or contemplation), or aesthetic regimes. However, the focus on the communicative level of the EHR highlights the plurality of interactions that compose the dynamics between science and religion developed by the semantic apparatus and aesthetic repertoire of Heisenberg's texts.

The framework of functional differentiation further facilitates the analysis of the changing role of religion in modern society. With the functional differentiation of society, religion becomes one communicative social system among many. Gladigow suggests that the system of religion is distinct by a communication around "meaning,

[94] von Stuckrad, *Locations of Knowledge*.
[95] Lukas Maierhofer, 'Interference Proposal of a Methodological Metaphor', In *Physics and Literature: Concepts, Transfer, Aestheticization*, edited by Aura Heydenreich and Klaus Reinhard Mecke, (Berlin/Boston: De Gruyter 2021), 253–275; Lukas Mairhofer, *Bertolt Brechts Interferenz mit der Quantenphysik. Das moderne Theater und die moderne Physik*, (Berlin/Boston: De Gruyter 2023).

symbols, or interpretation."[96] The communication gains validity through references to traditions or persona as well as cosmic order or eternal laws, which may invoke the transcendent.[97]

Any communication about the transcendent is always observed by historical actors in the immanent.[98] While earlier research, such as the phenomenology of religion had focused on the essence of the transcendent, cultural studies have shifted the attention to communication that refers to the transcendent. Moreover, the shift to the distinction of religion as meaning, symbols, and interpretation in the cultural study of religion has opened the field to the "double-pluralism of religion."[99] Double-pluralism describes the pluralism among historical religions (e.g., Christian denominations, Judaism, or Islam) and the pluralism among different systems of meaning (e.g., religion and "concomitant alternatives," like Neo-Platonism, Romanticism, or *Naturphilosophie*).[100]

Interference is a particularly fruitful concept for the analysis of the dynamics between science and religion in a framework of functional differentiation and the double-pluralism of religion. This is represented in the pluralism of systems of meaning demonstrated in the example Gladigow gives of one possible interference pattern :

> Renaissance, Humanism and Romanticism drew their alternatives to Western Christian culture largely from the sciences [*den Wissenschaften*]. Thus, a revitalised Platonism could form very close links with Christianity or continue to operate as a theory of magic and irrationalism into the 18th century; Gnostic schemes and ideas of salvation could create interferences with Asian religions imported through the philologies.[101]

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[96] Gladigow, 'Europäische Religionsgeschichte,' 293.
[97] Galdigow, 'Gegenstände und wissenschaftlicher Kontext von Religionswissenschaft', In *Handbuch der religionswissenschaftichen Grundbegriffe. Systematischer Teil. Alphabetischer Teil: Aberglaube — Antisemitismus*, edited by Hubert Cancik, (Stuttgart: W. Kohlhammer 1988), 26–40.
[98] Luhmann, *Die Wissenschaft der Gesellschaft*; Luhmann, *Die Religion der Gesellschaft*, (Frankfurt/Main: Suhrkamp 2002).
[99] Grieser, '"European History of Religion:" Revisited,' 37.
[100] Gladigow, 'Europäische Religionsgeschichte,' 296; Gladigow 'Gegenstände und wissenschaftlicher Kontext von Religionswissenschaft.'
[101] Gladigow, 'Europäische Religionsgeschichte,' 294.

In this case, the interference pattern is observed between different forms of meaning and facilitated by philological work. Moreover, the example indicates that research and academic knowledge are not neutral towards social practices and issues, but are entangled in the practices of missionaries or colonialists. As such, the sciences serve as medium of importing and transporting systems of interpretation, meaning, and symbols. Once imported, the systems may be used to interpret academic knowledge, such as quantum mechanics (see Chapter 6).[102] The focus on the pluralism of religion recognises the export of religion/s across the world as well as the receptions of non-European traditions by the European landscape of religion.[103] As such, interference asks researchers to go beyond the discussions on the relationship between science and religion or their concepts to study the complexity that characterises the research field of science-and-religion.

Other interference patterns rely instead on the characteristics of the social system of science. The autopoietic communication of science revolves around, among other things, the production of new and true knowledge about the world.[104] With science and religion made distinct through specific symbols, concepts, or functions, the study of the dynamics between them, then, focusses on the references between

[102] Erwin Schrödinger's *My view of the World,* (Cambridge: Cambridge University Press 1951) is a prime example of the reference to imported philosophies, such as the Upanishads. For an analysis of this phenomena, see Gladigow, '"Wir gläubigen Physiker:" Zur Religionsgeschichte physikalischer Entwicklungen Im 20. Jahrhundert', In *Der Untergang von Religionen*, edited by Hartmut Zinser (Berlin: Reimer 1986), 321–330.
[103] On the impact of the program on the Academic Study of Religion see Auffahrt, Grieser, and Koch *Religion in Culture—Culture* in Religion, in particular the two chapters in the handbook: Grieser and Koch 'Religion in Culture—Culture in Religion'; Grieser, '"European History of Religion' Revisited" and the perspective of science-and-religion Makrides, 'The Natural Sciences in the Framework of a European History of Religion.'
[104] Luhmann, *Die Wissenschaft der Gesellschaft*; Rudolf Stichweh, 'Differenzierung der Wissenschaft', Zeitschrift für Soziologie, 8(1) (1979), 82–101; David Kaldewey, *Wahrheit und Nützlichkeit: Selbstbeschreibungen der Wissenschaft zwischen Autonomie und gesellschaftlicher Relevanz,* (Bielefeld: transcript 2013).

the systems or shared discourses.[105] A prominent dynamic between science and religion results from the reference to academic knowledge and incorporation of scientific concepts by interpretative systems, such as the new age movement.

These are just two of many possible interference patterns between science and religion that can also be observed in connection with Heisenberg texts (see Section 8.5). In this study, I lay the focus on the interference patterns developed by the popularisation of science through Heisenberg's popular writings, opting to use interference both as a model and as a concept. Firstly, I use interference as a model to differentiate the different levels of the structural dynamics between science and religion, such as explicit communication, aesthetic repertoire, institutional structures, or actors. Secondly, I use interference as a model to assert different patterns that develop once science and religion meet on these different levels. Lastly, I use interference to describe the different dynamics between science and religion on the structural level of society. On the communicative level, we can observe and describe transfers of academic concepts into the communication of religion or communication within the same discourse. On the social level the interference patterns may include subtractions of the social relevance of religion by science,[106] the compensation of science by religion (see Section 5.2), or, as von Stuckrad describes it ,the 'scientification of religion,'[107] as well as the development of its opposite, described by Laura Vollmeer as a 'religionisation of science.'[108] Because of the focus on the

[105] von Stuckrad, 'Naturwissenschaft und Religion,' 444f..
[106] Taylor, *A Secular Age*.
[107] von Stukrad, *The Scientification of Religion: An Historical Study of Discursive Change, 1800–2000*, (Berlin/Boston: De Gruyter 2014).
[108] Laura Vollmeer, *The Relationality of Religion and Science: Toward a New Discourse-analytical Framework*, (Dissertation 2017).

structural dynamics, interference offers a more nuanced perspective on the individual aspects of the dynamics between science and religion.[109]

2.2 A Mechanism of Meaning-Making: Popularisation of Science

The popularisation of scientific knowledge plays a central role in the self-fashioning of science as an indispensable part of modern society as well as the public. As a distinct form of the communication of science, popularisation can contribute to the autopoietic communication of science, but more often, it processes scientific knowledge in a way that connects it to public debates. Historical research has offered insight into the economic and social aspects of science popularisation, though Gladigow's consideration of religion suggests that popularisation is one of the fastest ways to create meaning in modernity.[110] Science popularisation as a mechanism of meaning-making becomes possible because the meaning and interpretation are derived increasingly from the world, especially nature, but also society. Under this condition, Gladigow is able to recognise the importance of popularisation of science as an important mechanism of meaning-making.

> Since 'meaning [*Sinn*]' is increasingly obtained through the interpretation of 'world', natural scientists also appear as 'producers of meaning [*Sinnproduzenten*]' or are made into such through the mechanism of popularisation. The popularisation of scientific results is probably the mechanism by which meaning [*Sinn*] is produced the fastest - sometimes even without the intention of the primary authors [*Primärautor*].[111]

Gladigow describes two modes of meaning-making resulting from the popularisation of science: scientists interpreting their scientific knowledge and third parties referencing

[109] Overall, interference holds heuristic potential. Moreover, it does not politicise the dynamics and relationship, like the concept of 'border work' used by Harrison in *Territories of Science and Religion,* and it further resists economising the dynamics, like the concept of "trading zones" that Galison proposes in *Image and Logic: A Material Culture of Microphysics,* (Chicago: University of Chicago 1997), or the 'flow' of concepts introduced by Rens Bod, *et al*, 'The Flow of Cognitive Goods: A Historiographical Framework for the Study of Epistemic Transfer,' in *Isis* 110 (3), (2019).
[110] Gladigow, 'Europäische Religionsgeschichte,' 298.
[111] Gladigow, "Europäische Religionsgeschichte," 296.

scientific knowledge in their meaning-making. He describes the first mode as the "willingness of many relevant scientists to develop religious perspectives of their work."[112] These interpretations of research by scientists lean on a "religious framework" and "traditionally religious concepts," such as God, religiosity, belief, or Christianity.[113] Examples of these interpretations are the texts by renowned physicists like Max Planck or Albert Einstein, who use concepts traditionally associated with religion, such as God, belief, or cosmic religiosity in their interpretations of modern physics.[114] While the current study focuses on Heisenberg's colleagues, it does not deal with the use of concepts that have been and continue to be part of the semantic apparatus of religions, such as religion or God in the interpretations of modern physics presented by Heisenberg's texts.

The second mode of meaning-making can be observed when third parties, like journalists or publicists, incorporate scientific knowledge in news reports, popular science books, science-fiction, and, more recently, YouTube videos, podcasts, and TikToks. In these cases, scientific knowledge can be incorporated in stories and videos that interpret the world. The historian Daum suggests that the growing commodification of modern life in the later 20th century and economic interests shaped science popularisation to the extent that it started to compete with the *bildungsbürgerliche* ideals of active self-formation of public education in the name of citizenship.[115] In the case of Heisenberg, the mode is visible in an interview Heisenberg gave in 1966 for a Catholic Magazine, in which the interviewer offers his interpretation of Heisenberg's texts and letters given by strangers who offered their view on his beliefs

[112] Ibid. 296.
[113] Gladigow, '"Wir Gläubigen Physiker,"' 322.
[114] Ibid..
[115] Andreas W. Daum, *Wissenschaftspopularisierung im 19. Jahrhundert: Bürgerliche Kultur, naturwissenschaftliche Bildung und die deutsche Öffentlichkeit, 1848-1914*, (Münich: R. Oldenbourg Verlag 2002).

and who ask if Heisenberg would expand on his views in order to confirm their interpretation.[116] While the focus of my study lies on the interpretations of science by Heisenberg himself, these reinterpretations by third parties are important testimonies on the effectiveness of Heisenberg's texts (see Section 8.4). Both modes of popularisation can function as mechanisms of meaning-making.

Historically, popularisation of scientific knowledge merges with the professionalisation of science to become an important aspect of modern science and modern society in the late 19th century. The functional differentiation of science is accompanied by the specialisation of knowledge that becomes successively "esoteric."[117] One path to acquire that specialised knowledge was through professionalisation at a growing number of universities. As a result, the newly acquired knowledge was usually available only to an eclectic circle of people. However, at the same time, a growing number of scientists went on to share the esoteric knowledge with a lay audience—which had little to no knowledge about the topic presented—through lecture fairs or in magazines and museums.

In the German speaking world, the popularisation of scientific knowledge and the study of "esoteric" knowledge became a central practice of the self-fashioning of the *Bildungsbürgertum* (educated *bourgeoisie*) and the concept of citizenship.[118] A central element of the *Bildungsbürgertum* is a comprehensive education paired with lifelong self-formation. The formal aspect of *Bildung* took place in schools and universities that were shaped by the reform movement of the Prussian monarchy between 1807–15. Wilhelm von Humboldt, the minister of education and culture at

[116] Heisenberg and Terzano, 'Harmonie der Materie', In *Heisenberg, Werner Gesammelte Werke: Abteilung C: Allgemeinverständliche Schriften. Physik und Erkenntnis (1956-1968)* edited by Walter Dürr, Hans–Peter Blum, and Helmut Rechenberg, (München: Piper 1984), 388–393.
[117] Ludwick Fleck, *Entstehung und Entwicklung einer wissenschaftlichen Tatsache: Einführung in die Lehre vom Denkstil und Denkkollektiv*, (Frankfurt/Main: Suhrkamp 2019).
[118] Daum, *Wissenschaftspopularisierung im 19. Jahrhundert.*

the time, initiated lasting changes in the education system, modelled after a humanistic tradition. Today known as the Humboldtian ideal of *Bildung*, the humanistic formation was meant to be *holistic*, educating pupils in different disciplines including philosophy, literature, and science. Beyond the institutions, the ideal of *Bildung* shaped the individuals' specialised knowledge or literary canon to foster the self-actualisation.

With the growing emphasis on education and specialised knowledge, science and the scientists gained public visibility and relevance. Within this cultural context, scientists like Heisenberg became prominent figures, serving as public intellectuals as well as role models for citizenship. With the popularisation of scientific knowledge, researchers took on the role of "science populariser" and "scientific advisor" to become recognisable personae of high society.[119] Other scientists used the platforms of popular science communication to voice critique of contemporary research and society. Within the public debate, these critical scientists paired their roles as public scientists with the "literary intellectual" and the "liberal *bildungsbürgerliche* practitioner."[120] Regardless of the form of the science communication, it contributes to the scientist's public persona.

The "scientific persona" captures the "intermediate" between the social institutions and the individual biographies of scientists like Heisenberg.[121] As such, the scientific persona is a cultural identity, which, in the case of the Heisenberg, is based on his profession as a physicist and his public roles. This cultural identity shapes the individual scientist on a somatic and psychologic level, creating a collective of "the scientists" with a shared and "recognisable physiognomy."[122] As such, each persona

[119] Klein, 'Science, Industry, and the German "Bildungsbürgertum."'
[120] Carson, *Heisenberg in the Atomic Age*, 256.
[121] Daston and Otto Sibum, 'Introduction: Scientific Personae and their Histories', In *Science in Context*, 16(1-2), (2003), 1–8, 2.
[122] Ibid., 2.

is created in a historical circumstance and bound to material conditions within which it emerges and disappears. By focusing the attention on the scientific persona, the social dynamics and collective ways of thinking, working, feeling, and meaning-making tied to the popularisation of scientific knowledge become visible.

A prominent place where the scientific persona is created and maintained is the public lecture. Public lectures became a key medium of science popularisation and, by extent, of meaning-making. In the 19th century, lecture halls were designed to offer the scientist and the audience a unique experience.[123] For women, public lectures presented an opportunity to enter into academic spaces and learn about research before they were admitted to study at universities on a regular and formally recognised basis. At the same time distinct public lecture series were founded and housed in what were designed as and came to be iconic halls.

A prominent example of a public lecture series are the annual Gifford Lectures. Established in 1887 by the Will of Lord Adam Gifford, the Gifford Lectures continue to be held today at four universities in Scotland (St. Andrews, Glasgow, Edinburgh, and Aberdeen). The lectures were, from the beginning, open to the public and aimed to "promote and diffuse the study of Natural Theology in the widest sense of the term."[124] Over half a century later, Heisenberg was invited to give several such lectures at St Andrews in 1955/6. Afterwards, the lectures, which were given in English, were published in English in 1958 and translated into German in 1960.[125] In the case of the Gifford lectures, the meaning-making is embedded in their goal of science popularisation. This thesis does not intend to take a closer look at how these lectures

[123] See Diarmid Finnegan, 'Finding a Scientific Voice. Performing Science, Space and Speech in the 19th Century', In *Transactions of the Institute of British Geographers* 42(2), (2017) 192–205; Golinksi, 'Humphry Davy's Sexual Chemistry.'
[124] 'The Gifford Lectures: Over 100 years of lectures on natural theology,' https://www.giffordlectures.org/ [Accessed 13 July 2021].
[125] Heisenberg, *Physics and Philosophy*.

contributed to meaning-making developed by third parties (except in their reception by biographers and newspapers; see Section 8.5) but rather their contributions to the interpretation of scientific knowledge by the scientist Heisenberg, himself.

2.3 An Analytical Concept: Scientific Masculinity

The research of the field of science-and-religion has largely focused on the texts written by men. While these extant studies offer thorough insight into the intellectual history of "the relationship between science and religion," feminist research and masculinity studies support the need to recognise the material and embodied conditions of this history, as well as the cultural *imaginaire* it is entwined with. In a special issue on "Scientific Masculinity" the historians of science Robert Nye and Emily Milam drew attention to the role ideals of masculinity played in shaping academic practices and demonstrated that institutions of science engendered distinct masculinities. Gender approaches require historians to rethink science as a "fundamentally gendered activity, whether or not women are present."[126] In the tradition of Joan Wallace Scott's "Gender: A Useful Category of Historical Analysis,"[127] scientific masculinity presents an analytical category for the historical research of science. As such, scientific masculinity holds the heuristic potential to scrutinise social structures and ideals built on the distinction between and among men and women embedded in the institution's practices, knowledge, and metaphors of science.

The focus of scientific masculinity lies on the construction and maintenance of the identities of the "historically dominant sex," even in the absence of a plurality of

[126] Milam and Nye 'An Introduction to Scientific Masculinities,' 2.
[127] Scott, 'Gender: A Useful Category of Historical Analysis.'

sexes and/or genders.[128] While feminist scholars have highlighted the absence of women from scientific institutions and the knowledge produced in science, the role ideals of men and masculinities played in the negotiation of research practices has, so far, received little attention.[129] Although masculinity studies have highlighted the potential that a focus on the negotiation of masculinities holds for the understanding of social structures and ideals, the situatedness of men is rarely named and investigated. The sociologist Armin Nassehi traces the appearance of men and masculinity back to the gendered structures of stratified society, which built on several distinctions including that between men and women. Here, men started to represent the whole of humanity and at the same time a distinct category of humans: men. In a homosocial sphere of men, historical individuals are only recognised as men if their masculinity is confirmed with the norm.[130] This doubling of masculinity as the 'superior' gender and simultaneously the 'genderless universal' human is the paradox of masculinity.[131] Women, on the other side of that distinction, are simultaneously a part of the whole of humanity and the excluded other.[132] The contestation of masculinity is often a result of the intersection with other identifying markers, such as class, disability, sexuality, race, nationality, or religion. Any divergence leads often to an individualisation and/or a feminisation of manhood. Often, some men are associated with the other side of the distinction (women), and as such, their masculinity is presented and often rejected as a feminised one, like in the case of the Dandy or the feminine Jew.

[128] Milam and Nye 'An Introduction to Scientific Masculinities,' 14.
[129] Ute Frevert, 'Männergeschichte als Provokation?!,' In *Werkstatt Geschichte*, 6 (1993), 9–11.
[130] Armin Nassehi, *Gesellschaft der Gegenwarten*, (Frankfurt/Main: Suhrkamp 2011), 286f.
[131] Ulrike Brunotte and Rainer Herrn, *Männlichkeiten und Moderne: Geschlecht in den Wissenskulturen um 1900*, (Bielefeld: Transcript 2008), 9.
[132] Nassehi, Gesellschaft der Gegenwarten, 270.

The feminisation of a man's masculinity is at play when it comes to the incorporation of Romantic aesthetics into scientific practices, especially the sensitivity towards nature at the core of intuitive knowledge production. This is visible in, for example, the negotiation of Sir Humphry Davy's masculinity. While his rural background and his approach to research did not stand in his way to become a Sir and the president of the Royal British Academy of Science, his unconventional methods and appearance challenged the ideal of the gentlemen scientist. The exhaustion of his body and developing a sensibility towards nature raised eyebrows. Furthermore, the use of a poetic language and the evocation of emotions in public lectures, which were also open to women, lead to representations of him as a Dandy and a feminised man.[133]

The masculinity of the Romantic genius stands next to the scientific masculinities of the gentlemen of science, the scientist, the scholar, the engineer, or the professional scientist. In the German-speaking context of the 19th century, the engineer emerged as an alternative to the masculinities of "the men of action," "the inventor," and "the artist."[134] At the same time, the 'professional scientist' emerged in the USA. Antithetical to the Romantic genius and the men of science, the professional scientists sought out commercial relations, linking researchers with private enterprises.[135] In Britain, the scholar and the gentlemen scientists presented two diametrical ideals. Coming from an aristocratic background, the gentlemen had the financial means to conduct his studies independently, whereas the scholar, often from a working-class or rural background, had to rely on a beneficiary to conduct studies and ultimately challenged the masculine ideals of the upper-class and aristocratic

[133] Golinski, 'Humphry Davy's Sexual Chemistry', 20f.; Jan Golinski, 'The Care of the Self and the Masculine Birth of Science,' In *History of Science*, 40(2), (2002), 125–45.
[134] Paulitz, *Mann und Maschine*.
[135] Lucier, 'The Professional and the Scientist in Nineteenth-Century America.'

gentleman.[136] In the 1920s, the man of science was praised as a model citizen because of his contribution in the First World War.[137] The political tensions in Europe leading up to the Great War thus found their way into the negotiation of masculinities. The perception of German scientists by their English contemporaries depended, for example, on the context. While the Romantic sensibility, represented by the heroic persona of Alexander von Humboldt, offered a masculinity that could be incorporated into aristocratic structures and reflected the gentlemen of science mode, the practices and attitudes of German physiologists were rejected as "cold and calculative."[138] The link between a scientific masculinity and ideals of citizenship, as in the case of the scientist as a national hero in Britain, can be observed in many contexts.

In the German speaking-world, the interplay between masculinities and social contexts becomes prominent in the ideal of "the coherent man [*ganze Mann]"*[139] as the model citizen. The coherent man is tied to the emergence of the *Bildungsbürgertum* within the nation-state of the 19th century. It is the masculinity of this social class and culture that shapes the hierarchies of gender in the differentiated society of modernity.[140] The coherent man served as the head of the family, striving for social advancement through education and self-formation.[141] This combination of the coherent men, who is engaged in science communication, and the Romantic genius can be observed in the creation of Heisenberg "scientific persona" in his popular

[136] Shapin, '"Scholar and a Gentleman." The Problematic Identity of the Scientific Practitioner in Early Modern England', In *History of Science*, 29, (1991), 279–327; Finnegan, 'Finding a Scientific Voice'.
[137] Ellis, *Masculinity and Science in Britain*, 109, 209f.
[138] Ibid., 11.
[139] In reference to the observation Carson makes in *Heisenberg in the Atomic Age* about Heisenberg's scientific persona as coherent, I use the translation of coherent men for the *bürgerliche* concept of the *"ganze Mann."* This distinguishes discourses about *bürgerliche* ideals from contemporary discourses about the "real man," tied to an identity of fighting and protecting; Richard Godfrey "Military, masculinity and mediated representations: (con)fusing the real and the reel" in *Culture and Organization*, 15(2), (2009) 203–220.
[140] Brunotte and Herrn, *Männlichkeiten und Moderne,* 10; Robert A. Nye, *Masculinity and Male Codes of Honor in Modern France*, (Oxford: Oxford University Press 1993).
[141] Peter Davis, 'Introduction: "Crisis" or "Hegemony"? Approaches to Masculinity', In *Masculinities in German Culture*, edited by Sarah Colvin, (Rochester: Camden House 2008), 1–18, 14.

writings, and his public reception. Together, they contributed to his scientific masculinity becoming a model for West-German citizenship.

Many of the studies on scientific masculinity offer some insight into the negotiation of competing masculinities that will inform this case study. Falko Schnicke systematised the different axes along which scientific masculinity and the consolidation of a discipline like history in German can be scrutinised as a form of masculinisation.[142] The five non-hierarchical axes are: actors, institutional structures, the body of knowledge or canon, academic practices, and symbolic orders. Individually and together, these axes facilitate a heuristic study of the poly-temporal structures through which masculinities negotiated and shaped science.

Scientific masculinity holds great potential for the study of the role of religion in Heisenberg's texts as an important factor in the creation of cultural ideals. While Carson focuses on Heisenberg's public communication, using the concept of scientific persona, scientific masculinity sheds light on the way a scientist's voice, academic practices, or authority not only shape the reputation of a scientist but may further contribute to the manifestation of a masculinity.[143] The recognition of Heisenberg's communication on religion, which lies beyond his expertise as a scientist, relies, among others, on his authority as a physicist. This authority builds on academic affiliation, social network, or awards like the Nobel Prize. As such, authority serves to reduce the complexity of assessing the validity of the produced knowledge through the proxy of reputation.[144] In many cases, the masculinity is central to the assessment of authority, which then led to the work of female scientists being subsumed into the achievements of their husbands, brothers, fathers, or lovers, with the result that their achievements

[142] Falko Schnicke, *Die Männliche Disziplin: Zur Vergeschlechtlichung der Deutschen Geschichtswissenschaft 1780-1900*, (Göttingen: Wallstein 2015).
[143] Carson, 'Objectivity and the Scientist: Heisenberg Rethinks', In *Science in Context, 15(1–2),* (2003), 243–269.
[144] Luhmann, *Die Wissenschaft der Gesellschaft*, 352.

and heroic lives have been eradicated from popular discourse and even institutional records.[145] As such, the work of women or men with diverging masculinities are 'forgotten' by (future) historians, which leaves a canon that is made up by great men. Linked to the institutional aspects, the authority of scientists and their masculinities are shaped by practices and symbolic order. Aesthetic repertoires like metaphors, allegories, topoi, or paintings develop subtle and explicit hierarchies, which translate into the construction and maintenance of different masculinities.[146] Scientific masculinity is a particularly helpful concept when studying the aesthetic repertoire of religion in Heisenberg's writings, as it opens another layer to the study of the dynamics of science and religion when it comes to the cultural *imaginaire* of the physicist or practices of knowledge production.

2.4 A Research Lens: Aesthetics of Knowledge

While earlier studies of the discourse between science and religion have been thorough,[147] research on the aesthetic aspects of knowing and knowledge point to a need to examine the aesthetic repertoire of knowledge production and science communication. Most recently, Arianna Borrelli and Alexandra Grieser coined the approach of the aesthetics of knowledge in a special issue from 2017 "The 'Beauty Fallacy' Religion, Science, and the Aesthetics of Knowledge" and expanded on it in a chapter from 2019, "Aesthetics of Knowledge." The aesthetics of knowledge, presented by Borrelli and Grieser, is distinct in its approach to knowledge from the

[145] Annette Lykknes, Donald L. Opitz, and Brigitte Van Tiggelen, *For Better or for Worse? Collaborative Couples in the Sciences*, (New York/London: Birkhäuser 2012).
[146] Schnicke 'Wissenschaftsmetaphern: Zur männlichen Kodierung der Germanistik und Klassischen Philologie in der zweiten Hälfte des 19. Jahrhundert', In *Jahrbuch für Universitätsgeschichte,* 20, (2019), 69–96.
[147] Standing exemplarily for an intellectual history of the discourses on the relationship, see Harrison, *Territories of Science and Religion.*

processes of sensing, feeling, or imagining under the consideration of the material and somatic conditions of knowing. Through this aesthetic lens, the non-propositional aspects of knowledge, including practices, narratives, or aesthetic judgments, come into focus. Inspired by the aesthetics of religion and cultural research of science, the lens of the aesthetics of knowledge brings another layer of the dynamics between science and religion to the fore.

In the history of science, Lorraine Daston and Peter Galison's study of objectivity has likewise[148] brought attention to the practical, somatic, and imaginative abilities involved in the production of scientific knowledge as objective.[149] More recently, Milena Ivanova has shown that aesthetic judgments also play a crucial role in the development and evaluation of experiments.[150] These two studies exemplify the insights gained from focusing on the somatic aspects of knowledge production and the imagination involved in it. Whereas the investigation of non-propositional aspects of knowledge in the history of science stands out in thorough case studies, the aesthetics of knowledge starts by shifting the conceptual framework of knowledge and knowing.

Standing in the tradition of the aesthetics of religion, the starting point of the aesthetic of knowledge is the Greek term *aisthesis*. As an epistemological concept, aesthesis denotes sensory perception while referring to the larger process of how humans make sense of their environment and themselves through the senses.[151] The aesthetics of religion builds on the work of Hubert Cancik and Hubert Mohr, who

[148] Beyond the influence on the history of science, Daston and Galison's study paved the way for the "Aesthetics of Knowledge," see Grieser and Borelli, 'Recent Research on the Aesthetics of Knowledge in Science and in Religion,' 8f..
[149] Lorraine Daston and Peter Galison, *Objectivity* (Massachusetts: MIT Press 2007).
[150] Milena Ivanova, 'The Aesthetics of Scientific Experiments', In *Philosophy Compass*, 16(3), (2021), 1–9.
[151] Grieser and Johnston, 'What is an Aesthetics of Religion? From the Senses to Meaning—and Back Again', In: *Aesthetics of Religion*, edited by Ibid., (2017), 1–49.

published the seminal paper "Aesthetics of Religion [*Religionsästhetik*]."[152] Part of the scholarly network in which Gladigow coined the program of the European History of Religion, Cancik's and Mohr's paper is distinguished by being motivated by a similar ambition for a cultural study of religion. In this case, the shift away from church history and the phenomenological studies of religion were guided by the study of somatic and imaginative practices and processes that are part the social system of religion. Since then, the research inspired by the aesthetics of religion highlights the plethora of practices, forms of imagination, or aesthetic regimes that constitute and are part of religion.[153] This distinct approach to religion is also apparent in the aesthetics of knowledge, where it is complemented with case studies of knowledge and knowing.

The different studies on the aesthetic aspects of knowledge and religion are distinct in their connection of different approaches to the research problem. The handbook *Aesthetics of Religion. A Connective Concept,* edited by Alexandra Grieser and Jay Johnston, places the connectivity of the different approaches and methods involved in the aesthetic studies at the centre. This connectivity can be observed on two levels: first, the fruitful combination of historical, sensory, or interpretative approaches to sensing, perceiving, and sense-making; and second, the use of diverse material, media, or data that offer together new insight into the different modes of academic knowledge (about religion).[154] The aesthetics of knowledge is an interdisciplinary endeavour that brings the aesthetics of religion together with the

[152] Hubert Cancik and Hubert Mohr, 'Religionsästhetik', In *Handbuch der Religionswissenschaftlicher Grundbegriffe: Systematischer Teil. Alphabetischer Teil: Aberglaube — Antisemitismus,'* edited by Hubert Cancik, (Stuttgart: W. Kohlhammer 1988), 121–156.
[153] In 2007, the working group *Religionsästhetik* was founded. The working group on the German Association of the Academic Study of Religion (DARW) transformed into the AESToR network, funded between 2015–2018 by the German Research Fund. Grieser and Johnston offer in their introduction to the volume *Aesthetics of Religion. A Connective Concept* an excellent histography of the aesthetics of religion and highlight the crucial role of the German research network, which produced this volume and a handbook *The Bloomsbury Handbook of the Cultural and Cognitive Aesthetics of Religion* (London: Bloomsbury 2019) edited by Anne Koch and Katharina Wilkens.
[154] Grieser and Johnston, 'What is an Aesthetics of Religion?', 30f..

diverse approaches and methods employed by historical studies on the aesthetic and material aspects of science and knowledge production. This connectivity can be observed in Daston and Galison's study of scientific objectivity that combined the study of images and bodily practices with an intellectual history of virtues, such as self-restrain or immediacy, that shaped ideals of nature, the scientists, and what it means to conduct research.[155] Similarly, Grieser's study on the pictures of the Hubble Space Telescope bring together the analysis of images with a cultural perspective on the aesthetic regime of Romanticism to show how the images develop in intuitive ways the sensing the universe.[156] The connectivity is also at play in the analysis of aesthetic judgments, such as beauty or symmetry, in the theory of high energy physics. In different studies in high energy physics, Borrelli combines narratology with the analysis of mathematical formulae and images to show that theories in high energy physics are built around plausibility and incorporate aesthetic judgments.[157] These cultural approaches to science and knowledge show that aesthetics are integral to the production of (scientific) knowledge.

These studies on the aesthetic aspects of knowledge and knowing can also render the interference pattern between science and religion visible. While these patterns remain invisible in studies that focus on the explicit discussion of the concept of religion, this implicit religion is highly influential in structuring the perception and presentation of the world. For example, the topos of intuitive knowing in the case of the Hubble Space Telescope stand in the tradition of the modern aesthetic religion shaped by German Romanticism, most notably the work of Schleiermacher.[158] A

[155] Daston and Galison, 'The Image of Objectivity', In *Representations*, 40(Special Issue: Seeing Science), (1992), 81–128.
[156] Grieser, 'Imaginationen des Nichtwissens'.
[157] Borrelli, 'Symmetry, Beauty and Belief in High-Energy Physics'; Borrelli, 'Die Genese des Gottesteilchens' In *Erzählung und Geltung. Wissenschaft zwischen Autorschaft und Autorität,* edited by Sofia Azzouni, Stefan Böschen, and Carsten Reinhardt, (Stuttgart: J.B. Metzler 2015), 63–83.
[158] Grieser, 'Blue Brains,' 258.

central aspect of this modern aesthetic religion is the development of links between stories of knowledge production and/or scientific knowledge and the topos of the experience of nature (see Sections 5.1 and 7.2). Moreover, the aesthetic judgments of beauty or symmetry transport elements of Neo-Platonism.[159] This led von Stuckrad to the conclusion that German Romanticism was pivotal for the development of interference patterns between science and religion.[160] The aesthetics of knowledge and knowing are further entwined with masculinities, such as the Romantic genius in the case of aesthetics of sensitivity and immediacy tied to knowledge production.[161] As such, the aesthetics of knowledge is potentially a productive lens when studying the role of religion in shaping knowledge as well as the practices of science and ideals of scientists.

2.5 Conclusion

This chapter introduced the conceptual framework within which I approach the question of the role of religion in Heisenberg's texts. Accompanying the conceptual framework of science and religion as two functional systems of a differentiated society, I presented the conceptual tools and analytical lenses that I use to study the dynamics between science and religion in the case of Heisenberg. On the back of this framework and tools, interference presents not only a conceptual alternative to the linear term of relationship, but also a model and concept to study different layers and forms of the dynamics between science and religion. The fruitfulness of interference lies in the heuristic potential to distinguish and analyse different layers of the dynamic as well as

[159] Grieser, '"European History of Religion": Revisited,' 282; Borrelli, 'Poetic Imagination in Scientific Practice: Grand Unification as Narrative Worldmaking.'
[160] von Stuckrad 'Naturwissenschaft und Religion,' 425.
[161] Borrelli, 'Poetic Imagination in Scientific Practice', 318.

the patterns that appear when science and religion interact. In order to study the different layers, I characterise science and religion as two of many functional systems that are distinct by their autopoietic communication. In the case of religion, the communication evolves around religion, meaning-making, or interpretation of events and experiences, sometimes with a reference to the transcendent, and which is accompanied by practices of contemplation, aesthetics of revelation, and symbols. In the case of science, the communication evolves around the reflection on science, research practices, the formulation of certified theories about the world, or the production of new knowledge, which is accompanied by practices of observing or problem solving, and aesthetics of rationality. However, as we have seen, the aesthetic repertoire of science exhibits great influences from the aesthetics of revelation and religion. Both systems are entwined with institutional structures or material objects that remain largely in the background of my study. It is rather the scientist who wrote the popular writings that presents the core material of this study.

Chapter 3 Material: Heisenberg's Popular Texts and Letters

During his life, Heisenberg wrote over 500 texts which include a large number of scientific publications and reviews as well as presentations, articles, interviews, and books for a lay audience.[162] To investigate the thesis question about the role of religion in Heisenberg's popular writings I selected around seven texts from this extensive corpus.

Most of Heisenberg's texts have been edited by former students and colleagues of his, including Walter Blum, Hans-Peter Dürr, and Helmut Rechenberg. The scientific papers are edited in two series that include three volumes of the *Collected Works Series A. Original Scientific Papers* and one volume of the *Collected Works Series B. Scientific Reviews Papers, Talks, and Books* both published by Springer Verlag.[163] The popular texts written for a wider audience are published by Piper Verlag under the same editorial team. These popular writings include five volumes of the *Collected Works Series C: Philosophical and Popular Writings*. [164] All seven texts used in this thesis are published in the *Series C*. Along with these texts, letters stored in archives or edited informed my analysis. Moreover, I consulted manuscripts, interviews, newspaper

[162] Cassidy and Baker, *Werner Heisenberg: A Bibliography of his Writings*.
[163] Werner Heisenberg, *Gesammelte Werke: Series A, Part I, Original Scientific Papers*, edited by Walter Blum, Helmut Rechenberg, and Hans-Peter Dürr (Berlin: Springer Verlag 1985); Werner Heisenberg, *Gesammelte Werke: Series A, Part II, Original Scientific Papers*, edited by Walter Blum, Helmut Rechenberg, and Hans-Peter Dürr (Berlin: Springer Verlag 1989); Werner Heisenberg, *Gesammelte Werke: Series A, Part III, Original Scientific Papers*, edited by Walter Blum, Helmut Rechenberg, and Hans-Peter Dürr (Berlin: Springer Verlag 1993); Werner Heisenberg, *Gesammelte Werke: Series A, Scientific Review Papers, Talks, and Books Wissenschaftliche Übersichtsartikel, Vorträge und Bücher*, e. by Walter Blum, Hans-Peter Dürr, and Helmut Rechenberg (Berlin: Springer Verlag 1984).
[164] Heisenberg, Gesammelte Werke: Abteilung C, Allgemeinverständliche Schriften, I Physik und Erkenntnis (1927–1955), edited by Walter Dürr, Hans–Peter Blum, and Helmut Rechenberg (München: Piper 1984); Heisenberg, Gesammelte Werke: Abteilung C, Allgemeinverständliche Schriften, II Physik und Erkenntnis (1956–1968), edited by Walter Dürr, Hans–Peter Blum, and Helmut Rechenberg (München: Piper 1984); Heisenberg, Gesammelte Werke: Abteilung C: Allgemeinverständliche Schriften. III Physik und Erkenntnis (1969–1976), edited by Walter Dürr, Hans–Peter Blum, and Helmut Rechenberg (München: Piper 1985); Heisenberg, *Gesammelte Werke: Abt. C. Allgemeinverständliche Schriften. IV Biographisches und Kernphysik,* edited by *Hans–Peter Blum, Walter Dürr, and Helmut Rechenberg* (München: Piper 1986).

articles, broadcasting records, employment records, and student records located in various archives.

In this chapter, I introduce and contextualise the main texts my analysis is based on and touch superficially on their biographies of translations and especially their German and English publications. Additionally, I discuss how distinct correspondences, in particular those with his parents, his wife Elisabeth, and Wolfgang Pauli informed this thesis. The chapter showcases the relevance of the diverse material in answering the research question.

3.1 Popular Writings from the 1930s to the 1970s

The aim to popularise science is explicitly presented in some of Heisenberg's texts. Most prominently, in the introduction to the memoir, titled: *The Many and the On: Conversations in the Area of Particle Physics* [*Der Teil und das Ganze. Gespräche im Umkreis der Atomphysik*][165] where the author, Werner Heisenberg, explains his intention behind the book. With the book he sought to empower laypeople to engage in philosophical, ethical, and political debates tied to the development of modern physics,

> At last, the author [*Verfasser*] pursued another goal with the recording [*Aufzeichnen*] of the conversations. Modern atomic physics posed anew fundamental philosophical, ethical, and political questions; and many people [*ein grosser Kreis von Menschen*] should engage in this conversation [*dieser Diskussion*]. Maybe the present book can also contribute, [sic] to lay [*legen*] the foundation for it.[166]

Heisenberg presents modern physics as a turning point for the important questions that concern a wider audience not just physicists. At the same time the claim of modern physicists reopening seemingly settled questions reinforces the importance

[165] Heisenberg, 'Der Teil und das Ganze: Gespräche im Umkreis der Atomphysik,' In *Werner Heisenberg Gesammelte Werke. Series C: Allgemeinverständliche Schriften*. Vol 3 (Munich/Zurich: Piper 1986), 3–334; Heisenberg, *Physics and Beyond*.
[166] Heisenberg, 'Der Teil und das Ganze,' 10.

of modern physics in shaping not just science but also society. One of the questions discussed in memoir is the role of religion in modernity.

A similar argumentation about far-reaching consequences of modern physics can be found in the preface of the German version of the collected lectures, *Steps across Frontiers: Collected Speeches and Essays [Schritte über Grenzen. Gesammelte Reden und Aufsätze] from 1971.*[167] In these cases, Heisenberg situates the edited speeches and the ambition to publish them as a collection in the context of the novelty and the fundamental character of modern physics.

> The present collection of speeches and essays, which emerged directly or indirectly from the author's occupation [*Beschäftigung*] with atomic physics, repeatedly goes beyond the boundaries of this field. This is due to the universal character of the science of the atom [*der Wissenschaft vom Atom*]. Anyone who takes it seriously—with all its consequences in philosophy, technology, and politics—has no choice but to step far outside beyond the boundaries [*die Grenzen weit zu überschreiten*] of the actual physical realm when thinking [*Nachdenken*] about this feedback [*Rückwirkungen*].[168]

Once more, Heisenberg suggests that the insights gained by modern physics requests a wider engagement on the new knowledge, in particular about its consequences for social and practical questions. As before it is the new insight, rather than Heisenberg's interests that makes him reflect and speak of subjects that are not part of his expertise as a theoretical physicist.

The speeches on topics such as religion that lie beyond his expertise and relate them to his knowledge as a physicist were often instigated by events. The speech "Scientific and Religious Truth [*Wissenschaftliche und Religiöse Wahrheit*]" (1973) stands exemplarily for the speeches written for a special occasion. While I show in section 5.3 that parts of the arguments appear in other texts, the speech's context and Heisenberg's reflection on the speech are noteworthy. Heisenberg gave the speech for

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[167] Heisenberg, *Steps across Frontiers: Collected Speeches and Essays* (1971) and German translation Schritte über Grenzen. Gesammelts Reden und Aufsätze (1984).
[168] Heisenberg, 'Vorwort', in *Werner Heisenberg Gesammelte Werke: Series C: Allgemeinverständliche Schriften. Physik und Erkenntnis (1969–1976*), 393–394, 393.

the first time on March 23rd, 1973, upon receiving the Romano Guardini Prize. The prize is awarded by the Catholic Academy of Bavaria for people with outstanding achievements in offering "interpretations of time and the world."[169] While working on the speech, Heisenberg wrote a letter to the Swiss diplomat and historian, Jakob Burkhard. In this letter, he shares some thoughts about the speech,

> I am currently facing a difficult task in this context [on the importance of contemporary science]. I am supposed to give a lecture on the contrast 'Scientific truth [and the?] Religious tru[th] [*Wahrhei*] [sic],' at the Catholic Academy in Bavaria.[170]

The speech has a distinct focus on the trials against Galileo Galilei. This focus might be in some part the results of an inter-Catholic debate on how to handle the trials against Galilei. The debate dated back to at least the Second Vatican Council (1962–1965) where a number of German theologians worked towards the reprieve of Galilei, however without success. The political ambitions exceeded the institutional boundaries of the Roman Catholic Church to reach the Nobel Prize laureate meeting in Lindau. In 1968, Cardinal König appealed to the scientists at the meeting to facilitate a dialogue between the Roman Catholic Church and contemporary science.[171] Carson suggests that Heisenberg's speech must be viewed within this context because König went on to congratulate Heisenberg for his words on Galilei and the relationship between science and religion.[172] The speech bears further witness to a changed landscape among the denominations in Germany. Heisenberg, a Protestant, gave the speech in front of a mainly Catholic audience upon receiving the prize. Later, he gave the same speech at the convention of the Protestant Bavarian Order of Saint John

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[169] The first Romano Guardini Prize was awarded in 1970. For a short description of the prize and a list of past awardees the web page of the Catholic Academy in Bavaria: https://www.kath-akademie-bayern.de/ ueber-uns/preistraeger.htm, [Accessed April 18th, 2024].
[170] Heisenberg to Burkhardt 1.1.1973, In Nachlass Carl Jacob Burkhardt, Universitätsbibliothek Basel, NL 110.
[171] Herbert Marcuse, 'ZEITMOSAIK', *Die Zeit*, 5 July 1968, 27 edition; Carson, *Heisenberg in the Atomic Age,* 131.
[172] Carson, *Heisenberg in the Atomic Age*.

[*Bayrische Johanniterordern*] on May 24th–26th, 1974.[173] Heisenberg's willingness to give the same speech for audiences from two different denominations suggests that he did not distinguish between denominations. The speech is now not only interesting for its discussion of religion and its relationship with science (see Chapter 5) but it further points to the ways that the social systems of science and religion are interwoven through institutions and actors.

The speech was widely disseminated via a variety of public and scholarly media. At the time, the speech was broadcasted over the radio and television.[174] Soon after, different magazines and newspapers reprinted it, such as in the academy's magazine *zur Debatte* (1973), the academic periodical of the Max Planck Society, *Mitteilungen aus der Max Plank Gesellschaft* (1973), and the German newspapers from the progressive-liberal *Süddeutsche Zeitung* to the liberal-conservative *Frankfurter Allgemeine*. An English translation, titled "Scientific and Religious Truth" was published in 1975—without a reference to the translator—in *CrossCurrents*, a periodical founded in 1950 with the aim of pursuing social justice and interreligious work. Another translation, by Peter Heath, was published as part of the collection *Across the Frontiers* with the German title *Schritte über Grenzen*.[175] These two translations show that the speech was also disseminated via different forms of publication in the English-speaking context.

The second prominent text in my analysis, is Heisenberg's 1969 memoir *The Many and the One* which is the longest text studied in this thesis. This is a memoir composed as a collection of conversations between the protagonist, Werner Heisenberg, and characters including friends and colleagues, for example Wolfgang

[173] Correspondence Heisenberg and Graf Castell 02.1974, MPGA III_093_1886.
[174] Carson, *Heisenberg in the Atomic Age*, 129.
[175] Heisenberg, *Schritte über Grenzen*.

Pauli or Niels Bohr. Set between 1919 and 1965, some biographers and scholars have used these conversations as testimonies to the current events rather than as Heisenberg's recollections from the late 1960s. The conversations evolve around religion, epistemology, or social responsibility and their ties with modern physics and inform as such Chapters 5 through 7 of this thesis. The memoir was published during Christmas to target the Christmas sales market. Heavily advertised for a mass-market, the memoir ranked 4th at the end of the year on the non-fiction best-seller list of *Der Spiegel*, a weekly German magazine with a focus on investigative journalism. The meaning of the German title got lost in the 1971 English translation by J. Pomerans, *Physics and Beyond: Encounters and Conversations*. Despite being a rather loose translation, as already noted by Heisenberg,[176] this version remains the standard translation. The English translation was published by Harper & Row in the World Perspective series, edited by Ruth Nanda Anshan and as the current standard translation informed my translations.

A decade earlier, Heisenberg had already worked with Anshan, when he had published his Gifford lectures *Physics and Philosophy: The Revolution in Modern Science* (1958) in the same series which was then part of the publisher Harper & Brothers. *Physics and Philosophy* is one of the few texts Heisenberg wrote in English. The reason for the English texts is the fact that Heisenberg had held the Gifford lectures, on which the book is based, at the University of St Andrew's (Scotland) in 1955-6. The lectures focus on the historical formation of quantum mechanics and its epistemological consequences. Here the reference to religion remains mostly limited to historical anecdotes, such as the trial against Galileo or Kepler's interpretation of laws. The German translation was published in 1959 by the publishing house S. Hirzel

[176] Heisenberg to Lamm, Aug 3rd, 1971, In Carson, *Heisenberg in the Atomic Age,* 149.

under the title *Physik und Philosophie.* Hirzel specialised in non-fiction with a focus on philology and science books and was the only German publisher of Heisenberg's popular writings and handled all the licenses for the translations at the time.[177]

I chose to further include two interviews of Heisenberg that aid in elucidating his position on religion. The first interview, "Harmony of matter *[Harmonie der Materie]*" (1967) was conducted in 1966 by T. Mazerano, an employee of the monthly magazine *Neue Stadt*. *Neue Stadt* is published by a publisher of the Catholic movement, Focolare. The Focolare movement was founded in the 1940s to promote interreligious dialogue, a lifestyle guided by the gospel, and a brotherly and sisterly culture in politics and community.[178] The interview is printed in two consecutive issues and accompanied by five pictures: two of Heisenberg in conversation with students and colleagues and three more of the institute, the computers, and the laboratory.

In his answers, Heisenberg explains the novelty of quantum mechanics and also highlights the limits of drawing consequences for theological and religious claims. The interview is interesting in the context of religion as it shows how third parties derived meaning from Heisenberg's popular science communication and reinforces Heisenberg's authority as a physicists and public intellectual (see Chapter 8).

The second interview consists of two parts published in 1974 under the title "*Double Dialogue with Werner Heisenberg*" in the journal *THEORIA to Theory* and has a more complex story.[179] The first part of the interview was conducted by the Hungarian author Vintila Horia in 1966 and first printed in the February issue of 1971 in the magazine *Ecrits de Paris*.[180] Horia's interview of Heisenberg was translated by Philip

[177] AMPG Nachlass Werner Heisenberg, III/93/1688.
[178] https://neuestadt-online.de/de/index.php/uber-uns/ , [Accessed April 20th, 2024].
[179] In Werner Heisenberg, *Gesammelte Werke: Series C. Allgemeinverständliche Schriften Vol. 3*, 464–486.
[180] *Écrites de Paris. Revue des questions actuelles* was a far-right periodical published between 1944–1951 and 1978–2021. While the Romanian writer Vintila Horia received recognition for his novel *God was Born in Exile,* he had praised the fascists, like Adolf Hitler or Benito Mussoli during the

Mairet for *THEORIA* and was complemented with a second interview, conducted by an unnamed member of the *THEORIA's* editorial board in 1973. *THEORIA* was a journal on Science, Philosophy, and Contemplative Religion, published between 1966–81 by the Epiphany Philosophers, a group of British academics and philosophers. The editors at the time were the philosophers Dorty Emmet and Anthony Appiah along with the physicist Ted Bastin. The second interview builds on the first one, with both focusing on the philosophical traditions that shaped Heisenberg's epistemological interpretations of quantum mechanics. Both interviews touch on the positions Heisenberg put forward in his texts on the relationship between science and religion (see section 5.3).

The explicit discussion of religion is just one among many topics in Heisenberg's texts. Other subjects that are relevant for the study of the role of religion in Heisenberg's texts, and as such the dynamics between science and religion, are the reflection on the practices and aims of science. These reflections are in many cases paired with a critique of modern science and modern society. Furthermore, these reflections are central for the two other layers of religion: the uses of concepts in the interpretation of modern physics and the presentation of knowledge production. This study of implicit religion builds on more texts than the ones I introduced so far.

In a speech from 1933, "On the history of the physical explanation of nature [*Zur Geschichte der physikalischen Naturerklärung*]", Heisenberg first refers to Johann Wolfgang von Goethe and argues that von Goethe did not go far enough with his critique of Newton. This juxtaposition of von Goethe and Newton becomes the main subject of the texts from 1941 and 1942, which include "Goethean and Newtonian

second World War. Heisenberg's willingness to give an interview in a far-right magazine illustrates how brought the appeal was and how he did not refrain from the engagement with audiences and actors across the political spectrum.

Theory of Colour in Light of Modern Physics [*Goeth'sche und Newton'sche Farbenlehre im Licht der Modernen Physik]"* (1941). The same year, Heisenberg gave a lecture on November 26th, 1941, at the University of Leipzig, "The Unity of the Scientific *Weltbild*" published 1942 by Johann Ambrosius Barth Verlag in the series "*Leipziger Universitätsreden."* The lecture structures the world through the lens of modern physics which has a similar outlet as the manuscript for a lecture "The *Weltbild* of Physics [*Das Physikalisch Weltbild]*" (1941/42) and "On the *Weltbild* of Science [*Über das Weltbild der Naturwissenschaft*]" (1942). A good decade later, Heisenberg was invited to give a talk at the meeting of the Bavarian Academy of Arts. The title and the scope of the talk, he held on November 17th, 1953, resembles the ones from the 1940s, "The Picture of Nature of Contemporary Physics *[Das Naturbild der heutigen Physik*]." The speech was printed in the 1953-yearbook of the *Max Plank-Gesellschaft zur Förderung der Wissenschaft e.V.* (1954). These texts inform the analysis of the Chapters 6 and 7.

A manuscript from 1942 stands somewhere between these texts on the consequences of modern physics and the explicit discussion of religion. Heisenberg refers to the manuscript as "my philosophy" in letters to his wife. Posthumously the manuscript was titled by the editors "Order of Reality [*Ordnung der Wirklichkeit]* (1942)". However, a letter from 1944 suggest that Heisenberg continued to work on the manuscript way beyond the cut-off of 1941/42 suggested by the editors. While Heisenberg had shared the manuscript in 1942 with friends, Heisenberg did not want the manuscript to be published. In a letter to his editor Fritz Kraus from February 10th, 1947, Heisenberg explains the reasons for objecting to the manuscript publication, including that it contained "his very personal presentation of his view about the general

question of philosophy."[181] While the editors titled it using a phrase from within the manuscript—"Order of Reality"—I will follow Carson and refer to the text as *Philosophy*.[182] The manuscript sketches an order of reality modelled after the order presented by von Goethe in his "The Theory of Colour [*Zur Farbenlehre*]"[183] and incorporates knowledge of quantum physics and the theory of relativity. As such the manuscript *Philosophy* is central to the analysis presented in Chapters 5 and 6 of this thesis.

With a distinct focus on the aesthetic judgment of beauty, the last text sits in a category of its own. Held on July 9th, 1970, at the annual meeting of the Bavarian Academy of Fine Arts, the speech "The Role of Beauty in the Precise Science [*Die Bedeutung des Schönen in der exakten Naturwissenschaft*]" was published a year later in the collection Ensemble 2 by R. Oldenbourg. The English translation by Peter Heath informed the translation presented in the study informed section 6.2.

At large the introduced texts present ample material for the study of the role of religion in Heisenberg's popular communication. They include discussions of religion and the relationship between science and religion and activate concepts and aesthetic repertoire that stand in the tradition of concomitant alternatives of religion, such as Naturphilosophie and German Romanticism.

3.2 Letters from the 1920s to the 1970s

Along with Heisenberg's popular writings, I consulted an extensive number of letters and archival materials. These letters have been invaluable for the development of this

[181] Carson, *Heisenberg in the Atomic Age*, 55.
[182] Ibid.,
[183] Johann von Goethe, *Zur Farbenlehre* was first published in German in (1810) and an English translation, *Theory of Colours* was published in 1840, here the translation by Charles Lock Eastlake from 2002.

thesis; however, they primarily inform the analysis indirectly. Often the letters remain in the background by complementing the analysis of the arguments and aesthetics of the popular writings. During my research, the letters presented me with different impulses and confirmed some suspicions, such as the presentation of science as homosocial sphere of men in Heisenberg's texts or the influence of von Goethe's literature. The study of edited letters and letters in archives largely elevated my research, by offering insights into Heisenberg's life and private correspondence that complements his public publications and utterances.

The first corpus of letters is the exchange between Heisenberg and his wife Elisabeth (née Schumacher). Edited by their daughter Anna Maria Hirsch-Heisenberg, *'My Dear Li!' Correspondence ['Meine Liebe Li!' Der Briefwechsel] 1937–1946* has been translated by Heisenberg's daughter-in-law, Irene Heisenberg. The letters confirmed my intuition that it is fruitful to incorporate the analytical category of scientific masculinity to study the creation of hierarchies and ideals of masculinity in Heisenberg's texts.

The letters illustrate the division of labour between Heisenberg and Elisabeth, not only about child-rearing but also of intellectual labour. This also translates into the presentation of caring working in the memoir (see section 7.3). An example of the role of the letters in examining the division of labour is presented in a letter from 1941. In the letter, Elisabeth asks Heisenberg for "much, much good typing paper" which she needs in order to type a manuscript of Heisenberg's, "I am making quite a lot of progress with your work"[184] and on February 26th, 1944 Heisenberg tells Elisabeth "The philosophy is now finished; maybe in Urfeld, during the summer you can find the

[184] Elisabeth to Heisenberg June 1941, In Anna Maria Hirsch-Heisenberg, *My Dear Li!: Correspondence 1937-1946*, trans by Irene Heisenberg (New Haven: Yale University Press 2016), 146.

time to type it."[185] While the work around the manuscript was divided with Elisabeth's typing becoming secondary and invisible in light of Heisenberg's "your work", the manuscript presents a shared space while being separated. In the letters Heisenberg shares his progress and sentiments about the manuscript, "Towards the evening I wrote on the private philosophy [...] I now write on these things with great enjoyment."[186] For Elisabeth, the manuscript presented a way to remain in conversation with her husband about philosophical questions in his absence.[187] For this study, the exchange informs a reflection on the masculinity of Heisenberg as a physicist and intellectual.

Elisabeth's role in his work is further demonstrated in letters from 1937, when Heisenberg's colleagues congratulate him. The congratulation from Pauli indicates the role wives play in the lives of scientist, here as an aside from Heisenberg's research he congratulates Heisenberg with the note that a marriage will prove beneficial to his research, "Perhaps you will already be married when this letter arrives, so accept my warmest congratulations once again [...] I have no doubt that the new way of life will only benefit your work."[188] However, in most letters, Elisabeth appears in the greetings and is bound to the household, "My wife sends also many wishes."[189] The letters at the Niels Bohr Archive in Copenhagen indicate that Elisabeth and Heisenberg's mother, Annie, also played a more active role in Heisenberg's professional network, conversing with Margarethe, Niels Bohr's wife.[190] However, Elisabeth's role in Heisenberg's work

[185] Ibid., 146.
[186] Heisenberg to Elisabeth July 10th, 1941, In Hirsch-Heisenberg, *My Dear Li!,* 153.
[187] Elisabeth to Heisenberg June 1941, In Hirsch-Heisenberg, *My Dear Li!*, 146.
[188] Pauli to Heisenberg May 2nd, 1937, In Wolfgang Pauli, *Wissenschaftlicher Briefwechsel mit Bohr, Einstein, Heisenberg, u.a. Volume II: 1930-1939*, edited by Karl von Meyenn, Armin Hermann, and Victor Frederick Weisskopf, (New York: Springer 1985), 549.
[189] Heisenberg to Pauli December 21st, 1957, In Wolfgang Pauli, *Wissenschaftlicher Briefwechsel mit Bohr, Einstein, Heisenberg u.a. Volume IV, Part IV: 1957*, edited by Karl von Meyenn (New York: Springer 2005), 738.
[190] Niels Bohr Archive: BSC HEI370924, BPC-HEIA-360304t

seemed to be less active than Margarethe's.[191] In the memoir, the role of both women is one of caring and supporting their husbands' work (see Section 7.3)

The second corpus of letters is the exchange between Heisenberg and his parents *Dear Parents! Correspondence from the Critical Time [Liebe Eltern! Briefe aus kritischer Zeit] 1918 bis 1945*, once more edited by Hirsch-Heisenberg.[192] The letters cover his life to up until his mother Annie's death and bear witness to Heisenberg's financial struggles which he faced until he received the call for a full professorship in 1927. Together with the letters to his wife, they offer insight about the role music played in his life and the literature he read. For this study the letters offered important insight into the *bildungsbürgerliche* culture within which Heisenberg came of age and viewed himself.

The third corpus of edited letters is the correspondence of Wolfgang Pauli. The correspondence between the two fellow students and later friends and colleagues give insight into the active exchange of work. This collective research in the medium of letters is further presented in the memoir (see Section 7.2.). Along with the technical subjects of physics, the letters give insight into the cultural influences on the physicist's work. For example, during their intensive work on a unified field theory in 1956–1957 Pauli refer repeatedly to a mathematical problem as "the kernel of the brute [*Pudels Kern*]."[193] The kernel of the brute is a reference to the character of the devil in von Goethe's *Faust: Part One* (1808) which also makes an appearance in the memoir (see Section 7.3.2). While these letters provide a lot of information on Heisenberg's research, they offer little insight into the development of Heisenberg's positions on

[191] Megan Shields Formato ,'Crafting Quantum Theory: Margrethe Bohr and the Labor of Theoretical Physics' In https://thenewinquiry.com/blog/crafting-quantum-theory-margrethe-bohr-and-the-labor-of-theoretical-physics/ (2018), [Accessed April 18th, 2024].
[192] Anna Maria Hirsch-Heisenberg, *Liebe Eltern! Briefe aus Kritischer Zeit 1918 bis 1945*, (München: Langen Müller 2003).
[193] Pauli to Heisenberg December 27th/28th 1957, In Wolfgang Pauli, Wissenschaftlicher Briefwechsel mit Bohr, Einstein, Heisenberg u.a. Volume IV, Part IV: 1957, 762.

religion or Pauli's influence on his epistemology and social positions (see Section 6.2.1).

The last publication with edited letters of Heisenberg is a study on Heisenberg's time as a boy scout by Heinrich Becker.[194] The book includes an interesting letter from 1937 to Heisenberg's friend Wolfgang Rüdel, in which Heisenberg reflects on the change and the influences of his view on religion (see Chapter 8). Beyond this letter, we learn a lot from Becker's book about the importance of the boy scouts in Heisenberg's life and the cultural influence, in particular, of German Romanticism during his formative years.

The letters located at various archives have informed different aspects of this study. The letters of the *Heisenberg Nachlass* at the Archive of the Max Planck Society (AMPG) offer insight into Heisenberg's response to inquiries about his position on religion or his personal beliefs. Most of the responses are quite brief and often include references to his publication with the remark that he has nothing to add to what he has already said. The study of the letters in Heisenberg's *Nachlass* revealed information about his publishing activities, while the manuscripts offered the chance to compare different versions, such as the handwritten, typed, edited ones. Correspondence held in other archives, such as the Niels Bohr Archive, offered insight into Heisenberg's correspondence with Niels Bohr and the Lise Meitner Papers at the Churchill Archives Centre in Cambridge bear witness to the formal correspondence Heisenberg conducted with Meitner on the nomination and awards of the Max Planck Medal. The correspondence with Jakob Burkhard located at the University of Basel revealed information about Heisenberg's engagements at CERN and his travel

[194] Heinrich Becker, *Die Gruppe Heisenberg. Beitrag zur Geschichte der Jugendbewegung und der Pfadfinder sowie zur Biografie Werner Heisenbergs*, (Self-Published 2019), 449.

schedules, it further shows his willingness to engage in discussions on topics other than physics unlike in the case of inquiries from the public.

The diverse material at the Archive der Max Planck Gesellschaft offered insight into the institutional structures, Heisenberg's social network, as well as the construction of Heisenberg's scientific persona. The employment and registration records[195] offer a better understanding of the personnel who worked under Heisenberg, particularly the presence of female students, researchers, and assistants (see Chapter 7). I further consulted pictures of Heisenberg and his awards as well as news reports on Heisenberg leading up to his death in 1976. These news reports give insight into the ways Heisenberg was presented in public and in particular how central topoi of his texts shape the narratives around him (see Chapter 8). Lastly, I consulted Thomas Kuhn's interviews with Heisenberg available on the Oral History repository of the American Institute of Physics' Niels Bohr Library and Archive.[196] In these interviews, Heisenberg recollects his professionalisation and role in the formulation of quantum mechanics. The different letters and archival material shaped my analysis in many different ways, though these insights often remain in the background.

3.3 Conclusion

The presented texts and letters are the backbone of this analysis. By introducing these different texts, I highlight the diversity of their characteristics and historical contexts. At the core of the study stand eight texts that fall into one or more of the three categories: first, the explicit reflection of religion; second, the implicit communication

[195] This includes records at the AMPG, the Archive of the Ludwig Maximilian University of Munich, the Archive of the University of Leipzig, and the Maximilian Gymnasium in Munich. The University of Göttingen did not provide me with data

[196] For a historiographical perspective on the interviews see Anke te Heesen *Revolutionäre im Interview: Thomas Kuhn, Quantenphysik und Oral History*, (Berlin: Klaus Wagenbach Verlag 2022).

of religion (e.g., the use of ideas and the concept of concomitant alternatives, in particular *Naturphilosophie*); and third, the presence of an aesthetic repertoire that stands in the *longue durée* of the modern aesthetic religion coined Romanticism. While the focus lies on the popular writings, the letters, news articles, records, and objects were also crucial for the development of the categories and identifying trends. Together, the material offers ample data for the thesis' objectives.

Chapter 4 Multimethod Approach: Semantics and Aesthetics

I combine two approaches for the study of the different layers of religion in Heisenberg's texts: the semantic and the aesthetic. Together, these allow me to embed the study of Heisenberg's texts in a wider dynamic between science and religion in the 20th century. The semantic analysis used here assesses the implicit and explicit communication of religion–distinct from the linguistic concept of semantics that describes the intra-textual meaning.[197] Meanwhile, the aesthetic analysis draws attention to the aesthetic repertoire of religion,[198] including the "sensory-aesthetic texture" of texts.[199]

In this chapter, I introduce the multimethod used for the analysis of Heisenberg's texts. First, I characterise the semantic analysis and discuss how it informs the study. Second, I discuss how the aesthetic analysis builds on a combination of different methods. The chapter shows how this multimethod approach allows me to analyse the concepts, topoi,[200] ideas, or allegories present in Heisenberg's texts. This analysis works out the different layers of religion as well as situates it in a *longue durée.*[201]

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[197] Kaldewey, *Wahrheit und Nützlichkeit*, 123.
[198] Grieser and Johnston, 'What is an Aesthetics of Religion?.'
[199] Vernon K. Robbins, *Exploring the Texture Texts: A Guide to Socio-Rhetorical Reinterpretation,* (Valley Forge: Trinity Press International 1996).
[200] A common term in rhetoric and literature, the topoi denote known forms (or places) of argumentation and relationships between ideas.
[201] The term *longue durée* (long term) was coined by the French *Annales School* of historiography, to complement the focus on the *court durée (short term)* that prioritized events in their research. By tracing social structures, (economic) cycles, institutions, ideas, or worldviews over the decades and centuries, the *longue durée* renders the persistence and change of "unconscious" structures visible Fernande Braudel, *Afterthoughts on Material Civilization and Capitalism*, translated by Patricia M. Ranum (Baltimore/London: Johns Hopkins University Press 1977).

4.1 A Semantic Analysis

The semantic analysis focuses on the explicit reflection on religion as a concept and social system. Along with focus in terms of religion, the sematic analysis looks at the use of concepts and ideas that stand in the tradition of the concomitant alternatives in particular, pantheism, Neo-Platonism, Romanticism, or *Naturphilosophie*. Thus, the semantic analysis presents a heuristic approach to study religion in popularising texts, like Heisenberg's. The aim of the semantic analysis is to analyse the explicit reflection on religion, ranging from the distinction of a "genuine religion" (see Section 5.2) to the use of aesthetic judgments, e.g. simplicity in arguments about a unifying theory (see Section 6.2.1).

In cultural and historical studies, the semantic analysis studies concepts and ideas as part of the textual and cultural contexts within which they become meaningful. This also includes the reflection on the role of aesthetic judgments (e.g., simplicity, symmetry, and beauty) for the assessment of a theory as valid and true. While prior research of science-and-religion has focused on the concepts and institutions of religion and science, the semantic analysis employed in this thesis recognises and illustrates the plethora of concepts and ideas that contribute to the dynamics between science and religion.

Standing in the tradition of Gladigow's and Daum's research on the popular writings of physicists (see Section 1.3), the proposed semantic analysis builds on the studies of Reinhard Koselleck and Niklas Luhmann. Koselleck's concept of semantic use for the historical analysis is distinct from the linguistic concept of semantics that describes the intra-textual meaning.[202] Within this framework, the texts at the core of this study presents a knot that ties together "the historical utterance of agencies" with

[202] Kaldewey, *Wahrheit und Nützlichkeit*, 123.

"the linguistic articulation of specific semantic structures."[203] By combining the Koselleck's study on the historicity of concepts and ideas with Luhmann's work on the social systems of a functionally differentiated society, we can lay the focus on the dynamics between social systems established on the semantic level. Similar to Koselleck's concept of semantics, Luhmann characterises semantics as a "higher-level generalisation of meaning" in communication such as terms, concepts, problems, or solidified ideas. As a result, such a semantic analysis recognises the cultural and social context within which the concepts and arguments become meaningful and contribute to the ongoing communication. Similar to the content analysis, the semantic analysis is to make valid and replicable inferences about the arguments made in the texts.[204] The semantic analysis offers a method to identify characteristics of textual material, and study how these characteristics, like concepts or arguments, draw and maintain the semantic apparatus of religion.

The semantic analysis guides this study of Heisenberg's texts on two levels: first, the explicit reflection on religion and second, the use of concept and idea that contribute to the social system of religion in rather implicit ways. The focus on the explicit reflections draws the attention to the use and combination of different concepts of religion. While the texts use phenomenological, psychological, and social concepts of religion, it is the discussion of "the religious experience," accompanied by the talk about a "central order" that stands out. Whereas the social or psychological concepts of religion are part of Heisenberg's critique of modern society and modern science, the discussion of the religious experience is not explicitly presented as a solution to a social problem (see Section 5.1). The explicit reference to religion in

[203] Koselleck, *Futures Past*, 158.
[204] Klaus Krippendorff, *Content Analysis: An Introduction to its Methodology*, (Beverly Hills: Sage Publications 2004).

Heisenberg's texts, for example the distinction of a "genuine religion" from immanent alternatives (see Section 5.2), is otherwise entangled with a cultural critique of modernity. Similarly, the discussions of different positions about "the relationship between science and religion" (see Section 5.3) is entwined with critiques of a materialist science or modern society. My focus on the explicit references to religion, I show how Heisenberg's popular texts use and combine different concepts of religion thus contributing to the ongoing communication of religion.

The semantic analysis used here goes beyond identifying the concepts and analyses the arguments they are part of to include a historical perspective. This historical perspective draws attention to the *longue durée* of the concepts and the arguments. Moreover, the analysis situates these in the political and cultural context within which the texts were written (and became effective). Thus, the analysis further encourages questions about the role of religion in these references, in particular, it is tied to a cultural critique. As such, the analysis gives insight into the ways the structural changes of a differentiated society are negotiated in the texts.

In a similar way, the semantic analysis proceeds to the study of a second layer. The main difference is that the focus lies on terms, such as "creative forces," "unity," "harmony," or "understanding" that might not look like religion on the first glance. Many of these terms come only into focus for the study of religion because of the cultural and social approaches introduced above (see Section 2.1). With the same combination of identifying and situating concepts and claims, the analysis shows how the texts use terms from the concomitant alternatives, Neo-Platonism or *Naturphilosophie*. By using the analysis, we can observe how these concepts are used in the explicit reflection on science and nature in light of quantum mechanics (see Chapter 6 and Section 7.1). I will show that in these cases religion serves as an interpretative framework to makes sense of the structural, epistemological, and

ontological implications of modern physics, rather than the cultural critique. The analysis gives insight into the interpretative gap left by the shift from classical to quantum mechanics and how the interpretations Heisenberg develops contribute to the dynamics between science and religion.

4.2 An Aesthetic Analysis

The aesthetic analysis focuses on the allegories, description of sensory qualities and changes, or aesthetic judgments and qualities to begin to name a few. Thus, it goes beyond the explicit reflection on aesthetics judgments (e.g., beauty or harmony). To study the role of religion in this "sensory-aesthetic texture," the aesthetic analysis offers a framework to combine different methodological approaches coined by various disciplines, such as the analysis of metaphors, narratives,[205] and sensory topoi in texts and images. For the study of the role of religion in Heisenberg's texts, the aesthetic analysis draws the attention to the use of allegories and narratives but more importantly, certain kinds of sensory qualities (e.g., feeling dizzy or "understanding with the heart") and/or aesthetic topoi. Since the Romantic reinterpretation of religion as experience, aesthetic topoi have become wildly influential, such as 'experience of nature'. The aim of the aesthetic analysis is to study these aesthetic repertoires in Heisenberg's texts.

To that end I focus on two levels: the use of aesthetic qualities and the aesthetic repertoire. The explicit reflection is tied to the aesthetic qualities of scientific knowledge, such as beautiful theories (see Section 6.3.1) and the quality of the

[205] Laura Feldt 'The Literary Aesthetics of Religious Narratives: Probing Literary-Aesthetic Form, Emotion, and Sensory Effects in Exodus 7– 11', In Grieser and Johnston, *Aesthetics of Religion* (Berlin: De Gruyter 2017), 121–145; Borrelli, 'Poetic Imagination in Scientific Practice.'

language used to speak about the new knowledge of quantum mechanics, such as poetic language (see Section 6.3.2). In many cases, the study of these aesthetic qualities relies on the semantic analysis as well. Once identified, these aesthetic qualities can be situated in a *longue durée* of concomitant alternatives (e.g., Neo-Platonism) transported by *Naturphilosophie* and Romanticism. In these cases, the texts draw on an important alternative of imagining and encountering nature a part of the knowledge production. The aesthetic analysis encourages us to go beyond the explicit discussion of the epistemic role of beauty or poetry. While such aesthetic judgments might serve as epistemic values in Heisenberg's texts, the identifiers of mathematical formulae using aesthetic categories of localisation (e.g., 'under') or illumination (e.g., 'shining through') activate ideas, such as that of a sacralised nature (see Section 7.2.3) in the tradition of *Naturphilosophie*.

The aesthetic repertoire includes, along with the aesthetic judgments, also aesthetic shifts, sensory changes, and emotional responses. These different aspects are often combined in selected topoi of the encounters of nature. Such encounters of nature present in the two topoi of mountaineering and experience of nature with both of them using a language of somatic, sensory, and emotional responses. In the texts, both topoi are linked to knowledge production (see Section 7.2). Another topos tied to knowledge production is physical exhaustion, here the presentation of the scientist activates the figure of the martyr who endures and faces the suffering in the name of scientific advancement (see Section 7.2.4). In these cases, the aesthetic repertoire standing in the tradition of Romantic religion serves an interpretative framework for knowledge production.

In combination with scientific masculinity, the aesthetic analysis also offers a way to study the masculinisation of science and the creation of masculine ideals beyond the presence or rather absence of women. Beyond the influence of the topoi

of encounters with nature for the masculine ideal of the Romantic genius, the scientific masculinity draws attention to the presentation of the history of physics by Heisenberg's texts. The narrative analysis and change of registers facilitate the study of the history of modern physics presented in the texts, especially where the author switches from descriptive to affective (e.g., the production of knowledge at the core of quantum mechanics is entwined with the experience of nature, see Section 7.2). In addition, the topos of the Platonic dialogue is central in creating physics as a male discipline. The aesthetic analysis facilitates the study of how emotions, practices, or allegories contribute to the development of a "subtle hierarchy"[206] between practices and characters (see Section 7.3). Moreover, the narrative structure of genealogies of scientists suggests inevitabilities and salvations (see Section 7.4).[207] While these stories suggest an inevitability of a new theory and legitimacy through objective story, the personal encounters of nature develop Heisenberg's authority as physicist through his immediate participation in knowledge production. I will show that in these cases religion provides an aesthetic repertoire to make sense of processes and practices of knowledge production. As such, the aesthetic analysis gives attention to the presence of religion that would otherwise go unnoticed.

4.3 Conclusion

The multimethod approach resulting from the combination of a semantic analysis with the repertoire of approaches offered by an aesthetic analysis. Together it facilitates the study of the multiple layers where religion is mobilised in Heisenberg's texts. As indicated above, the arguments and the aesthetic repertoire as well as the different

[206] Schnicke, 'Wissenschaftsmetaphern.'
[207] Koselleck, *Futures Past*.

levels are entwined. Moreover, the approach facilitates the study of the different roles that religion plays in Heisenberg's texts and recognises how they contribute to the interference between science and religion. Hence the multimethod approach offers a finer resolution of the interference patterns by distinguishing different levels, of explicit religion, the activation of concomitant alternatives, or the aesthetic repertoire.

Part II: Analysis of *Religion and Science*

The second part of the thesis encompasses the analysis of the role of religion in Heisenberg's texts. In Chapter 5 I examine the explicit reflection on religion, in Chapter 6 I trace the use of concomitant alternatives in the explicit reflection on science, and in Chapter 7 I investigate use of the (aesthetic) topoi in the presentations of knowledge production. Together the three chapters investigate and make different interference patterns between science and religion that are analysed in Part III.

Chapter 5 Religion for Modern Society

The explicit reference to religion in Heisenberg's popular writings is tied to a wide range of subjects e.g., "the religious experience" and problems e.g., "the relationship between science and religion." Together the different references to religion show how the combination of concepts of religion e.g., phenomenological and functional, combined in Heisenberg's texts are entwined with a social commentary, in particular the influence of modern science.

In this chapter, I analyse how Heisenberg's explicit discussions of religion uses and changes concepts and ideas, in particular "the religious experience," "the central order," and "the relationship between science and religion" that are part of the semantic apparatus of religion. In the first section, I show how the religious experience is a key idea of religion as a system of meaning-making in Heisenberg's texts. In many cases, Heisenberg actualised Christian concepts of religion as a universal and singular phenomenon. I show in the second section that standing next to the individual aspect of the religious experience, Heisenberg emphasis in his texts the social importance of religion. As a social scheme, religion is presented as a framework of community and an ethical framework for contemporary research. The social importance of religion tied to a critique of science and society is prominent in Heisenberg's distinction of

"genuine" religions. The combination of these different concepts is prominent in the discussion of different positions about "the relationship between science and religion." In the third section, I show how the questions about "the relationship between science and religion" is entwined with a cultural critique of modern society and modern science. The rejection of the three positions about the relationship: "conflict," "compatibility," and "exclusivity" are for example associated with contemporary problems. As part of these discussions, he introduced and defend a fourth position: "complementarity" in reference to his work in physics. Taken together, these discussions on religion work towards one core concept of religion as a scheme that offers meaning and guidance for individuals and modern society.

5.1 "The Religious Experience": Heisenberg's use of Phenomenological Concept of Religion

Experience holds a central place in Heisenberg's discuss of religion. In one of his first texts, the manuscript *Philosophy* from 1942, he dedicates a whole section to religion. As part of the chapter titled "The Creative Forces [*Die schöpferischen Kräfte*]," the section "Religion [*Die Religion*]" opens with this statement: "All religion begins with the religious experience."[208] In this section, I show that with his focus on experience, Heisenberg draws on a phenomenological concept of religion in his popular texts that stands in the tradition of German Romanticism.

The notion of the religious experience becomes a focal point of the concept of religion with the "re-invention" of religion by the German Romantics.[209] Most

[208] Heisenberg, 'Ordnung der Wirklichkeit (1942),' 296.
[209] Alexander Hampton, *Romanticism and the Re-Invention of Modern Religion: The Reconciliation of German Idealism and Platonic Realism,* (Cambridge: Cambridge University Press 2019).

prominently, Friedrich Schleiermacher, the Protestant theologian and philosopher, redefined religion as "sensing and feeling," in particular the idea of religion as a "sense and taste for the infinite" setting the experiential ideal that romantic artists strive to evoke in landscape paintings and continues to structure contemporary images.[210] Schleiermacher's redefinition of religion marks a turning point towards the "modern aesthetic religion"[211] that informed the study and public understanding of religion while further shaping the cultural *imaginaire* of knowledge. In the early 20th century, this concept of religion entered the *bürgerliche* understanding of religion with a wildly successful publication, *The Idea of the Holy* by the German theologian and philosopher Rudolf Otto.[212] With the characterisation of the religious experience as an experience *sui generis* (one of a kind), the phenomenological study of religion builds on Schleiermacher's redefinition of religion. Moreover, the phenomenologists universalise this religious experience built on Christian ideals, similar to Heisenberg's reduction of all religion to the religious experience.

Following the opening sentence that establishes the phenomenological understanding of religion, Heisenberg proceeds with explaining this religious experience and its role in shaping the individual's life, along with the cultural repertoire of a society. Much in the tradition of the Romantic religion and the phenomenology of religion, it is the sensory changes and feelings that characterise the religious experience and how it manifests in interpersonal communication (i.e. language).

> We can only speak of the content [*Inhalt*] of the experience in parables, as far as we are concerned. We can say, for example, that we suddenly realised the connection with another, higher world in a way that is binding for our whole life, or that in a certain situation God met us immediately [*unmittelbar*]

[210] Friedrich Schleiermacher's second speech *On Religion: Speeches to Its Cultured Despisers,* (Oxford: Oxford University Press 1996), was first published in 1799. For an interpretation of the Schleiermacher's speech and its influence on the aesthetic repertoire of modern society, see Grieser, 'Blue Brains', 258.
[211] Ibid., 258.
[212] Rudolf Otto, *The Idea of the Holy: An Inquiry into the Non-Rational Factor in the Idea of the Divine and its Relation to the Rational*, translated by John W Harvey, (Oxford: Oxford University Press 1917).

> and spoke to us (I myself would first think here, e.g. of the night on the balcony [*Söller*] of the Pappenheim ruins in the summer of 1920); or we can express it in such a way that the meaning of our life suddenly became clear to us and that we can now distinguish clearly between the valuable and the worthless. […] This realisation of the other, higher world is something that approaches us quite suddenly [*unvermittelt*], from outside, so to speak, so that we cannot doubt that another world suddenly confronts [*gegenübersteht*] and challenges [*fordern*] us […] Yet this other world touches us as something that we have known for a long time, that has been familiar to us from the beginning of life.[213]

The experience is characterised as sudden and out of the control of the individual, from outside. These are characteristics of religion as experience in the tradition of Schleiermacher and (later on) Otto.[214] The examples Heisenberg gives for the experience is the development of a connection with a higher world, God, or an epiphany about the meaning of life. In terms of language, the experience exceeds everyday language (be it precise or not), for the intelligibility of said experience may only emerge in and through parables. The idea that the religious experience cannot be grasped by common language is notably laid out in Schleiermacher's second speech, where he shifts from a propositional discussion of the experience to a poetic presentation of the encounter with the nature. Similarly, Otto argues that only a person who has had the experience can understand and thus study it.[215] Heisenberg presents the experience as an immediate encounter with the transcendent that stands outside of the immanent observable world. The encounter challenges and comforts the individual as if it was something already known. In the tradition of the phenomenology of religion, the experience is highly consequential to the point of becoming life changing. It constitutes an experience that is binding for life and guides meaning-making and/or establishes the foundation of value systems.

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[213] Heisenberg, 'Ordnung Der Wirklichkeit (1942)', 296.
[214] Rudolf Otto, *The Idea of the Holy*. For a comparative discussion of the role of emotion in Schleiermacher's and Otto's concept of the religious experience, see Jacqueline Marina "Friedrich Schleiermacher and Rudolf Otto", In *The Oxford Handbook of Religion and Emotion,* (Oxford: Oxford University Press 2008), 456–473.
[215] Otto, *The Idea of the Holy*,

As the variety of the examples already suggests, the experience for Heisenberg is not restricted to traditional religion with music and philosophy offering alternative vehicles. Heisenberg's reference to alternative vehicles of the religious experience and religion, is part of a wider cultural development. With the growing influence of immanent modes of experiencing and interpreting the world, the "religious experience" becomes an influential ideal and practice as part of the Romantics re-invention of religion. As part of the Romantics reinvention the transcendent is no longer restricted to religion but can be experience in cultural practices, such as literature, music, or science. In return these practices become alternatives of religion in "an age of immanence."[216] This change finds two ways into Heisenberg's texts, first as part of the discussions of religion (analysed in this chapter) and second as part of his presentation of knowledge production (see Section 7.2.3).

In the manuscript *Philosophy*, we can observe the discussion of alternative vehicles of the religion experience. Following the explanation of religious experience, Heisenberg reflects on the decline of religion in contemporary society. He concludes that with the decline of religion, music or science become possible alternatives to religion in regard to experience of the transcendent, "the higher world."

> Regardless of the image we use to capture the experience: the commitment [*Verpflichtung*] remains for our whole life and is recognised by us, even if we do not fulfil it. Who should forget this commitment in his lifetime, he has lost the access to the most valuable aspect of the human life [...] This also applies today, especially for many people, who do not belong to any religious community and who encountered the other world in the notes of a Bach's fugue or in the illumination [*Aufleuchten*] of a scientific insight [*wissenschaftliche Erkenntnis*], for the first time.[217]

Heisenberg links the absence of an affiliation to a historical religion, "a religious community", to the possibility of experiencing the transcendence in and through music

[216] Hampton, *Romanticism and the Re-Invention of Modern Religion*.
[217] Heisenberg, 'Ordnung der Wirklichkeit (1942),' 296.

or even science. By suggesting that science might be an alternative vehicle for the (religious) experience, Heisenberg activates the topos of the experience of nature which was crystalised in the study of nature by the Romantics and *Naturphilosophen*. This link of knowledge production and the aesthetic repertoire of experience is a central feature of Heisenberg's texts that can be observed throughout the decades (see Chapters 6 and 7). He further claims that the experience of the other world through these alternative vehicles has the same binding effect as the "religious experience."

In the manuscript *Philosophy*, Heisenberg gives a personal example of a religious experience, which he had during "the night on the balcony [*Söller*] of the Pappenheim ruins in the summer of 1920." By giving a personal account, Heisenberg suggests that he holds intimate knowledge about religious experience. The same event appears to be addressed in the memoir 1969, the protagonist recounts a memorable night at the Castle Prunn[218] that is set in the summer of 1920.[219] It is the aesthetics repertoire that actualises religion as experience in the tradition of the modern aesthetic religion. We can observe a somatic shift – from agony and heat to chill – and a change of register – from the reflection of orders and description of cognitive activities (i.e. discussions) to the sight and experience of order. Upon examining the aesthetic

[218] In the Manuscript from 1942, Heisenberg situates the experience at the ruin Pappenheim, while in the memoir the experience is set at castle Prunn. While being roughly 60 kilometers apart, both places are located along the river Atlmühl in the south of Germany. Other sources, such as the logbooks of of his boy scout troop suggest that Heisenberg spend a memorable night at ruin Pappenheim, on July 17th, with notes such as "we sang out songs into the starlight night." Three years later, the group would spend another night at the castle this time in April (Becker, *Die Gruppe Heisenberg,* 65, 206). In a letter to his parents, from the 21st of July [?] 1920, Heisenberg writes about an evening spent at the "beautiful quatre on the castle in Pappenheim," during which "until 2am we were sitting with the guitars [*Klampfen*] on a turret overlooking the whole area paired with a twinkling clear [*glitzernd klarer*] sky of stars" (in Hirsch-Heisenberg, *Liebe Eltern!,* 23). The discrepancy between the historical sources and the memoir about the place of Heisenberg's experience in the summer 1920 illustrate that the memoir is inspired by historical events but is not a representation of them. With the focus on the semantics and aesthetics, the discrepancy does not affect the analysis of the experience told in the memoir.

[219] Written in the years after the Second World War and during the West-German student movement in 1968, I suggests that the conversations about the future of Germany described by the protagonist rather reflects the political context of the memoir than of the 1920s.

repertoire of this experience, we notice a resemblance with the landscapes of Romantic paintings. What is evoked is some ruins nestled in a valley, where the clarity of the surroundings is partially obscured by drifting fog. Amidst this mist, the moonlight casts its soft radiance upon the landscape, revealing its details. This aesthetic repertoire plays with the paradox of an imagined clarity that is hidden from the spectator.

> I listened and thought about the concept of 'order' itself. The confusion in the subjects of the speeches seemed to indicate that even real orders can come into conflict [*Widerstreit*] and that this fight [*Kampf*] brings about the opposite of order. This, it seemed to me, was only possible if it was about partial orders [*Teilordnungen*], about fragments that had detached from the central order [*zentrale Ordnung*] and that had not yet lost their creative power [Gestaltungskraft], but which had lost the orientation towards the center [Mitte]. The longer I listened, the more agonisingly aware [*quälender bewusst*] I became of the absence of this effective centre [*wirksame Mitte*]; I almost suffered physically [*physisch*] from it, but I myself would not have been able to find a way back to the central area [*Bereich*] from the thicket [*Dickicht*] of the conflicting opinions. Thus, the hours ticked by, while speeches were made, and arguments were had. The shadows in the castle's courtyard lengthened, and finally the hot day was followed by a grey-blue twilight and a moonlit night. People were still talking, but then a young person with a violin appeared on the balcony above the courtyard, and once it was silence and above us, we heard the first great D minor chords of Bach's Chaconne. Suddenly, the connection to the centre was undoubtedly established. The Altmühl valley below us doused in moonlight would have been reason enough for a romantic enchantment [*Verzauberung*]; but it was not. The clear [*klaren*] figures of the Chaconne were like a cool [*kühler*] wind that tore the fog apart and rendered the sharp [s*charfen*] structures behind it visible. One could speak of the central area, it had been possible at all times, with Plato and with Bach, in the language of music or philosophy or religion, so it had to be possible today and in the future. That was the experience.[220]

The section presents the shift from chaos to order. This shift from chaos, or rather conflicting orders, to a connection and a clear sight is presented as sudden and definite. What makes the shift effective is the change of the aesthetic qualities, from day to night or from hot to cool. This change follows the aesthetics repertoire of the Romantic landscape and experience of nature. The depicted order stands in opposition to the confusion and conflict the story begins with. The protagonist's pondering on the

[220] Heisenberg, 'Der Teil und das Ganze,' 23f.

ideal of order is tied to bodily agony and physical suffering. The protagonist listens to the conversations without engaging in them. From this position he reflects on the possible ontological foundation of the observed confusion. The confusion is traced back to the breaking of one central order into different pieces. Along with it goes a sense of being lost and stuck in the intellectual debates on society, unable to find a way out. The unfolding of that agonising state is emphasised with the description of passing hours, growing shadows, and the day turning into the night. With the turn from day to night, the protagonist establishes a connection which was absent while he was following the conversations and reflecting on the concept of order. As such the way out of this state of chaos[221] is not reached by a reflection on order but through an experience

The experience centres around a transition from day to night with a concomitant change of aesthetic qualities such as the shift from heat to a chilly wind as well as from chatter to a moment of silence, embedded in the melody of a single violin. It is only in the absence of the day, the heat, and the conversations that a connection to the order is established and becomes visible, facilitated by the melody of Johann Sebastian Bach, whose highly structured and transparent compositions count as a centre piece of Protestant church music.[222] While, the protagonist Heisenberg rejects he idea of the experience as a Romantic enchantment, the aesthetics repertoire activates the Romantic topos of the encounter of nature. The topos builds here on the dynamics between the blurriness of the fog and the clarity of the sharp structure, illuminated by the moon light, resembles a Romantic landscapes

[221] The term of the thicket (here used to describe the chaos) appears once more in the memoir, when the protagonist describes the state of the physics leading up to his breakthrough on Helgoland (see Section 7.2).
[222] Birger Petersen, 'Praedicatio sonora: Musik und Theologie bei Bach', In *Kirchenmusik und Verkündigung – Verkündigung als Kirchenmusik: Die Referate des Symposions zum Verhältnis von Theologie und Kirchenmusik*, (Eutin: Books on Demand 2003), 45–60.

painting with the fog veiling the focal point of the picture and thus evoking a feeling of aspiration.

Similarly, the explanation of the religious experience, in the *Philosophy*, the experience of nature presented in this focal paragraph includes the idea of a return to a familiar or previously established state. Furthermore, the protagonist presents, just like in the *Philosophy* music, philosophy, or science as alternatives to religion when it comes to the experience. While the *Philosophy* opens with "the experience" the paragraph closes with it and expresses the hope that in the future, humans might be able to relate to the "central order." The presentation of the central area as a reference point that has existed in the past and the future bestows it with the idea of an eternal structure (see Chapter 6 on the role of Plato in the discussion of structures in Heisenberg's texts).

In addition, we also find a reference to the experience at the ruins of Pappenheim in a letter to his mother, dated October 27th, 1932. In the letter, Heisenberg interprets the experience within the framework of meaning-making. Along with the experience at the ruins and the inter-personal relationships with the family of his friend Carl Friedrich von Weizsäcker, Heisenberg names his research as a place of such experiences and resource to draw meaning from.

> only the night at Pappenheim and the time with Weizsäcker's[223] gives my life any meaning. […] There might also be some moments in my research [Wissenschaft] when I move into the sphere of serious things [*ernsten Dinge*] that were close to me at Pappenheim or at Weizsäcker's. It is as if an outside power [*Macht*] tells me what to do, then an insight [*Erkenntnis*] lights up immediately [*leuchtet unmittelbar auf*].[224]

[223] In letters to his mother, Heisenberg speaks about his interest in Carl-Friedrich von Weizsäcker's younger sister, Andelheit (see Hirsch-Heisenberg, *Liebe Eltern!*, 198–211). At the time Adelheit was, 16, almost half Heisenberg's age and her family enjoined Heisenberg from seeing her (see Hirsch-Heisenberg, *Liebe Eltern!*, 206).
[224] Heisenberg to Annie Heisenberg in Hirsch-Heisenberg, *Liebe Eltern!,* 207f.

This quote illustrates from what angle Heisenberg interprets the experience along with his research. It is one of the few examples where Heisenberg explicitly presents the experience in terms of an intervention of the transcendent, "the outside power" in the immanent, observable world. This idea of the break into the immanent world is a central aspect of the phenomenological concept of religion and, as I have shown, the modern aesthetic religion. This intervention leads to the illumination of the scientific insight that is linked to the topos of knowledge production as experience of nature. For the presence of this idea in Heisenberg's texts, see the Chapters 6 and 7.

The "religious experience" is a central subject of the explicit reflection on religion in Heisenberg's texts. In the tradition of the modern aesthetic religion and the phenomenology of religion, the experience is used as an anchor term in Heisenberg's description of religion. Moreover, the texts actualise the aesthetic repertoire of the religious experience coined by the Romantic Schleiermacher and the phenomenologist of religion Otto. In both cases and in extend Heisenberg's texts the religious experience gives form to the transcendent in an age of immanence.

5.1.1 "The Central Order"

The "central area", "order," or "central order" is a key term in Heisenberg's discussion of religion. In the discussion of "the religious experience," the central order is the reference point of the experience. As such, the central order is encountered by the individual. Beyond its role in the "religious experience," the central order contributes to the reflections on science (see Chapter 6) as well as the relationship between science and religion (see Section 5.3.3). In this section, I will focus on the central order in the *Memoir* and the Gifford lectures because the term is part of the explicit reflection on religion.

The term 'central order' appears in the *Memoir* as part of the protagonist's reflection on the concept to God. While the protagonist rejects the idea of a personal God, he replaces the personal God with the terms of "central order" and the "creative force," both of which are not further explained in the texts. Nevertheless, the protagonist touches on the connection between the central order and God as well as their relationships with science. In the chapter, "Initial Conversation about Science and Religion (1927)," it is the utterance "What does it mean that Einstein speaks a lot about the dear Lord [*dem lieben Gott*]?"[225] that opens the discussion on the relevance of religion in light of modern physics. Einstein's talk about the 'dear Lord' is described towards the end of the previous chapter, "Departure to the New Land [*Aufbruch in das Neues Land*] (1926–1927)." The protagonist recounts how the character, Einstein, voiced his discontent with the probabilistic side of quantum mechanics during the fifth Solvay Conference in 1927.[226] Rather than discussing the mathematical or epistemological difficulties of quantum mechanics, Einstein opposed the new theory with the claim, "The dear Lord [liebe Gott] does not throw dice."[227] Wildly known today and associated with Einstein, the quote is described as "a phrase one could often hear from [Einstein]."[228] In the chapter, "Initial Conversations" the character Pauli suggests that Einstein did not refer to the dear Lord of the Bible but rather an abstract unity.

> The God he refers to is somehow related to the immutable [*unabänderlich*] laws of nature. Einstein has a feeling for the central order [*zentrale Ordnung*] of things. He can detect this order in the simplicity of natural laws. We may take it that he felt this simplicity very strongly and directly during his discovery of the theory of relativity. Admittedly, this is a far cry from the contents of religion. I don't believe Einstein is tied to any religious tradition, and I rather think the idea of a personal God is entirely foreign to him.[229]

[225] Heisenberg, 'Der Teil und das Ganze,' 116.
[226] Initially funded by Ernest Solvay, a Belgian industrialist, the Solvay Conference continues to be an invitation only event which offers eminent scientists a space to debate open problems in physics and chemistry. The 1927 conference focused on the newly formulated quantum theory.
[227] Heisenberg, 'Der Teil und das Ganze,' 114.
[228] Ibid. 114.
[229] Ibid. 118.

Here the idea of a personal God is rejected in favour for a non-monistic idea of the central order. This central order is visible and can be felt in the natural laws. The natural laws, such as the theory of relativity are the subject of scientific research not traditional religions. The feeling of nature as a way of understanding nature becomes a foundational idea of the *Naturphilosophie*.[230] As a result nature is presented as a revelation of the divine which presents a central idea of a pantheistic concept of nature.[231]

In chapter 17 of the memoir "Positivism, Metaphysics, and Religion (1952)" the character Pauli asks the protagonist, Heisenberg about his view on a personal God, "Do you believe in a personal God?"[232] In his answer, the protagonist invokes the central order. Further, he develops an analogy between human interaction and the interaction between a human and this central order, through the concept of the soul.

> I myself prefer the following formulation: Can you, or anyone, reach the central order of things or events [*die zentrale Ordnung der Dinge oder des Geschehens*], its existence seems beyond doubt, as directly as you can reach the soul of another human being? I am using the term 'soul' quite deliberately so as not to be misunderstood. If you put your question like that, I would say yes. [...]
>
> 'the word 'soul' refers to the central order, to the core [*Mitte*] of a being whose outer manifestations may be highly diverse [*mannigfaltig*] and confusing [*unübersichtlich*].[233]

In his answer, the protagonist characterises the central order by linking it to the human soul. The analogy between the interaction between humans and the interaction between the human and the central order stand in the tradition of the neo-Platonic idea of the human soul as the image of the cosmic soul. As such, the soul of a human individual, such as Heisenberg, is imagined as a part of a whole.[234] This idea of the

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[230] Von Stuckrad, *Die Seele im 20. Jahrhundert eine Kulturgeschichte,* (Leiden: Wilhelm Fink 2019), 12; Daston and Galison, 'The Image of Objectivity.'
[231] Von Stuckrad, 'Naturwissenschaft und Religion,' 452.
[232] Heisenberg, 'Der Teil und das Ganze,' 293.
[233] Ibid.
[234] Von Stuckrad, *Die Seele,* 8.

soul as part of a bigger entity is evident in the way the protagonist explains why he talks about the soul rather than God.

A decade earlier, in the Gifford lectures from 1958, we find a similar connection being made between experience, God, and the soul. Moreover, the debate into the context of the epistemological questions, meanwhile the link to Plato and Neo-Platonic ideas are explicitly made.

> The real philosopher is the prisoner who has escaped form the cave into the light of truth, he is the one who possess real knowledge. This immediate connection with truth or, we may in the Christian sense say with God is the new reality that has begun to become stronger than the reality of the world as perceived by our senses. The immediated connection with God happens within the human soul, not in the world.[235]

The link to Platonism is established through the reference to Plato's Allegory of the Cave, where knowledge production is presented as a departure from ignorance to the truth. Once escaped from the cave, the real philosopher in Heisenberg's interpretation has immediate sight of truth. Heisenberg links this truth, however, to the sight of God and ultimately presents a Christianised version of Plato. Heisenberg locates the visual access to the real knowledge as the immediate connection with God within the person. By locating the connection within the "human soul" Heisenberg actualises an aspect of the modern aesthetic religion that re-defined religion as an individual experience. In addition, while the allegory illustrates the power of reason to understand reality, it also introduced an influential aesthetic repertoire. The aesthetics of the allegory, the change from the darkness, the shadows to the light, the sun, aestheticises the step from ignorance to reason, immediacy, and clarity. This aesthetic repertoire, in particular the link between truth and light but also the aesthetics of immediacy can be observed in the descriptions of knowledge production and justification of theories in Heisenberg's texts (see Section 6.3 and Chapter 7).

[235] Heisenberg, *Physics and Beyond*, 39.

The *central order* is an anchor term in Heisenberg's texts. In the explicit reflection on religion, the central order plays a role in the idea of religion as experience. Moreover, the central order is a key term that links knowledge production with the sight and imitation of the divine in nature. This idea of feeling and experiencing the central order in nature, as well as with humans, actualises the topoi of the emotional connection between humanity and the sacralised nature shaped by *Naturphilosophie*. Furthermore, the texts change Platonic and Pantheistic ideas of knowledge production and the soul by embedding them in a Christian framework.

5.2 "Genuine Religions": Discussions on the Plurality of Systems of Meaning

In texts from the 1940s to the 1970s, Heisenberg distinguishes a "genuine religion" from immanent alternatives like political ideologies or worldviews, such as materialism. The idea of political ideologies or science as alternatives to religion is coupled to the narrative of a decline of religion. As shown in the previous section, Heisenberg suggests that music or science may present alternative vehicles for religious experience.

However, beyond the individual concept of religion developed around religious experience, science or political ideologies are also tied to the social concepts of religion discussed in Heisenberg's texts. This chapter shows that Heisenberg engages in a debate on the plurality of religions and systems of meaning and manages to tie it back to a decline of "genuine religion."

By taking a closer look at the characteristics of this "genuine religion," I show how Heisenberg in fact defends one religious tradition and the place of religion in a modern society. In that regard, it becomes visible how religion serves as a medium of cultural critique in Heisenberg's writings. In his manuscripts *Philosophy* and the speech

"Religious and Scientific Truth," he distinguishes "genuine religion" from political ideologies, such as National Socialism and Bolshevism, and enters the debate on political religions, a notion shaped by the book *The Political Religions* by Eric Vögelin from 1938.[236] Along with the critique of immanent religions and *Weltanschauungen* in the manuscript *Philosophy,* Heisenberg discusses science as an alternative that could take the place of religion. However, after the Second World War, the idea of science as an alternative to religion is absent in his texts. In the speech "Religious and Scientific Truth," for example, it is religion that is presented as the ethical framework of research and the solution to the challenges of modern society, such as the influence of technology or the alienation of the individual. The distinct character of the "genuine religion" illustrates how the discussion of religion in Heisenberg's texts is embedded in and shaped by historical context, a situatedness which becomes notably visible in his practice of cultural critique.

5.2.1 "Immanent Religions" and "*Weltanschauung*"

In the manuscript *Philosophy*, Heisenberg observes a decline of religion which leaves a void. This void, Heisenberg claims, is filled by the alternatives, "immanent religions." The discussion about immanent religion is accompanied by a characterisation of "genuine religion."

> One could argue here that, particularly today, a large group of humanity has explicitly renounced all religious ties. However, it is the ties to the religions, in which God is explicitly mentioned that are being loosened. However, this creates space for religious ties of a different kind, for example, the myths of these ties refrain as far as possible from the creative power [*schöpferische Kraft*] of the soul. For a part of humanity, the renunciation [*Abkehr*] of existing religions is obviously only the preparation to commit to new ties. The emergence of such strange [*merkwürdige*] immanent religions [*Diesseits-*

[236] In the Collected Works of Eric Voegelin, Vol 5: *Modernity without Restraint: The Political Religions; The New Science of Politics; and Science, Politics, and Gnosticism*, edited by Manfred Henningsen, (Baton Rouge: Louisiana State University 2000).

> *Religionen*], such as National Socialism and Bolshevism indicates that new decisive changes in the structure of human consciousness [*Bewusstsein*] may be on the way.[237]

The critique of society and politics focuses on the decline of genuine religion, which leaves an opening for immanent alternatives, such as National Socialism. The shift away from genuine religion to the immanent alternatives is interpreted as a sign of a change in the structures of the human consciousness (see Section 5.3.3). The reflection on alternatives that may fill this void is tied to a critique of contemporary politics. Writing during the Second World War and under the control of the National Socialist Party, Heisenberg characterises the political ideologies of National Socialism and Bolshevism as "immanent religions [*Diesseitsreligionen*]" and elaborates on their inadequacy to replace the "genuine religion." The term "immanent religion" was used by intellectuals and scholars of religion in the early 20th century.[238] Immanent religion served as a way to characterise and discredit political movements and ideologies, like Marxism. In the demarcation of an immanent religion, genuine religion is characterised by reference to the creative power of the soul. In the above quote Heisenberg invokes the pantheistic concept of religion that we have come across in the previous section.

In the distinction of another alternative to religion, *Weltanschauung*, it is also the care of the soul that distinguishes genuine religions. Heisenberg criticises the focus on the material world of the *Weltanschauung*.

> But the question is to what extent this *Weltanschauung* can be compared to other religions. It does have some common traits with the other religions [...] Like the other religions, this *Weltanschauung* too points us humans to something that is beyond or above us and which is no longer a subject to our will: the eternal laws according to which the objective world runs [*abläuft*]. But the fact that no myth in this *Weltanschauung* speaks in a symbolic way of the creative forces of the soul, means that it is worth less than the genuine [*echte*] religions. While the genuine religions always turn the gaze inwards [*nach innen*] and thus ensure that the creative area of the soul remains unharmed, despite all the misfortune in the world, the *Weltanschauung*, dedicated to the objective, leaves the soul defenceless against all adversity

[237] Heisenberg, 'Ordnung der Wirklichkeit (1942),' 298.
[238] See for example Johannes Wendland's *Die neue Diesseitsreligion,* (Tübingen: J.C.B. Mohr 2014).

> [*Unbilden*]; whereby the damage caused by it can be even greater because it generally does not enter people's consciousness [*Bewusstsein*]. Thus, it is probable that this *Weltanschauung* won't survive in the long term once the words of Christianity might have become completely incomprehensible. Rather, another language will have developed, in which the forces–that transform the world through our souls–are explicitly named.[239]

When comparing the *Weltanschauung* with other religions, Heisenberg notes that both have in common that they are pointing towards something that stands outside of human power. The question whether this reference points outside of the immanent remains unanswered in both systems. However, what is more interesting is the distinction Heisenberg draws between the *Weltanschauung* and the genuine religion when it comes to the care of the soul. Heisenberg rejects the *Weltanschauung* as a viable alternative to genuine religions because it leaves the soul without protection. Here the distinguishing factor in a genuine religion is the myths that constitute a language that protects and cares for the soul (which he 'locates' inside) the human.

Throughout the paragraph, Heisenberg suggests a plurality of the genuine religions, good however, in the end it is the decline of Christianity he is concerned with. The *Weltanschauung* cannot fill the void left by Christianity in the long run. Rather, Heisenberg suggests that a new language and as such an alternative to the genuine religions will emerge and fulfil the function of protecting the soul. Following the transformation of the world, the new language, Heisenberg suggests, is not the result of intellectual reflections but the language will develop by itself.[240]

The central example of a *Weltanschauung* in Heisenberg's texts is a positivist materialism. Heisenberg associates this *Weltanschauung* with the culture of the United

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[239] Heisenberg, 'Ordnung der Wirklichkeit (1942),' 298f.

[240] The development of a rigorous language has been at the centre of the program of the Logical Empiricists, in particular Otto Neurath's attempt to develop of a unified science [Einheitswissenschaft], 'Unified Science and Its Encyclopedia', In *Philosophy of Science*, 4(2) (1937), 265-277. The claim that a new language has to emerge and cannot be invented can also be found in the interpretation of the epistemological challenges of quantum mechanics, see Chapter 6.

States of America and any research that focuses purely on the observable world. It is the focus on the observable, immanent world of this Weltanschauung that allows Heisenberg to compare it with the political ideologies of National Socialism and Bolshevism.

> For another part — especially in the Anglo-Saxon world — the former religion has long been replaced by a different kind of tie. This other tie links to the experience of the leading minds [*der führenden Geister*] of early modernity, who discovered another reality alongside the Christian one that had emerged from the revelation [*der Offenbahrung*]. The other reality was the one of the objective realities, that triumphed with the science formed in modernity. For a large part of today's mankind, the objectifiable layer [*objektivierbare Schicht*] of reality has been elevated to the reality par excellence, as such it forms the basis for every standard of value [...] Nevertheless, many people can be moved by the effects of the human spirit [*Geistes*] that are present in the objective material world; for example, the sight of a huge ship or the buildings of Manhattan reaching up to the clouds can instil in us a sense of wonder [*Staunen*] in which we clearly feel the demonic powers to which man has bound himself; and maybe the persuasive power of the Anglo-Saxon *Weltanschauung* is based on these experiences [*Erlebnissen*].[241]

In this paragraph, the genuine religion has already been replaced by the *Weltanschauung* of the materialists. Associated with science, Heisenberg compares the *Weltanschauung* with the genuine religion on the basis of the involved experiences. The experience (discussed in the previous Section 5.1) appears here in a modified way. While the religious experience is distinguished by the sudden sight of and connection to a reference point that lies beyond the observable world, the experience at the centre of the *Weltanschauung* is activated by the sight of the observable world. While the religious experience binds the person, the experience at the centre of the *Weltanschauung* is characterised by a sense of wonder. Furthermore, it is accompanied by a negative feeling of a demonic power. As such, Heisenberg challenges the triumphant narrative of modernity because of its focus on the objective world fostered by a materialist science.

[241] Heisenberg, 'Ordnung der Wirklichkeit (1942),' 298.

Over three decades later, in the speech "Scientific and Religious Truth," Heisenberg distinguishes once more the genuine religion from possible alternatives on the basis of their reference to the transcendence (or lack thereof).

> The concept of religion should include in the *geistige* content of many cultures and different ages, even the ones without a reference to the notion of God. Only regarding the communal forms of thinking [*gemeinschaftlichen Denkformen*], which are being pursued by the modern totalitarian states, where the transcendental [*Transzendente*] is fully excluded, could there be some doubt as to whether the term religion can be applied in a meaningful way.[242]

Similarly to the "immanent religion," it is the political ideologies manifested in totalitarian states that Heisenberg rejects as alternatives to religion under the concept of the "communal forms of thinking." This distinction defines religion on the basis of the reference to the transcendent, which he explicitly does not limit to God. Furthermore, the claim that his definition of religion ought to include a wide range of historical traditions,[243] follows the concept of the phenomenologists, such as Otto who universalised a distinct (and Christian) idea of religion.

Heisenberg's discussion of political alternatives of religion invokes the rhetoric of the cold war. In the speech "Scientific and Religious Truth" he leaves the discussion of National Socialism and Bolshevism from 1942 behind to distinguish now between the "liberal democracies" of the West and the "totalitarian states" of the East. Despite the rhetoric of the cold war, Heisenberg does not present the liberal democracies of the West as the solution to political and economic problems. Rather, the "liberal democracies" just like the "totalitarian states" are critiqued for providing inadequate value systems. The inadequacy of these value systems is developed through a comparison with the value system of "the genuine religions."

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[242] Heisenberg, 'Wissenschaftliche und Religiöse Wahrheit,' 428.
[243] On other occassions, Heisenberg name different traditions (e.g., Buddhism) explicitly, see Section 5.2.3).

> At this stage one can recognise the characteristic difference between the genuine [*eigentlichen*] religions, in which the *geistige* area, the central *geistige* order of things, plays a crucial role, and the narrower forms of thinking [*Denkformen*], particularly of our times, which relate only to the experiential [*erfahrbare*] form of a human community. Such forms of thinking exist both in the liberal democracies of the West and the totalitarian state systems of the East. Here, too, an ethic is formulated, but with reference to a norm of moral [*sittliches*] behavior, and this norm is deducted from a *Weltanschauung*, i.e. the observing of the directly visible and tangible [*erfahrbare*] world. The real religion does not speak of norms, but of guiding images [*Leitbildern*] according to which we should adapt our actions and which we can approach if we are lucky.[244]

The value system provided by the two state forms diverges from the values offered by religion. He characterises these values as images, which are relatable and even present the opportunity for interaction, the chance to approach them. Here, the text presents a functional concept of religion which rests on the reference to the intangible. Religion is opposed to the immanent norms of the political systems. Heisenberg's detailing of the true values' distinctness accompanies a critique of contemporary politics and social developments.

When distinguishing genuine religions from worldly alternatives (e.g., political alternatives or materialism) Heisenberg develops a concept of religion that stands in the tradition of Romanticism. As such, the concept of religion transcends historical contexts while being explicitly grounded in a reference to the transcendent.

5.2.2 Science as Religion

In the manuscript *Philosophy*, Heisenberg discusses science as a possible alternative to religion. In light of the decline of religion and the influence of politics, the natural sciences may emerge and serve as a replacement for religion.

> Perhaps, in the future, science will play an even more important role in shaping the world than it has so far. Not only because it is part of the preconditions of political power, but maybe because it is the place where the people of our time confront the truth [...] in science, we enter an area in which

[244] Heisenberg, 'Naturwissenschaftliche und Religiöse Wahrheit,' 429.

> what we say is in the end either true or false; here a higher power still exists, that uninfluenced by our wishes, makes the final decision and thus evaluates [*wertet*]. Therefore, the areas of pure science are the most important, in which there is no longer a discussion about practical applications, but rather in which the pure thinking traces [*nachspüren*] the hidden harmonies [*verborgenen Harmonien*] of the world. This innermost realm, in which science and art can barely be distinguished, is perhaps the only place for today's mankind [*Menschheit*] where the truth confronts it, completely pure and no longer veiled by human ideologies or desires. Certainly, the great mass of people has no more access to this area than they used to have to the Holy of Holies [*das Allerheiligste*] in the temple. But for the masses it is enough to know that some people are able to advance to it [*vordringen*], and that one *cannot* deceive [*betrogen*] here, that it is the Dear Lord who decides and not us.
>
> As long as this central area of science remains untouched, the danger is probably not too great, conjured up [*heraufbeschworen*] by the fact that we control the forces of nature to a much greater extent than in earlier times. These forces can be guided in their effect for the good as long as they are still ordered by us, from a centre [*einer Mitte*] that is not set [gesetzt] by us but by a higher power [...] The researcher is, even if against his will, the magician for the people whom the forces of nature obey. But his power can only work for the good if he is also a priest and only acts on behalf of the deity [*Gottheit*] or the fate [des *Schicksals*].[245]

This is the only case where Heisenberg compares the scientists' social role to the role of the priest as well as the magician. In the role of the priest, the scientist uses his insight for doing good and to serve as a mediator between the people and the truth, which Heisenberg compares with a deity in religion. Here Heisenberg develops a link between the content of research, the hidden harmonies of the world and a transcendent entity, the "Dear Lord" or "deity." This link combines two different traditions of *Naturphilosophie*, the idea of the harmonies structuring the world and the idea of the clockmaker. On the one hand the scientist traces the structure of reality, which he encounters in the absence of personal preferences, desires, of ideologies. It is the immediate encounter with the structures of nature, independent of human premises and impacts, that grants authority to the scientist (see Chapter 7). On the other hand, the scientist enters a realm where a higher power steers the processes of nature.

[245] Heisenberg, 'Ordnung der Wirklichkeit (1942),' 306.

Heisenberg roots his reflections on the possible replacement of religion by science in the observation of a changing society. A change that is driven by a growing importance of science in shaping the world through technology and the influence of political ideologies. While the political ideologies are presented as a hindrance to the central order and the truth, science is presented as an alternative that provides an immediate access. Under the social conditions, Heisenberg suggests that pure science takes the places of religion in a world shaped by science with the scientists embodying the authority of the priest. As such, the scientists fill the void, Heisenberg identifies with modernisation, the growing influence of science as well as politics. In other examples, Heisenberg also presents research as an alternative way to access and attend to structures of reality. The claim of science replacing religion rests on the *tertium comparationis*, the social function of accessing the truth, the realm of the deity and harmonies.

Heisenberg presents science as a possible alternative to religion, because of the observed independence of theoretical, pure research from social and political interest. This optimism about science is absent in the texts after the Second World War. In light of the culpability of science during the war, for example with the research on nuclear arms the texts shifts to the opposite sentiment, with religion stepping in to compensate for the focus of modern science by offering an ethical framework.

5.2.3 Religion Compensating Science

After the Second World War, science is no longer discussed as an alternative to religion. It is rather religion that is presented as the ethical framework within which research ought to be conducted. In the speech “Scientific and Religious Truth,” Heisenberg lists accomplishments of modern science (e.g., “modern medicine prevented the death of

millions through diseases") to then turn to shortcomings of science and disastrous inventions (e.g., "weapons of the most destructive power)." On the ground of these observations, Heisenberg suggests that science is not able to assess the value of its research and results. Instead, his text turns to a discussion of religion as a value framework for modern science.

> The decision on the goals cannot be made from inside science and technology; they must–if we are not to go completely astray–be made from a point [*Stelle*], which considers the whole human and his whole reality [...] To this reality belong many things which have not yet been discussed [...] this *geistige* form does not only determines the ethics of a community, but its whole cultural life [...] only here can we talk of a sense for the life of the individual. We call this *geistige* form the religion of the community.[246]

The specialisation of science and technology are presented as a cause for social challenges, that might lead humans – that is, us – astray. In opposition to the specialisation of science, Heisenberg suggests that the value system provided by religion must be considered when evaluating scientific goals. Here, religion is characterised not only as a system of values but also of meaning.

The suggestion that religion may compensate and regulate the specialisation of science with a value system, builds on a distinction of science and religion, which Heisenberg compares to two languages, that should not be conflated.

> Part of the careful process of keeping the two languages, the religious and scientific, apart is also a matter of avoiding a weakening of their content through intermingling them. The correctness [*Richtigkeit*] of proven scientific results cannot sensibly be doubted by religious thinking, and, vice versa, the ethical demands which proceed from the core [*Kern*] of religious thinking should not be dissolved by too rational arguments from the area of science. Here is no doubt that, with the extension of technological opportunities, new ethical questions arise which cannot easily be solved [...] The reflection about these problems has nothing to do with a softening of ethical principles. Nor can I imagine that such questions can be answered by mere pragmatic expedients. Rather, it will be necessary to remember the interconnection [*Zusammenhang*] of the whole [*Ganzen*]: the basic human attitude [*Grundhaltung*] expressed in the language of religion and from which the ethical principles derive.[247]

[246] Heisenberg, 'Naturwissenschaftliche und Religiöse Wahrheit,' 427.
[247] Ibid., 437.

The two languages, religion and science fulfil different functions as they attend to different issues. While science is associated with truth, religion is associated with ethics. This distinction builds on a widely shared position about the relationship between science and religion.[248] The solution Heisenberg suggests for the expansion of science and technology is presented as common sense; the basic human attitude expressed in religion. It becomes clear that Heisenberg does not recognise secular alternatives to religion when it comes to the foundation of ethics.

On a few occasions, Heisenberg explicitly refers to Christianity. One such occasion is the discussion of the relevance of a religion-based ethics in a modern society.

> Here the well-known objection against the Christian religion, that men behave just as terribly within the Christian world, as outside it, loses its validity. Of course it is unfortunately true, but men do retain in the Christian world a clear capacity to distinguish between good and evil; only where we have this is there any hope of betterment. Where there are no examples to point the way, we lose our scale of values and with it, the sense underlying our action and suffering, the final result being nothing but negation and despair. So, religion is the basis of ethics, and ethics is the prerequisite of life. For we must make decisions daily, we must know the values which determine our actions, or at least have an inkling of them.[249]

Here Heisenberg makes explicit that it is not just any religion but Christianity that offers the values in modern society. Serving as a defence of Christianity, Heisenberg rejects the objection of the value system of Christianity for not preventing atrocities by presenting the moral compass of Christianity as superior. While he acknowledges that Christianity does not prevent evil, he defends it as the religion that offers the chance for betterment. Written after the Second World War, the texts stand in the contexts of the political context of the Holocaust, events that shaped theological and social

[248] See reflections and use of this understanding of science and religion, for example Barbour, *Religion and Science* or Stenmark, *How to Relate Science and Religion*.
[249] Heisenberg, 'Naturwissenschaftliche und Religiöse Wahrheit,' 429.

debates in West-Germany.[250] Furthermore, he presents religion as the foundation of ethics and, consequently, of life. The call he makes is that, in and through our lives, religion must be put to use. In consequence, religion is here characterised as an individual and social practice.

The praxiological concept of religion as a lived activity is further present in a critique of modern society. Heisenberg critiques the growing influence of modern technology because of its consequences for the individual. Here, religion is presented as a compensation for the isolation of the individual associated with the growing focus on the material world.

> We must try to overcome the isolation [*Isolierung*] which threatens the individual in a world dominated by the practical demands of technology. Theoretical consideration of questions of psychology or the structure of society will not be much help unless we succeed in regaining a natural balance in the *geistige* and material spheres of life, through practical action. It will be a matter of reviving the values enshrined in the *geistige* form of the community, in everyday life, and giving them so much illuminating power that the individual's life will once more align itself with them.[251]

His critique builds on the lamentation about the growing influence of materialism in the form of technology and science. As a result, he observes and addresses the isolation of the individual. The remedy he presents to solve this problem is to turn to values. With a turn towards values, which he identifies as Christian in everyday life, the individual ought to be able to relate, once more, to the values and in consequence the community. As this happens, life will be able adjust itself, without the work of the individual. Whereas, in the *Philosophy*, which I addressed above, Heisenberg suggests that a new language will emerge that protects the individual – a practical device capable of dealing with the matter of reviving existing but dwindles values.

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[250] See for an overview of the theological debate see, Matthew D. Hockenos, 'The German Protestant Debate on Politics and Theology after the Second World War,' In *Religion and the Cold War*, edited by Dianne Kirby, (London: Palgrave Macmillan UK 2003), 37-49.
[251] Heisenberg, 'Naturwissenschaftliche und Religiöse Wahrheit,' 438.

Nevertheless, Heisenberg ends the speech "Scientific and Religious Truth" with the invitation to take action. The action he suggests is an inter-generational dialogue about the social contract. Here, another cultural context in which the text is situated becomes visible, the West German student movement of 1968. Like other student movements of the later 1960s, the West German students protested against the Vietnam War. Beyond that, the students called for a reformation of the universities (particularly in light of the incomplete denazification) and protested against plans for nuclear armament. At the core of the speech's call for an inter-generational dialogue stands the renegotiation of the dynamics between the *geistige* and the material needs of a community.

> Science has made great progress in the last hundred years. The wider spheres of life, about which we speak in the language of our religion, have perhaps been neglected in the process. We do not know whether we will succeed in expressing the *geistige* form of our future societies in the old religious language. A rational game with words and terms is of little help; honesty and directness are the things we need most. But, as ethics are the basis for [M]an's communal existence, and ethics can only be gained from that basic human attitude which I called its *geistige* aspect, we must all make every effort to agree with the young generation on a common human attitude. I am convinced that we can succeed if we find, once more, the right balance between both truths.[252]

The paragraph builds on the observation that social change is facilitated by modern science. One element of this change is the observable decline of religion, as people increasingly focus their attention on the material world. The answer Heisenberg's offers to this change is an inter-generational conversation about the social values, more specifically the role of the Christian ethics. This agreement, however, depends on the development of a balance between the truth of science and the truth of religion, "both truths." Here, Heisenberg speaks on a non-scientific issue in a way that offers orientation. He takes on the role of the benevolent scientist, or the priest who informs societal debates. In consequence, he contradicts his own definition of science and

[252] Ibid., 439.

religion as languages that should be kept separated. As will become clear further down, Heisenberg concerns himself explicitly with the renegotiation of the relationship between science and religion as part of a critique of modern society (see Section 5.3). Moreover, his reflections on the language used to communicated modern physics develops yet another interaction between the social systems of science and religion (see Section 6.2.2).

In the speech "Scientific and Religious Truth," Heisenberg criticises a social change that he associates with the growing influence of a materialist science and a simultaneous decline of religion. Religion is characterised as a value system and a pivotal pillar of modern society. This concept of religion is further invoked in the call for a revitalisation of values and an inter-generational settlement on the ethical framework that guides the communal life. In these claims religion functions as a medium of cultural critique, mainly by serving as the ethical framework for modern science and modern society. These explicit reflections and suggestions on an issue that lie beyond Heisenberg's expertise as a scientists appear as one specific interference pattern between science and religion.

Here Heisenberg's reference to religion is entwined with a critique of science and society. The possibility to use religion as a medium of cultural critique is an effect of the functional differentiation of modern society within which religion becomes one system among many. Religion as a medium of critique is closely tied to the cultural critique voiced by German intellectuals since the late 18th century. In the final decade of the eighteenth century, the Romantics, for example, challenged the growing focus on the immanent brought forward by different traditions, including material empiricism, historicism, the critique of metaphysics, or anti-clericalism. Each of these developments captivated theologians, *Naturphilosopher*, artists, and poets in Germany. The Romantics' response was a creative attempt to "invent a renewed

means of understanding and describing transcendence."[253] Within the Romantic program, nature was made out to be an ontological as well as a spiritual entity.[254] As such, the study of nature also offered new ways of experiencing the transcendent. This idea of the study of nature can be found, for example, in von Goethe's *Naturphilosophie* and literature. His response to the growing rationalism, especially in the form of scientific materialism, was the pursuit of the unity of nature and its vitality through the study of nature.[255] Von Goethe's response reverberates in Heisenberg's texts, in particular in his reflections on the consequences of modern physics for the study and understanding of nature (see Chapter 6).

Religion as a medium of cultural critique is prominent in Heisenberg's arguments about the social role and importance of religion. The combination of functional and existential concepts of religion demonstrates the general importance of religion for a changing society and the physics that came under scrutiny after the Third Reich and the use of the atomic bomb. The religion defended in the texts consolidates ideas that are in accordance with a *bildungsbürgerliche* Christianity.

5.3 "The Relationship between Science and Religion:" Discussions on the Problems of Modern Society

"The relationship between science and religion" is the most prominent way that Heisenberg refers to religion in his writings. Different positions of that relationship are discussed in his *Memoir*, where a fictionalised version of Werner Heisenberg, writing as the protagonist, holds conversations on this matter with, for example, his

[253] Hampton, *Romanticism and the Re-Invention of Modern Religion*, 5.
[254] Von Stuckrad, *The Scientification of Religion*, 455.
[255] See Henri Bortoft, *The Wholeness of Nature: Goethe's Way Toward a Science of Conscious Participation in Nature*, (Hudson: Steiner Books 1996), 50–60.

colleagues, and specifically in the chapter titled “Initial Conversation on Science and Religion [*Erste Gespräche über Wissenschaft und Religion*] (1927).”[256] While the discussion of different positions on “the relationship” is central to this particular chapter, science, religion, and how they relate are also discussed separately in the speech “Scientific and Religious Truth.”

Already in his manuscript *Philosophy* from 1941/2, Heisenberg establishes a position about the relationship between science and religion. This relationship shows great similarities with the “complementarity” position that he defends in his later texts (see Section 5.3.3). Along with the “complementarity” position, Heisenberg discusses and ultimately rejects three more positions about the relationship between science and religion: “conflict,” “compatibility,” and “exclusivity.” In the debates of “the relationship between science and religion” Heisenberg defends ideals of religion, science, and society.

He repeatedly ties these debates about the relationship back to the new insights gained from quantum mechanics. The ideal of science negotiated in relation to religion has taken different forms. In the case of the conflict position, science is often demarked from religion and historical religions. This strategy of demarcation stands next to positive characterisations of science through institutional structures (e.g., laboratories and universities, or practices like research and publications).[257] Heisenberg’s rejection of the conflict position is based on re-interpretations of historical examples that are cited as evidence for the conflict between science and

[256] Heisenberg, ‘Der Teil und das Ganze,' 116–130.
[257] The handbook *Handbuch Wissenschaftsgeschichte*, edited by Marianne Sommer, Staffan Müller-Wille, and Carsten Reinhardt from 2017 offers a great overview of these different traditions. Influential studies of this positive study of science include Fleck, *Entstehung und Entwicklung einer wissenschaftlichen Tatsache;* Thomas Kuhn*, The Structure of Scientific Revolutions (*Frankfurt/Main: Suhrkamp *2012) first published in 1962; Galison, Image and Logic: A Material Culture of Microphysics;* Rudolf Stichweh Differenzierung der Wissenschaft, in *Zeitschrift für Soziologie,* 8(1), 1979, 82-101.

religion. His opposition to the "compatibility" and the "exclusivity" positions are based on a cultural critique and the expression of personal preferences. In consequence, Heisenberg builds a case for his "complementarity" position.

5.3.1 The "Conflict" Position

The conflict position has shaped the discourse of the relationship between science and religion.[258] In the Anglophone world, two prominent examples of the late 19th century are the books *The History of the Conflict between Religion and Science (1874)* by the scientist and later historian, John William Draper, and *A History of the Warfare of Science with Theology*, by the educator and co-founder of Cornell University, Andrew Dickson White (1896).[259] Tied up in inter-theological and political debates, the two books proclaim a conflict between science and religion. These claims of a conflict between science and religion have been accompanied by arguments and works that challenged the conflict thesis. Heisenberg engages here in a "myth-busting"[260] of the conflict thesis.

As we will see, the re-interpretation of historical events, such as the trial against Galileo Galilei are entwined with the justification of an ideal relationship between science and religion. The trial against Galileo Galilei is a cornerstone of the speech "Scientific and Religious Truth." Heisenberg's interpretation of the trial is part of a larger argument about the absence of a *real* conflict and the importance of religion for science and a modern society. The speech is embedded in the context of the inter-Catholic debates surrounding the Vatican Council 1962–1965. Several German

[258] Jeff Hardin, Ronald L. Numbers, and Ronald A. Binzley, *The Warfare between Science and Religion: The Idea That Wouldn't Die*, (Baltimore: Johns Hopkins University Press 2018).
[259] John William Draper, *The History of the Conflict between Religion and Science*, (New York: D. Appleton & Company 1874); Andrew Dickson White, *A History of the Warfare of Science with Theology in Christendom*, (New York: Routledge 2009) first published in 1896.
[260] Harrison, 'Neo-Harmonists,' In *The Warfare between Science and Religion*, 239–257, 255.

speaking theologians and clergy members (such as, Karl Rahner and Cardinal Franz König) advocated for a public revision of the church's verdict in the trial against Galileo.[261] Carson suggests that the speech and particularly the arguments brought forward by Heisenberg are the product of the Romano Guardini Prize Award and the inner-Catholic politics. However, Heisenberg's interpretation of the trial also appears in other texts. This indicates that the "myth-busting" of the conflict position may not be as closely tied to the event as Carson suggests. Furthermore, Carson concludes that Heisenberg's prize speech performed a reconciliation between science and religion, while the content of the speech did not, "Religion and science were not just coexisting epistemic authorities but structurally set up to conflict."[262] However, as I have already show above, some of the arguments and conclusions that Heisenberg makes in the speech are contradictory. The analysis of the following section shows that the picture of the relationship between science and religion is in fact more complex than Carson suggests.

The speech, "Scientific and Religious Truth" follows three steps: an overview of the historical development leading to contemporary science, a description of religion, and a normative discussion of the contemporary relationship between science and religion. In the first part, Heisenberg discusses the trial against Galileo, presenting it as the initial "shock" that set of the conflict between science and religion. As shown in the extract below, Heisenberg conceptualised science and religion as two epistemic authorities as well as institutions that are concerned with truth.

> The fact that these two truths came into conflict has had a decisive influence on the history of European ideas since the 17th century. The beginning of the conflict is generally considered to be the trial proceedings of the Roman Inquisition [*römischen Inquisition*] against Galileo in 1616. […] The details of the trial need not interest us today, nor the human inadequacies which were a factor on both sides. But we can and must inquire into the deeper reasons

[261] See Carson, *Heisenberg in the Atomic Age*, 130f..
[262] Ibid., 133.

> for the conflict. First, it is important to be clear that both sides believed they were right. Both the church authorities and Galileo were equally convinced that high values were in danger and that it was their duty to defend them. Galileo had experienced, as I mentioned earlier, that through careful observation of phenomena on earth and in the sky [*am Himmel*]—the falling of stones or the movement of planets—mathematical laws come to light [*zu Tage tretten*] which make visible a previously unknown degree of simplicity in phenomena. He had recognised that this simplicity offers a new possibility of understanding and that we can trace with our thinking parts in the eternal order of the world of phenomena [...] Galileo wished under no circumstances to give up this new insight into the divine order [...]. The judges, too, had obviously the greatest respect for Galileo's scientific authority; thus they did not wish to prevent him from furthering his researches but they did wish to prevent disquiet and uncertainty being carried over into the traditional Christian view of the world, which had had such a decisive role in mediaeval society [...] We thus have to give the Inquisition court credit that they tried to reach a settlement at the first trial and passed a judgment we could readily accept.[263]

Contrary to Carson's interpretation, the close examination of the text shows, science and religion are not structurally set up to conflict but rather present two alternatives to relate to the same thing. On one level, the conflict between Galileo and the church is presented as an inner-religious conflict: a conflict between two different ways of practicing the worship of God – one accomplished through the church, the other through the study of nature. In the tradition of *Naturphilosophie*, Heisenberg presents Galileo's research as an uncovering of the structures nature leading to a sacralised nature. While Heisenberg opens the paragraph by describing science and religion as two epistemic authorities occupied with truth, he then turns to science as a practice and religion as an institution. As such, Heisenberg does not interpret the aim of science here associated with Galileo and the practice in pursuing of new knowledge and the immediate sight of the divine order as a threat to religion. However, he suggests that the Church, occupied with social cohesion, perceived the practice of science as a challenge to its authority. Heisenberg reaches the conclusion that the church is not to be blamed for the conflict that arose from the trail. This conclusion stands within the premise that Galileo and the Church contributed to the shock that set off the conflict

[263] Heisenberg, 'Naturwissenschaftliche und Religiöse Wahrheit', 432.

that shaped European history. In this paragraph, Heisenberg interprets an event, not as a subject of historical inquiry but rather as a moment to intervene in contemporary discourse.

A decade earlier, Heisenberg interprets the same event in *Physics and Philosophy* a little bit differently. Here Galileo's research and the Church are presented as two practices with the same goal, to study and worship the divine creation.

> Galileo did not only think about the mechanical motions, the pendulum, and the falling stone; he tried out by experiments, quantitatively, how these motions took place. This new activity was in its beginning certainly not meant as a deviation from the traditional Christian religion. On the contrary, one spoke of two kinds of revelation of God. The one was written in the Bible and the other was to be found in the book of nature. The Holy Scripture had been written by man and was therefore subject to error, while nature was the immediate expression of God's intentions [...] It was easily seen that this new attitude meant the departure of the human mind into an immense field of new possibilities, and it can be well understood that the Church saw in the new movement the dangers rather than the hopes. The famous trial of Galileo in connection with his views on the Copernican system marked the beginning of a struggle that went on for more than a century. In this controversy the representatives of natural science could argue that experience offers an undisputable truth, that it cannot be left to any human authority to decide about what really happens in nature, and that this decision is made by nature or in this sense by God. The representatives of the traditional religion, on the other hand, could argue that by paying too much attention to the material world, to what we perceive with our senses, we lose the connection with the essential values of human life, with just that part of reality which is beyond the material world. These two arguments do not meet, and therefore the problem could not be settled by any kind of agreement or decision.[264]

With science and religion being conceptualised as two different perspectives, Heisenberg interprets the conflict as the result of two incommensurable perspective on the same issue. On the one hand, the perspective of Galileo, the study of nature, is a practice of studying and relating to the world. As such, Galileo's study of motions through experiments presents an alternative to the church's practices and not an opposition. With this interpretation of research as the study of God's work, similar to the study of the Bible, Heisenberg's draws on the tradition of the two books of God, i.e.

[264] Heisenberg, *Physics and Philosophy*, 165f.

the Bible and nature. In this opposition, the study of the book of nature is superior to the study of the Bible because it allows immediate access to God's creation. This immediate access is granted through the study, or rather the reading of nature.[265] Unlike the Bible, the individual study of nature does not rely on the mediation of a text, which Heisenberg characterises as flawed, prone to error. Thereby, Heisenberg thus affirms the reformist tradition that the individual study of the Bible offers a true understanding of and immediate connection with God's work. This idea of immediacy is taken to another level in the Romantic tradition of religion as experience (see Section 5.1). Contrastingly, Heisenberg's interpretation of the church's perspective is that the immediate study of the divine work in nature challenges the existing practices and institutions. While Heisenberg concludes that Galileo's and the church's perspectives on the study of nature are incommensurable, he does not suggest that the two practices are structurally set up to conflict.

The critique of a materialist view of the world is not limited to Heisenberg's interpretation of the church's perspective on the natural sciences. His opposition to the materialist tradition of science appears in many of his texts. On some occasions – for example, in the *Physics and Philosophy* – the critique of the tradition is tied to the explicit reflection on religion.

> It was especially difficult to find in this framework room for those parts of reality that had been the object of the traditional religion and seemed now, more or less only imaginary [...] an open hostility of science toward religion developed [...] Coming back now to the contributions of modern physics, one may say that the most important change brought about by its results consists in the dissolution of this rigid frame of concepts of the nineteenth century.[266]

Associated with the 19th century, the positivist tradition of science becomes dated and with it a predecessor of modern physics. Heisenberg's critique of this tradition focused

[265] Hans Blumenberg, *The Readability of the World*, translated by Robert Savage, and David Roberts, (Ithaca: Cornell University Press 2022).
[266] Heisenberg, *Physics and Philosophy*, 137.

on its exclusion of the areas of the world that he associates among others with religion. It is this exclusion that manifested in the conflict, now driven by science. Quantum physics itself presents a way out of this conflict, one that materialised because of human inadequacy. It is the epistemological novelty of modern physics that presents the opportunity to renegotiate the relationship between science and religion.

Heisenberg's claim that the conflict is based on a misunderstanding can be further found in the *Memoir*. In this case, human inadequacy is the misunderstanding of different ways of speaking about the world.

> The conflict between the two areas, which has been raging since the eighteenth century, seem founded on a misunderstanding or, more precisely, on a confusion of the images and parables of religion with scientific statements, which is clearly nonsense [*unsinnig*].[267]

Heisenberg suggests that the practices of science are incompatible with religion because these two systems rely on different languages. Here, the responsibility for the conflict is attributed to the scientists who did not recognise the fundamental difference between their statements and the statements of religion.

In "Scientific and Religious Truth," Heisenberg expands on the consequences quantum mechanics has for the conflict between science and religion. Similar to his interpretation from 1959, Heisenberg's argument against a conflict between science and religion relies on his interpretation of quantum mechanics.

> The development of science in the last hundred years has forced [*erzwungen*] this more subtle thinking in its own field. As we no longer make the world of direct experience the subject of our research, but a world which we can only penetrate [*eindringen*] with the means of modern technology, the language of everyday life is no longer adequate. We can of course finally succeed in understanding this world by representing its formal structures in mathematical formulae; but when we wish to talk about it we must make use of images and parables, almost as in religious language. Modern science has brought to light [*zu Tage gefördert*] encompassing laws [*umfassende Gesetzmässigkeiten*] much more so than those with which Galileo and Kepler had to do. But it has been proven that with the width in the interpretation of the phenomena the degree of abstraction grows and with it the difficulty of

[267] Heisenberg, 'Der Teil und das Ganze', 117.

> comprehension. Even the demand for objectivity, which for a long time was considered a prerequisite of all science, has been limited in atomic physics [*Atomphysik*] by the fact that it is no longer possible to separate a phenomenon to be observed completely from its observer. Where [*Wie steht es*] is our contradiction [*Gegensatz*] between scientific and religious truth?[268]

The argument that leads to the rhetorical question at the end of the paragraph focuses on three epistemological novelties associated with quantum physics. The rhetorical question suggests that there is no longer a contradiction between science's and religion's ability to render the world intelligible, which in conclusion means that the epistemological foundations that manifested the conflict have shifted. The three novelties of quantum mechanics Heisenberg cites are: first, the language used by scientists, second, the scope of the laws uncovered by scientists, and third, the dependence of the research results on the observer. Together, all three novelties challenge premises of the 19th century modern science, particularly the ideal of objectivity and the materialist focus.

Heisenberg argues, first, that the inadequacy of the contemporary scientific language for quantum mechanics leads to the language becoming poetic. As he characterises the language of religion as poetic, this shift changes the dynamics between science and religion. The idea of a poetic language for the inquiry into nature stands in the tradition of the *Naturphilosophers* and Romantics who argued for and used a poetic language, because it facilitated immediate insight (see Sections 6.2.2 and 7.2). Heisenberg's second claim is that the modern physics allowed the formulation of laws that covered greater aspects of nature. These laws of greater scope rely on greater abstraction which makes the laws more difficult to understand. At the same time, this ability to formulate more precise and comprehensive laws of nature, moves modern science closer to the interpretations of religion that incorporate the whole of reality. This, Heisenberg argues is because the new theory departs from the

[268] Heisenberg, 'Naturwissenschaftliche und Religiöse Wahrheit', 436.

materialist ideal of science founded on classical mechanics. I discuss the idea and imagination of a unifying theory put forward by Heisenberg in the Sections 6.2 and 6.3. Last, Heisenberg interprets the insight of quantum mechanics that the observing scientists shapes the research results as a shift away from the ideal of objectivity at the core of classical mechanics. I will show, Heisenberg repeatedly associates science with objectivity and religion with subjectivity. With the insight of modern physics, in particular under the assumption of the uncertainty principle, the influence of the scientists on the research changing the conditions of the possibilities to know a research object. This leads science to incorporate a subjective moment and brings it ultimately closer to religion.

In the texts, the idea of great laws and immediate knowledge is further present in the discussion of another historical case, the fifth book of Johan Kepler's *Harmonic Mundi* from 1619.[269] It serves as a counterexample to the conflict between science and religion. Similar to the discussion of Galileo's work, Heisenberg interprets Kepler's descriptions as a confirmation of research as an alternative form of studying God's work. In "Scientific and Religious Truth" Kepler's work is presented as a pivotal moment for the practice of modern science.

> [A]t this early stage of modern science, the greatest conviction was borne by the newly discovered laws of mathematics. These mathematical laws were the visible expression of the divine will—this we read in Kepler—and Kepler goes into raptures at the fact that he was the first to recognise the beauty of the divine works. The new thinking, therefore, had nothing whatsoever to do with a renunciation [*Abkehr*] of religion. Even if the new findings did run counter to ecclesiastical dogma in some places, this was of little significance if one was able to experience the workings of God in nature so directly.[270]

Through the discussion of Kepler's work as an alternative practice of recognising God, rather than an opposition of religion, Heisenberg challenges the narrative of the conflict

[269] Johannes Kepler, *Harmonic Mundi* libri V, (1619).
[270] Heisenberg, 'Naturwissenschaftliche und Religiöse Wahrheit', 425.

between science and religion. Nevertheless, he is clear in presenting science as the superior alternative as it allows a direct sight of the divine work. Here, the production of knowledge stands in the tradition of the *Naturphilosophie*, where nature is sacralised in the framework of a Protestant theology. Furthermore, the production of knowledge is linked to the tradition of religion as experience. Here, the production of knowledge is not characterised in terms of painstaking work (e.g., experiments and mathematical theories) but rather as an immediate insight and experience (see Chapter 7 for this topos and Section 6.3 for the role of aesthetic values for knowledge production). While Kepler's practices are an alternative to religious ones, it is the institutions, such as ecclesiastical dogma or the Church that are caught up in the conflict.

This difference between the practices of the scientists and the institutions is at the core of Heisenberg's myth-busting. In Heisenberg's texts, the discussion of Kepler's work appears as early as the speech "The Unity of the Scientific *Weltbild*" from 1941. In the speech, Heisenberg interprets Kepler's research as a form of recognising God's work.

> Instead, the *Weltbild* was still determined by the belief in a supernatural revelation, which was laid down in the Holy Scriptures, and the natural scientist set himself the task to recognise God's work in nature and glorifying his work by understanding its lawful harmony. Neither Kepler nor Galilei might have thought about the possibility, that the conclusions from the scientific discoveries could get into conflict with the contemporary religious image of the world –even not when the teaching broke with the traditional views and the resulted in conflict with the church. Still for Kepler the study of the harmonies of the spheres was […] nothing other than a tracing of God's path of creation. Thus, at the end of the fifth book of Cosmic Harmony, the sentences […] This confession was certainly the basic attitude of early natural science and only the Church, in its struggle against the new teachings [*Lehren*], instinctively felt that this science could one day become dangerous to the religious *Weltbild* itself.[271]

[271] Heisenberg, 'Die Einheit des Naturwissenschaftlichen Weltbildes', 165.

Here, Kepler's book serves as a confirmation that science and religion are not in conflict but are rather compatible, even if not complementary in terms of practices. In Heisenberg's interpretation, it is not the scientist who had the foresight to recognise how revolutionary his work is but rather the Church's. It is once more the institution that facilitated the conflict between science and religion.

Unlike Carson's suggestion, the rejection of a conflict between science and religion is not limited to the Romano Guardini Prize speech. I showed how other historical events, such as the trial against Galileo or Kepler's *Harmonie Mundi* are mobilised as counterexamples in Heisenberg's texts. By interpreting these examples not as moments of a chasm but rather as a misunderstanding, he develops a narrative where science and religion are actually compatible if it were not for the human error of the scientists and the clergies. Some examples of this incapacity can be tied back to the scientists' side, Galileo's unwillingness to refrain from disseminating his theories or the scientists who study the interpretations of religion like scientific theories. On the clergies' side, the incapacity includes the inability to recognise research as an alternative practice of studying the divine work. Through the closer examination of those arguments, I further showed that Heisenberg presents science and religion as structurally compatible. This is mainly due to the fact that Heisenberg views science through the lens of a practice concerned with the study of (the divine work in) nature comparable to the practices of religion, the theological study and personal experience of God. Moreover, Heisenberg challenges the conflict position in reference to the interpretation of the epistemological consequences of quantum mechanics as a departure from the conflict that materialised under classical mechanics and a materialist science. As such, Heisenberg rejects the conflict between science and religion as a valid position regarding their relationship.

5.3.2 The "Compatible" and the "Exclusive" Position

The two positions of "compatibility" and "exclusivity"[272] shape the discussion of the relationship between science and religion in the *Memoir*. In the Memoir's chapter "First Conversations on Science and Religion (1927)," these two positions are discussed as alternatives to the "complementarity" position, which Heisenberg develops and defends in his texts.

Heisenberg opens the discussion on these positions about the relationship by introducing the compatibility position. Associated with the physicist Max Planck and the protagonist's parents, the position illustrated in the following extract regards science and religion as two distinct spheres of reality that are "compatible."

> 'I assume,' I must have replied, 'that Planck considers religion and science compatible because, in his view, they refer to quite distinct facets of reality. Science deals with the objective, material world. It presents us with the task to make accurate statements about this objective reality and to grasp its interconnections [*Zusammenhänge*]. Religion, on the other hand, deals with the world of values. It considers what ought to be or what we ought to do, not what is. In science we are concerned with what is true or false; in religion with what is good or evil, valuable [*wertvoll*] or worthless [*wertloss*]. Science is the foundation of technology, religion the foundation of ethics [...] This view, which I know so well from my parents, associates the two realms with the objective and subjective aspects of the world. Science is, so to speak, the way we confront, in which we engage with the objective side of reality. Religious faith, on the other hand, is the expression of the subjective decisions that help us choose the standards [*Werte*] by which we live.'[273]

Here the relationship between science and religion builds on an ontological distinction between science and religion. With science being occupied with nature and the material world on one hand, and religion being occupied with the social world on the other hand, the two realms are compatible. The protagonist's epistemic authority to explain the compatibility position is established through his intimate knowledge about

[272] Unlike for the other positions, Heisenberg does not characterize the exclusivity position as such. I chose this description which in reference to the other positions describes the quality of the relationship and not the way science and religion, as spheres of reality or social systems stand to one another.
[273] Heisenberg, 'Der Teil und das Ganze,' 116f.

the compatibility positions – an intimate knowledge that comes from personal conversations and experience rather than from intellectual studies. As I will show further down, the complementarity position he develops resembles in many ways the way science and religion are characterised (see the following Section 5.3.3).

Because of the fundamental distinction religion and science do not hinder either realm. Heisenberg suggests that this means concretely that someone's beliefs or denomination does not affect their research and vice versa. Thereby, Heisenberg turns to social questions.

> Max Planck, if I understand him right, has used this freedom and come down squarely on the side of the Christian tradition. His thoughts and actions, particularly as they affect his personal relationships, fit perfectly into the framework of this tradition, and no one will respect him the less for it. As far as he is concerned, therefore, the two realms–the objective and the subjective sides of the world–are quite separate, but I must confess that I do not feel comfortable about this separation. I doubt whether human societies can live with such a sharp distinction between knowledge [*Wissen*] and faith.[274]

Now, concerned with social questions, the protagonist rejects the compatibility position. While he acknowledges the position's validity, he rejects it on the ground of a feeling and belief that human society needs a different distinction between science and religion. It is the "sharpness" of this distinction between the two epistemic authorities that the protagonist reacts to. With this rejection, the protagonist indicates that he views the differentiation of modern society (see the following Section 5.3.3).

Later in the conversation, the protagonist expands on the reasons why he feels uncomfortable about the compatibility position. In his explanation, he explicitly refers to physics as a liberation from the rigid distinction of the compatibility position.

> But it seems to me that the whole division into the objective and subjective side of the world is far too violent, the fact that religions through the ages have spoken in images, parables and paradoxes can only mean that there is

[274] Ibid., 117.

> no other way of grasping the reality to which they refer [...] we couldn't do much with the division of reality into an objective and a subjective side.
>
> I therefore feel it is a liberation of our thinking that we have learnt from the development of physics in recent decades how problematic the terms' 'objective' and 'subjective' are. That started with the theory of relativity.[275]

Here, religion stands in the tradition of a phenomenological conceptualisation of religion. Religion is presented as a constant of human existence because of its uniqueness. By presenting religion in this way, Heisenberg activates the idea of religion as a phenomenon *sui generis*, which no other language can described accurately. The division between objective and subjective is characterised as violent, with the new path presented as a liberation of thinking. Although Heisenberg gives reasons to oppose the compatibility position, he, nevertheless, reverts to feeling as a justification for presenting an alternative starting point to conceptualise the relationship. The starting point of the discussion is the epistemological reflections on the distinction between a subjective and an objective area of reality.

The second position the protagonist rejects in the Memoir is the exclusivity position, defended by the character Paul Dirac. In the following quote, the character Paul argues that religion becomes obsolete in the course of modernisation and the development of modern science.

> 'I don't know why we are talking about religion,' he objected. 'If we are honest—and scientists must be—we must admit that a lot of false claims are made in religion, with no basis in reality. The very idea of 'God' is a product of the human imagination [*Phantasie*]. One can understand why primitive people [*primitive Völker*], who were much more exposed to the overpowering forces of nature than we are today. Those personified the forces out of fear and came up with the concept of a deity [*Gottheit*]. Nowadays, when we understand so many natural processes, we have no need for such images [*Vorstellungen*]. I can't, for the life of me, see how the postulate of an almighty God *[allmächtige Gott*] helps us in any way [...] If religion is still being taught, it is by no means because its ideas still convince us, but simply because some of us want to keep the people, the lower classes quiet. Quiet people are easier to govern than clamorous [*unruhig*] and dissatisfied [*unzufrieden*] ones. They are also very much easier to exploit. Religion is a kind of opium that is offered to the people [*dem Volk*] to lull it into wishful dreams and to comfort [*trösten*] it for the injustice that it experiences. Hence the close alliance between those

[275] Ibid., 123f.

> two great political forces, the State, and the Church. Both need the illusion that a kind God rewards–in heaven if not on earth–the ones who do not raise against injustice.[276]

This position builds on the distinction between science and religion as two competing and exclusive epistemic authorities. In the course of the advancement of modern science, religion becomes obsolete. While religion fulfilled a similar function to modern science in presenting interpretation of natural events, science renders these interpretations to be false. Here religion is associated with 'primitive people' and deception while science and scientists are made out to be honest. The character presents science as a tool for civilisation and progress. Dirac further rejects religion because it serves as a tool of power explicitly evoking the vocabulary of Karl Marx's critique of religion as "the opium of the masses."[277] As such, religion serves the ruling classes and the capitalist system built on the exploitation of the masses. It is for this link between the church's teaching of God and salvation that Dirac rejects the teaching of religion. The position he proposes presents science and religion as mutually exclusive authorities. In his claims, he combines an evolutionary concept of science that overcomes religion with a political critique of religion.

The protagonist, Heisenberg, challenges the exclusivity position. He opposes first Dirac's focus on the misuse of religion, "You [Paul Dirac] judge religion by its political abuses."[278] Heisenberg defends religion with the argument that its political abuse is not a good enough reason to reject it. He claims that "the judgment does not do justice to the subject," because everything in the world can be misused, including "the communist ideology you propounded recently."[279] Instead, religion ought to be

[276] Ibid., 121.
[277] Karl Marx, ‚Zur Kritik der Hegelschen Rechtsphilosophie,' In *Karl Marx. Philosophische und ökonomische Schriften*, edited by Johannes Rohbeck and Peggy H. Breitenstein, (Stuttgart: Reclam 2008), 9, initially published in 1844.
[278] Heisenberg, 'Der Teil und das Ganze,' 121.
[279] Ibid., 121.

evaluated by its function, as the framework of values and system that offers meaning. Ultimately, the protagonist challenges the exclusivity position because of the social value of religion. The rejection of the exclusivity position is, just as it was the case for the compatibility position, tied to a cultural critique.

Heisenberg opposes the "compatibility" and "exclusivity" position because they are inadequate for social reasons. In both cases he combines the epistemic and social concepts of science and religion. In particular for the compatibility position, it is the insight gained by quantum physics that presents an opening for an alternative relationship.

5.3.3 The "Complementary" Position

Complementarity is the main position Heisenberg develops and defends in his texts. While in the manuscript *Philosophy* he develops a relationship between science and religion without characterising it. Over the years, the idea of science and religion as two aspects of one form becomes an explicit position he defends against the "conflict," "compatibility" or "exclusivity" positions. Three decades later, in the second interview of the "Double Dialogue," he explicitly describes the relationship put forward by this position as complementary.

> I would rather say that these things [science and religion] must interact, I would rather say that they are two complementary sides of the same picture. Perhaps I should add a word about the term 'complementarity'. Bohr thought for a long time [...] he decided on this word 'complementarity' [...] Bohr emphasised that it was very important to have a word about which people would not say at once they know what it means. It is important for it to be somewhat vague to begin with because only then can you get a feeling for what is meant.[280]

[280] Heisenberg, Vintila, and X, 'Double Dialogue with Werner Heisenberg', 475.

Heisenberg accounts for why he chooses to conceptualise the relationship between science and religion as complementary. He takes the term from particle physics, where complementarity became a central term in 1927, when Niels Bohr introduced it to describe the findings that objects can have properties, such as being a particle or a wave, which cannot be observed simultaneously and require mutually exclusive theories. Nevertheless, together these theories offer a better understanding of an object. The principle captures the insight that observations in modern physics continue to be described using the concepts of classical mechanics. It further recognised that the observation of a phenomena and the act of observing can no longer be clearly separated like in the tradition of classical mechanics.[281] In the light of this theoretical approach, it becomes clearer what Heisenberg means, when he describes science and religion as two complementary sides of the same picture. Heisenberg goes even further by suggesting that they must interact. However, the paragraph remains vague about the two concepts of religion and science and how they relate to the complementary relationship Heisenberg defends.

By introducing the notion of complementarity, a term notably coined by modern physicists, in the discourse on "the relationship," Heisenberg contributes to an interference pattern between science and religion. Beyond this use of the term, it is his justification for introducing complementarity in a discourse linked to religion that makes the interference palpable. By identifying complementarity as a vague term that allows multiple but also immediate understanding, Heisenberg uses characteristics of the language of religion (see the above Section 5.3.1) but also activates a romantic concept of poetry as a way of knowledge production (see Section 6.2). As I have shown above and I will develop in Chapter 7, according to Heisenberg, the use of a poetic

[281] Károly Simonyi, *Kulturgeschichte der Physik: Von den Anfängen bis heute*, (Haan-Gruiten: Verlag Europa-Lehrmittel 2001), 435f.

language in science essentially contributes to his interpretation of quantum mechanics as well as the changing relationship between science and religion. In the tradition of *Naturphilosophie*,[282] Heisenberg presents the vagueness of the term as bearing an epistemic potential for an immediate understanding, not as an intellectual practice but as an experience. In these cases, the term complementarity is not used in the discourse of "the relationship" because of its heuristic and/or descriptive potential but rather introduced in the communication system of religion.

Once we go back to the first texts in which Heisenberg discusses a relationship between the science and religion, we can observe that science and religion are conceptualised as two complementary sides of one object. However, the object is not consistent. While sometimes science and religion appear as ontological facets of reality, on other occasions, they are treated as two different ways of knowing reality. The proclaimed aim of the manuscript *Philosophy* is an outline of an order of reality; however the result is a combination of an order of scientific disciplines, which are epistemic traditions of studying aspects of reality, and ontological realms of reality. I discuss the consequences of this order for the ideal of science in section 6.1. The premise of the developed order is that modern physics changes the understanding of the world. Heisenberg explicitly models his order of reality after the order von Goethe had proposed in his book *Theory of Colour.* However, Heisenberg identifies the need to re-evaluate von Goethe's order in the light of the modern physics because the original no longer represents the scientific insight about the world.

In the introductory section of the manuscript *Philosophy*, Heisenberg sets science and religion as the extremes that encapsulate the range of the order of reality. As the two

[282] Von Stuckrad, 'Naturwissenschaft und Religion,' 454.

extremes, science and religion are associated with the objective and the subjective part of the world respectively. Unlike the clear separation between the objective and subjective side of the world in the compatibility position, religion and science related through the areas in-between. The result is an order that combines epistemological and ontological perspectives on reality. This relationship is sought to present an alternative to the binary division of a subjective and objective side of reality, which resembles the foundational distinction of the 'compatibility' position. Heisenberg firstly describes science and religion as two ways of knowing reality.

> One path [*Weg*] to the order of the world leads through the faith. In religion, the human mind [*menschliche Geist*] turns to those creative forces [jene *schöpferischen Kräfte*] directly [*unmittelbar*], the ones, which binds us unconditionally wherever we enter their sphere of influence [Wirkungskreis]. But one cannot speak about the last things; therefore, all religion begins with the parable [*Gleichniss*]. It is through the parable that the language is first established or created, in which to speak about the interconnectedness [*Zusammenhang*] of the world. The words of the parable are obscure [*dunkel*]: in religion, from the outset, it is dispensed to give the words a scientifically sharply defined meaning, so that the meaning can come to light [*zu Tage tretten*] in the extent that the individual learns to understand the interconnection over the years and humanity over the centuries. The Holy Scripture enables [*fähig zu*] infinite interpretations; therefore, it can endure millennia.
>
> The common language created by the parable of religion [*im Gleichniss der Religion geschaffen*] binds people more firmly than any other shared language [...] But people of the same faith agree with each other about the basis of all interconnections [*Zusammenhänge*] and thus, as we have known since Plato, about the order of values.[283]

Religion is associated with faith and values, while its language is characterised by ambiguity, relying on parables that evade a clear meaning. The language of religion is opposed to the language of science, characterised by a clear meaning. Heisenberg claims that the ambiguity of the language he associates with religion serves the function of allowing immediate understanding of the words as well as the object of the creative forces they point towards. As I have shown above, the central order, which is

[283] Heisenberg, 'Ordnung Der Wirklichkeit (1942)', 228.

here almost used interchangeably with the creative forces, is a key term in Heisenberg's explicit discussion of religion. The longevity of religion is associated with the ambiguity of its language and the way it enables individuals to find personal meaning in and through that very ambiguity. The idea of religion presented in the paragraph combines individual with social concepts of religion. For the individual, religion offers faith and guidance through their life. For the society, religion presents a value framework and a shared understanding of reality.

Heisenberg locates the other end of the order science. Furthermore, he connects science and religion by presenting them as two complementary ways relating to the central order through knowledge.

> Science, or more specifically empirical science, takes a completely different path to the order of the world [...] While religion refrains from the outset to give words a clear meaning [...] science proceeds from the expectation that in the course of time words will eventually attain a clearly defined meaning. The language of science is changeable, it develops simultaneously with the experiences of men [Menschen] and the basic attitude of science is scepticism. In science there are no final formulations [*entgültige Formulierungen*] in the same sense as in religion. Only when overwhelming [*erstickendes*] material of experiences pressed [*gezwungen*] us to specific formulations [*Formulierungen*] and when these formula [*Formeln*] proved themselves again and again in many other experiences, then we feel forced to recognise that one specific area of experience [*Erfahrungsbereich*] is precisely represented by these formulae. These formulae become a definitive component of the scientific language.[284]

In this characterisation of science, Heisenberg firstly introduces science by demarcating it from religion. Where the language of religion is characterised by ambiguity and longevity (affording endless possibilities for reinterpretation), the language of science is distinguished by precise formulations. While these formulations are clear they remain open to change and are bound by the contingencies of the ongoing research. He suggests that unlike religion, the formulations in science are not

[284] Ibid., 229.

definite and depend on the repeated confirmation(s) that the accomplishment of research entails.

Heisenberg further sets science and religion in relation to each other as the two extremes of the order. In the act of relating science and religion, he mobilises these two concepts (science and religion) as two epistemic practices and as two ontological realms of reality.

> The paths [*Wege*] taken by faith and science to the order of the world [*Ordnung der Welt*] start, therefore, from exactly opposite poles [*Polen*]. While science starts from the realm of reality in which we can apparently completely disregard ourselves and our way of representing it, religion, on the contrary, starts precisely from the realm that its visible form must be shaped by us alone; in other words, *in the realm of the creative forces in which we shape reality ourselves.*
>
> That's why the religious order of the world has often been presented as 'subjective' and placed in opposition to the 'objective', scientific order. It must be admitted that the claim for truth of a particular religion is historically limited in space and time – in contrast to the one of science.[285]

The distinction between science and religion is drawn based on their epistemological differences. While the insight of the world offered by religion is shaped by the individual, the knowledge of science disregards the individual. Consequently, the knowledge and interpretation of historical religions is culturally situated, while the knowledge of science is universal. I discuss Heisenberg's interpretation of the encounter of these two systems in section 6.5. Furthermore, Heisenberg relates science and religion respectively to an objective and subjective side of the world. Associated with the subjective side, religion presents both an end of the proposed order and a path to the order of reality. Similarly, the objective side, associated with science, presents as an ontological entity of the order and an epistemic framework to learn about reality and in particular its order.

[285] Ibid., 230.

The double-folded characteristics of science and religion – that is, the objective and subjective – as two epistemic practices and realms of reality is even more visible in the rejection of the sharp distinction between subjective and objective.

> The terms 'objective' and 'subjective' describe two extremes from where an order of reality [*Ordnung der Wirklichkeit*] can start. They also denote two sides of reality itself; but it would be a too crude of a simplification if one would want to divide the world into an objective and a subjective reality.[286]

As the two ends of the "order of reality", religion and science present two epistemic lenses. At the same time, they hold an ontological status, as two sides of reality.

Almost three decades later, in the memoir, the character, Wolfgang Pauli, offers a similar interpretation of the relationship between science and religion, which he associates with Albert Einstein.

> Einstein is bound to a religious tradition, and I rather think that the idea of a personal God is entirely foreign to him. As far as he is concerned there is no split between science and religion: the central order is part of the subjective as well as the objective realm, and this strikes me as being a far better starting point.[287]

Rather than presenting science and religion (the objective and subjective realm) as two epistemic approaches to the central order, the central order presented as being part of the realms of science and religion.

Around 1970, Heisenberg uses the term complementarity in yet another way that develops a relationship between science and religion. By way of example, in the speech "Scientific and Religious Truth" from 1973,[288] Heisenberg uses the term to

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[286] Ibid., 230.
[287] Heisenberg, 'Der Teil und das Ganze', 119.
[288] Similar arguments can be found in the *memoir* on page 119 f. "The idea of a material object that is completely independent of observation is nothing but an abstract extrapolation, something that does not correspond to something real [*Wirkliches*]. In Asian philosophy and the religions there is the complementary idea of the pure subject of cognition [*reine Subjekt des Erkennens*], one that faces [gegenüberstehen] no object" and on page 473 of the "Double Dialogue": "I very much like a formulation by my old friend, Pauli [...]These two limiting ideas are the following: the one idea is of an objective world which goes on in in space and time. This idea was obviously the guiding picture of natural science [...] The other extreme is the mystic unity of the world envisaged by an individual in a mystic way. Man has the idea that the whole world is given as a unity, and this was the extreme idea which guided asiatic [sic] mysticism; asiatic [sic] philosophy; Buddhism; Hinduism [...] You can start from these extremes, but you know you have to be in the middle somewhere."

illustrates his view on the relationship between the subjective and the objective facets of reality. The need to renegotiate the relationship in this way and with it the relationship between science and religion is the new perspective on the idea of objective knowledge gained by quantum mechanics. Unlike other examples, this one shows how Heisenberg further confines the concept of science and religion to distinct traditions, empirical materialism of modern science and Asian mysticism.

> Once, the physicist Wolfgang Pauli spoke in this regard about two ideas of limitations [*Grenzvorstellung*] which have both been extremely fruitful in the history of human thought, although neither of them corresponds to a genuine reality [*echte Wirklichkeit*]. The one extreme is the idea of an objective world, which runs its course according to laws, independent of any observing subjects in time and space; it was the guiding principle of modern science [*neuzeitlichen Naturwissenschaft*]. The other extreme is the idea of a subject, which experiences the unity of the world in a mystical way, and which is not confronted [gegenüberstehen] with any object nor objective world; this was the guiding image [*Leitbild*] of Asian mysticism. Our thinking moves somewhere in the middle between these two limitations; we must endure the tension that results from the two oppositions [*Gegenstätze*].[289]

In reference to his colleague Wolfgang Pauli, Heisenberg discusses the opposition between objective and subjective from another perspective. As argued by using other examples, the objective side is associated with empirical science and the ideal that natural phenomena can be observed without the interference of the observer. Unlike in other texts, he associates the side of the subject with the pure experience of mysticism at large and 'Asian mysticism.' The two 'extremes' set the parameters for the position Heisenberg suggests of an intellectual approach to the world that stands between the two extremes of pure object and the pure subject. Heisenberg's reference to Asian philosophy is part of a longer tradition of the import and transport of religion through the medium of the sciences, including philosophy. In particular the interests of the German philosopher Arthur Schopenhauer in Vedantic and Buddhist thought had a lasting impact on the way Asian philosophical traditions were received and integrated

[289] Heisenberg, 'Naturwissenschaftliche und Religiöse Wahrheit', 437.

into the intellectual landscape of Europe.[290] Heisenberg's activation of "Asian philosophy" for the interpretation of quantum mechanics, in the widest sense, is less elaborated than Erwin Schrödinger's use of the Asian philosophy in his work. The writings of both physicists forestall the popular writings such as Frank Capra *The Tao of Physics* or Gary Zukav *The Dancing Wu Lee Masters* that use Asian philosophy to interpret modern physics and vice versa.

In the memoir, Heisenberg uses complementarity to conceptualise the relationship between different historical religions as expressions of the essence of religion.

> Hence, I can quite understand why we cannot speak about the content of religion in an objectifying [*objektivierenden*] language. The fact that different religions try to express [*gestalten*] this content in very different *geistige* forms, is no real objection of the real core [*wirklichen Kern*] of religion. Perhaps we ought to look upon these different forms as complementary descriptions which, though they exclude one another, convey, only in their totality [*Gesamtheit*], an impression of the richness that emanates from the relationship of mankind to the greater interconnection [*Zusammenhang*].[291]

Instead of an academic approach and reflection on religion through an objectifying language, Heisenberg reverts to a Romantic answer, to the pluralism of religion. The idea that historical religions, regardless of their space and time, are different expressions of the same thing stands in the tradition of the phenomenology of religion. That the core of religion is measured against Christian ideals shouldn't come as a surprise as the argument develops within the contexts of German Romanticism. Furthermore, the reduction of different religions to one common denominator is being developed together with the comparative study of religion. As such the reduction of a

[290] Urs App, 'Schopenhauer and the Orient', In *The Oxford Handbook of Schopenhauer,* edited by Robert L. Wicks (Oxford: Oxford University Press 2020), 87-107; R. Raj Singh, 'Schopenhauer and Hindu Thought', In *The Oxford Handbook of Schopenhauer,* edited by Robert L. Wicks, (Oxford: Oxford University Press 2020), 379–400.
[291] Heisenberg, 'Der Teil und das Ganze,' 125.

plurality of systems of meaning and interpretation to one core principle presents an answer to the growing complexity of modernity.

I showed that complementarity is a central term in Heisenberg's discussion of "the relationship between science and religion," even serving as a distinct position on "the relationship." The import of the concept of complementarity in the discourse on "the relationship" develops an interference pattern between science and religion. While Heisenberg does not develop an orientation system on the basis of complementarity, he brings it in the wider sphere of the communication system of religion. As a position about "the relationship," Heisenberg uses complementarity to present science and religion as two aspects of the world that only when taken together present a full picture of reality. This pursuit of a full picture of reality is set against alternative positions of the relationship, such as the conflict between science and religion. While complementarity describes one way science and religion are related, Heisenberg applies the term to different concepts of science and religion. First, I showed how science and religion are presented as two ways of knowing and relating to reality, in particular the central order. Second, we saw that science and religion are used as two aspects of reality. Both of these terms present an alternative to the "conflict," "compatibility" or "exclusivity" positions about the relationship between science and religion. Third, I addressed how Heisenberg uses the term of complementarity to conceptualise the connection between different historical religions as the expression of one universal object. Here we can observe different aspects of the explicit discussion of religion in Heisenberg's texts of which many stand in the tradition of the phenomenology of religion and ultimately keep religion relevant in a differentiated society.

5.4 Conclusion

This chapter has revealed two things about the discussion of religion in Heisenberg's popular writings. First, it exhibited the variety of arguments about religion present in Heisenberg's texts. Second, it shed light on the role of religion in an increasingly differentiated society and, in particular, the dynamics between science and religion. Together, these observations contributed to a deeper understanding of the historical case of religion in Heisenberg's texts and how these texts develop multiple interference patterns between science and religion, a phenomenon we will discuss in Chapter 8.

More specifically, this chapter demonstrated the influence of the phenomenology of religion, which builds on the Romantic religion centered around the individual's experience. The aesthetic repertoire of the religious experience is not only important to understand Heisenberg's arguments of religion, but also further paves the way for the study of the implicit religion in the aesthetic repertoire of knowledge production, which I expand on in Section 7.2. Furthermore, this chapter demonstrated how religion serves as a medium of cultural critique, a medium closely tied to the cultural critique by German intellectuals. In the final decade of the eighteenth century, the Romantics, for example, challenged the growing presence of models of immanence brought forward by different social developments, including material empiricism, historicism, a critique of metaphysics, or anti-clericalism. Each of these developments captivated theologians, philosophers, *Naturphilosophers*, artists, and poets in Germany. The Romantics' response was a creative attempt to "invent a renewed means of understanding and describing transcendence."[292] In the course of the Romantic program, nature was made out to be an ontological as well as a spiritual

[292] Hampton, *Romanticism and the Re-Invention of Modern Religion*, 5.

entity.[293] This appears already in the interpretation of research as a study of the divine structures in nature. In Chapter 6, I will show that this idea is central to Heisenberg's discussion of an alternative to modern science. Moreover, the response of *Naturphilosophers* to the aforementioned social developments, especially empirical materialism, was in the pursuit of discovering the unity of nature while recognising its vitality. As a result, the study of nature becomes in reference to the *Naturphilosophie* and Romanticism of the 19th century a 'new (old) way' of experiencing transcendence, an idea examined in Chapter 7.

[293] von Stuckrad, *The Scientification of Religion*, 455.

Chapter 6 Religion and Interpretation Patterns of Modern Physics

Following the mid 1950s, the idea of unity or unification appears in yet another discussion; reflections on the cultural and political order in Heisenberg's popular writings. Heisenberg invokes a universal character of modern physics in his arguments about the social role of science. In particular, practical application and its epistemological features are presented as an asset for the international extension of modern physics. He explicitly distinguishes between the political relevance of practical application and theoretical physics (for a discussion of the distinction on the epistemological level, see Section 7.1). This distinction is exemplified by the discussion of two sides of quantum mechanics: its technological application (i.e., nuclear weapons), which led to the growing influence and visibility of physics during the Second World War, and the epistemological insights, which facilitated the rise of theoretical physics across the globe, especially via the training of physicists and the emergence of international research institutions.

In the introduction to *Physics and Philosophy*, technological application of physics is prominent. Written during the Cold War, with its regime of nuclear armament and following the bombing of Hiroshima and Nagasaki, atomic weapons were socially and politically visible forms of modern physics. Here, the intersection between research and politics becomes explicit in Heisenberg's text and, by consequence, the influence of physics on social developments.

> When one speaks today of modern physics, the first though is of atomic weapons. Everybody realises the enormous influence of these weapons on the political structures of our present world and is willing to admit that the influence of physics on the general situation is greater than it ever has been before.[294]

[294] Heisenberg, *Physics and Philosophy*, 1.

Two years prior, in the 1953 speech "The Image of Nature of Today's Physics," the technological application of science as a means of internationalisation does not have the same explicitly political tone. Heisenberg rather takes on a Eurocentric position towards modern science by pointing towards the connections that science facilitated between Europe, on one hand, and the rest of the world on the other. Here, the technological structures serve as the facilitator for the internationalisation of science. While not explicit, the position he presents is no less political as it establishes a hierarchy between Europe as a progressive realm, because it leads the advancement of science, and the Occident: the rest of the world receiving Europe's output.

> [O]nly this technology has spread [*verbreiten*] science from the Occident [*Abendland*] around the whole world [*Erde*] and helped it to take a central place in the thinking of our time. In this development process of the last 200 years, technology has repeatedly been the condition [*Vorraussetzung*] and a consequence [*Folge*] of science.[295]

Heisenberg's arguments resonated with widely held positions of a perceived singularity of Europe as the bearer of progress.[296] Today, such Eurocentric perspectives on knowledge production, science, technology, and culture are complemented by insight on the dynamics between knowledge cultures relying on the transfer processes across geographical and cultural regions.[297] The insights gained by these studies draw attention to political context and the constellation of power within which science operates.

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[295] Heisenberg, 'Das Naturbild der heutigen Physik', 406.
[296] Today, the debate is widely associated with Oswald Spengler's *Der Untergang des Abendlandes: Der Untergang des Abendlandes: Umrisse einer Morphologie der Weltgeschichte* (Munich: C.H. Beck 1918), the replacement of Christianity by secular alternatives, i.e., Johannes Wendland's *Die neue Diesseitsreligion*.
[297] See, for an overview, Nadine Née, ‚Postkoloniale Ansätze,' In Handbuch Wissenschaftsgeschichte, edited by Sommer, Marianne, Staffan Müller-Wille, and Carsten Reinhardt, (Stuttgart: J.B. Metzler 2017), 80–91. Tampakis and Navarro include this perspective for their analysis on science and religion in their paper 'Science, Religion, and the Creation of Historiographical Categories.'

The link between scientific knowledge and power is a subject Heisenberg discusses explicitly. These reflections are tied to the competition between the theoretical and complete understanding of nature on one hand and experimental and practical application on the other hand, between which Heisenberg develops a hierarchy (see Section 7.1).

> In science, every individual question is subordinate to the great objective, to understand nature in its entirety [*im Ganzen*], similar to how every tiny technical advance serves the general goal to expand the material power of man [*Menschen*]. The value of this goal is questioned just as little as the value of the knowledge of nature [*Naturerkenntnis*] in science, and both goals merge into one through the banal slogan 'knowledge is power.'[298]

Heisenberg establishes a link between power and scientific knowledge through the comparison between the ambitions of science and the ambitions of technology. At the same time, Heisenberg mobilises this comparison to develop his critique of a materialist science that follows the goal of technical advancement. While the aim of science is presented as politically neutral, it is the value of knowledge that presents an entry point for politics once it serves to advance human power over the material world. By citing the dictum 'knowledge is power,' Heisenberg invokes Francis Bacon's *scientia potentia est* (knowledge is power) that shaped the intellectual and political history of science as well as its analysis.[299]

The internationalisation of science through the education system and research institutions also features in the introduction to *Physics and Philosophy*. Again, it is the expansion of a universal European science across the world that leads to a unification of societies and cultures.

> [T]he spirit of modern physics will penetrate the minds of many people and will connect itself in different ways with other traditions. What will be the outcome of this impact of a special branch of modern science on the different powerful old traditions? [...] One characteristic feature of this meeting

[298] Heisenberg, 'Das Naturbild der heutigen Physik', 408f..
[299] John Henry, *Knowledge is Power: Francis Bacon and the Method of Science*, (Cambridge: Icon Books 2002).

> between modern science and the older methods of thinking will be its complete internationality. In this exchange of thought, the one side, the old traditions, will be different in the different parts of the world, but the other side will be the same everywhere, and therefore, the results from this exchange will be spread over all areas in which the discussions take place.[300]

The international expansion of the intellectual and practical sides of science is presented as a process independent from technologies, social structures, traveling actors, or political interests. Despite its independence from any medium, the process is a forceful one of "penetration." The presentation of the internationalisation of the universal knowledge produced by physics as a penetration of the minds and cultures of the situated "older traditions" manifests a hierarchy between the knowledge produced by Western physicists and the rest of the world.

Heisenberg seems to be aware of the tension that arises from the entrance and reception of the new knowledge of modern physics into existing knowledge cultures. However, he reinforces the ideal of Europe and science as progressive when setting it in opposition to the "pre-modern" life. Highlighting the superiority of modern physics, he suggests that it holds the potential to minimise the negative consequences of modern science on local cultures by facilitating a less disruptive relationship between the universal science and the situated cultures.

> On should expect that, in many places, this new activity must appear as a decline of the older culture, as a ruthless and barbaric attitude that upsets the sensitive balance on which all human happiness rests. Such consequences cannot be avoided; they must be taken as one aspect of our time. But even there, the openness of modern physics may help, to some extent, to reconcile the older traditions with the new trends of thought.[301]

The friction that arises from the meeting of modern science and local cultures is presented as an inevitable effect of a greater development. The opposition between modern science and local cultures is evident in the description of modern science as

[300] Heisenberg, *Physics and Philosophy*, 1f.
[301] Ibid., 140f.

ruthless and barbaric which stands in opposition to a sensitive balance and human happiness associated with ancient, local, traditions. The positive view of alternatives to modern science, in particular in *Naturphilosophie* or Romanticism, is a reoccurring subject in Heisenberg's texts and, as we have seen, informs his critique of modern society and modern science (see further Sections 5.2, 5.3, and 7.1). In this case, it is modern physics, a branch of the universal science, that Heisenberg presents as a potential answer for the process of modernisation, or more specifically, the disruptions caused by modern science. A part of science, Heisenberg suggests that modern physics contributes to both the friction between and the solution to different knowledge cultures around the globe or the relationship between church and science. While modernist ideas inform Heisenberg's, he reinforces an imperialist ideal of science in his arguments on the universal character of science.

Occasionally, Heisenberg names professionalisation as a medium of transportation and institutions as the disseminators of science, in particular modern physics.

> Atomic physics as a part of modern science does actually penetrate in our time into very different cultural traditions. It is not only taught in Europe and the Western countries, where it belongs to the traditional activity in the natural sciences, but it is also studied in the Far East, in countries like Japan and China and India, with their quite different cultural background, and in Russia, where a new way of thinking has been established in our time.[302]

In this presentation of internationalisation of science, Heisenberg reinforces the geopolitical perspective of the Cold War through the lens of the West. On one side of the hierarchy, science appears as the intellectual heritage of Europe and on the other side of the dynamic, the East—addressed at higher level of granularity (notably, in the guise of Japan, China, and India)—appears as the recipient of modern science, where both sides have a clear role as the teacher and as the student. Standing as a third,

[302] Ibid., 129.

Russia, although associated with the East, is placed outside of this hierarchy as having developed an intellectual tradition of its own.

Standing out in the discussion of the reception of science by "the East" or "the Occident" is the development of theoretical physics in Japan. Reviving a nativist concept, Heisenberg suggests that it is the purity of the local knowledge culture, supposedly untouched by the materialist science, or more specifically Cartesian dualism, that facilitates a faster and better understanding of modern physics compared to Europe.

> For instance, the great scientific contributions in theoretical physics that have come from Japan since the last war may be an indication of a certain relationship between philosophical ideas in the tradition of the Far East and the philosophical substance of quantum theory. It may be easier to adapt oneself to the quantum-theoretical concept of reality when one has not gone through the naïve materialistic way of thinking that still prevailed in Europe in the first decade of this century.[303]

Heisenberg's presentation of Japan as an exemplary case of progress in theoretical physics is at the same time a critique of the materialist science that give precedence to matter in the Cartesian division.

Next to professionalisation, Heisenberg presents research practices and institutions as crucial media for the internationalisation of science and, simultaneously, as an opportunity for international understanding [*Völkerverständigung*]. It is Heisenberg's experience as a scientist and a representative of West-Germany at CERN in Geneva that find their way into his claims.

> [T]he scientist can do his best to promote international co-operation in his own field [...] Young scientists of many different countries may gather in research institutions in which a strong activity in the field of modern physics is going on, and the common work of difficult scientific problems will foster mutual understanding. In one case, that of the Geneva organisation, it has even been possible to reach an agreement between a number of different nations for building a common laboratory.[304]

[303] Ibid., 141.
[304] Ibid., 133f.

Here, the scientist occupies a central role in the dissemination of science and serving in this capacity as a facilitator of international understanding. Moving in internationally funded institutions, the scientists contributes to the international environment while learning different research practices. Moreover, the institutions shape international relations through research and through their political ties. Research presents a way to foster international understanding among younger researchers. The co-operative aspect of research is effective in the planning and maintenance of scientific institutions. Funding and location of these institutions can bring governments together, as it continues to be the case at CERN. Ultimately, Heisenberg presents science as a diplomatic tool for international cooperation and exchange. As recent research has pointed out, the use of research and scientific institutions as a diplomatic tool has been crucial for Western countries to maintain imperialist structures.[305] In the context of the science of diplomacy, Heisenberg's arguments seemingly fit into the (political) role of science after the Second World War. Along with his popular science writings, Heisenberg took on more political roles in the research landscape of West-Germany (e.g., representing West-Germany at CERN or serving as the first president of the Alexander von Humboldt Stiftung). While these positions offered Heisenberg a distinct perspective on international collaboration among academics, they made sure he remained a relevant figure in physics following his subtle alienation from the physics community following his decision to remain in German and be part of the *Uranverein*.

Long before his work at CERN, Heisenberg had been exposed to a fairly international work environment, during his time at the Niels Bohr's institute in

[305] For example, Simone Turchetti et al., 'Introduction: Just Needham to Nixon? On Writing the History of "Science Diplomacy,"' In *Historical Studies in the Natural Sciences* 50(4) Science Diplomacy, (2020), 323–339; Maria Rentetzi and Kenji Ito 'The co-production of Nuclear Science and Diplomacy: Towards a Transnational Understanding of Nuclear Things. Introduction to the Special Issue,' In *History and Technology*, 37(1) Nuclear Diplomacy, (2021), 4–20.

Copenhagen in the 1920s and early 1930s. Over the years, Heisenberg aimed to reproduce the vivid research environment he encountered during his time spent in Copenhagen and in his institutes in Germany.[306] Beyond his ambitions to create an international environment at his institutes, the ideal finds its way into the edited lectures of *Physics and Philosophy*.

> [O]ne can scarcely doubt that the exchange of ideas between young scientists of different countries and between the different generations in every country will help to approach, without too much tension, that new state of affairs in which a balance is reached between the older, traditional forces and the inevitable necessities of modern life. It is especially one feature of science that makes it, more than anything else, suitable for establishing the first strong connection between different cultural traditions: this is the fact that the ultimate decision about the value of a specific scientific work, about what is correct or wrong in the work, do not depend on any human authority.[307]

Once more, Heisenberg establishes an opposition between the existing, older traditions and modern life, with recent advances in science offering a way to bridge that gap. The opportunity of science to bridge difference is further invoked by the argument that research may foster understanding among scientists from different cultures and generations. In this example, Heisenberg attributes the opportunity presented by modern science to its neutrality with regard to ethical and moral questions. Because it is value-neutral, science can be an effective vehicle for cultural understanding and political co-operations.

This section demonstrated that Heisenberg invoked science, and in particular modern physics (and with it quantum mechanics), as a driving force behind the unification of cultures and international understanding. This process is related to three aspects: first, the impartiality and universality of scientific theories; second, the exchange among scientists in research institutions; and third, the role of politics in creating scientific institutions like CERN. With these claims, Heisenberg contributed to

[306] Heisenberg, *Das Politische Leben eines Unpolitischen,* 158.
[307] Heisenberg, *Physics and Philosophy*, 134.

widely held sentiments during the Cold War. In consequence it does not come as a surprise that, through his popular writings, Heisenberg perpetuated Eurocentric ideals of science as a European achievement that is disseminated across the world to bring about overall positive change.

6.1 "Simplicity," "Symmetry," "Beauty," and "Poetry:" Assessing and Communicating New Scientific Theories

The reflection on and use of aesthetic values, like beauty or the quality of the language used by scientists, are central topics of the explicit discussion of the epistemological consequences in Heisenberg's writings. In particular, the discussions of the "simplicity," "beauty," or "symmetry" of a theory become more prominent in his popular writings after 1940. Alongside these possible aesthetic judgments as descriptors of a theory, the epistemological potential of a poetic language for the interpretation and communication of quantum mechanics becomes a subject after the war.

In this section, I focus on the two ways that Heisenberg's texts relay and discuss aesthetic qualities for knowledge production. I show first, how the aesthetic judgments function as epistemic values. The use of aesthetic judgments as epistemic values has a long tradition, which includes the Romantic's engagement with aesthetics, most prominently in the creation of experiences. Like many of the aspects of *Naturphilosophie* and Romanticism, the use of aesthetic judgments (e.g., beauty and harmony) in the study of nature was inspired by Antique philosophy, such as Neo-Platonism in the tradition of Plotinus. Within the framework of the EHR, both traditions have been and continue to be relevant alternatives to religion.

Secondly, I discuss Heisenberg's call for a poetry-like language for the interpretation and communication of modern physics. Poetry as a medium of

knowledge production was discussed and used by the Romantics and *Naturphilosophers* alike. For the Romantics, poetry presented an alternative to quantitative studies of the material side of nature. Poetry presented a way to capture qualitative aspects and nature as an "organic and spontaneous whole."[308] Goethe's literary and scientific oeuvre is a prominent example of a *Naturphilosopher's* attempt to connect poetry with the study of nature. While he processed the study of nature in some of his literary works (e.g., *Faust*),[309] he employed poetry to capture "the creative and dynamic" activities of nature with which he concerned himself in his studies of nature. Here, it becomes clear that poetry is a medium of knowledge production and communication of knowledge for a wider audience.[310]

Heisenberg invokes this unique approach that poetry offers to the study of nature. The analysis of the reflection and use of aesthetic qualities for knowledge production shows how Heisenberg's texts develop interference patterns between science and religion through the use of Romantic and *naturphilosophische* concept for the interpretation of his theories.

6.1.1 Aesthetic Judgments

"Simple," "beautiful," and "symmetric" are the three main aesthetic judgments that feature in Heisenberg's popular writings. All three are invoked as confirmations for the validity of a theory, including that of matrix mechanics from 1925 and the *Weltformel* from 1956. The presentation of a theory as simple, or the defence of a theory as beautiful and thus correct, has a long tradition. Aesthetic judgments played a central

[308] Gorodeisky, '19th Century Romantic Aesthetics.'
[309] Schmidt, *Die Geschichte des Genie-Gedanken.*
[310] Astrida Orle Tantillo, *The Will to Create: Goethe's Philosophy of Nature*, (Pittsburgh: University of Pittsburg Press 2002), 182–186.

role in the Romantics' claims of truth—for instance, the German poet Friedrich Hölderlin suggests that "truth and goodness are siblings only in beauty."[311] Hölderlin's connection between truth, beauty, and goodness stands in a tradition of Platonic thought and, in focusing on its moralisation of the link between true and beautiful as good, in Neo-Platonic thinking.[312]

In this section, I focus on the three judgments of simplicity, beauty, and symmetry and how they function as epistemic values in Heisenberg's texts. Epistemic values describe values (e.g., the accordance of a theory with a phenomena or predictive power) that are used to confirm a theory's quality and its truth. While the study of epistemic values has been characterised by the attempt to formulate universal values of scientific practices, recent research has focussed on the context-dependency of epistemic values.[313] With this new focus on context-dependent values and historical cases, the study of the epistemic values has made room to analyse the use of aesthetic judgments,[314] for example, in Heisenberg's popular writings.

6.1.1.1 Simplicity

In the edited lectures titled *Physics and Philosophy*, Heisenberg reflects explicitly on simplicity as an epistemic value for theories in physics. In this case, he histories the value of simplicity, ultimately drawing a line between contemporary research and antiquity.

> If we follow the Pythagorean line of thought, we may hope that the fundamental law of motion will turn out to be a mathematically simple law [...] It is difficult to give any good argument for his hope for simplicity—except the

311 Jay M. Bernstein, *Classic and Romantic German Aesthetics,* (Cambridge: Cambridge University Press 2003), 186.
312 Paul Kalligas, 'Plotinus,' In *The Stanford Encyclopedia of Philosophy*, (2024).
313 Kevin Elliot and Daniel Steel, *Current Controversies in Values and Science* (New York: Routledge 2017).
314 Phillis Rooney, 'The Borderlands Between Epistemic and Non-Epistemic Values,' In *Current Controversies in Values and Science*, edited by Kevin Elliot and Daniel Steel, (New York: Routledge 2017), 31–46.

> fact that it has hitherto always been possible to write the fundamental equations in physics in simple mathematical forms. This fact fits in with the Pythagorean religion, and many physicists share their belief in this respect, but no convincing argument has yet been given to show that it must be so.[315]

The justification of simplicity through historical evidence as an epistemic value for mathematical formulation serves the universal claim presented by the protagonist of Heisenberg's memoir that simplicity is the main truth criterion of physics: "the most important criterion of truth in our science, the simplicity of the laws of nature."[316] As for the historical justification of simplicity, the main reference point is the antique philosopher Pythagoras, a Greek philosopher and polymath. Pythagoras' work on music has been a reference point for many influential scholars, such as Copernicus, who refers in *Harmonic Mundi* to Pythagoras' work.

As for Heisenberg's reference to Pythagoras, it is most likely that Heisenberg's collaboration with Wolfgang Pauli in the 1950s was an important factor. After a break of about three decades, the two physicists worked once more closely together in the search of a *Weltformel*. At that time, Wolfgang Pauli expressed great enthusiasm for symmetry,[317] which can be observed, for example, in his lecture "Science and the Thought of the Occident" in 1953.[318] Published a year ahead of Heisenberg's Gifford lectures, Pauli, in his lecture, discusses at length Pythagoras work and its contribution to modern science. Although Heisenberg does not explicitly cite Pauli's work, his arguments in the Gifford show great resemblance with Pauli's. With the reference to the historicity of simplicity as an epistemic value in the study of nature, Heisenberg further mentions the continuous confirmation of simple formulation.

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[315] Heisenberg, *Physics and Philosophy*, 37.
[316] Heisenberg, 'Der Teil und das Ganze,' 138.
[317] Blum, *Heisenberg's 1958 Weltformel*.
[318] Pauli, 'Die Wissenschaft und das abendländische Denken,' In *Quantenmechanik und Weimarer Republik*, edited by Karl von Meyenn, (Braunschweig/Wiesbaden: Vieweg 1994), 333–343.

The epistemic value of simplicity further finds its way into Heisenberg's texts in the activation of the idea of *musica universalis*. The idea of a *musica universalis* was central for the work of Nicolaus Copernicus, who drew on Pythagoras' work. The *musica universalis*, Copernicus claims, equate with the mathematical formulae of the laws of planetary motions he had described in his work. This idea of the *musica universalis* cannot only be found in Heisenberg's speech "Thoughts of the Antique Philosophy of Nature in Modern Physics" from 1937, but he even presents its description as the ultimate aim of scientific knowledge. The idea of the *musica universalis* is entwined with Heisenberg's critique of a materialist science which, as we have seen above, invokes concepts of *Naturphilosophie* and Romanticism.

> The conscious [*bewusste*] understanding of the rational proportions of numbers that underlie musical harmony is necessary for anyone who wants to build an instrument or make music. The genuine content of music, however, reveals itself to us in the unconscious *geistige* absorption [*Aufnahme*] of those rational proportions [*Verhältnisse*]. In a similar way, the conscious knowledge [*Kenntnis*] of the mathematically formulated laws of nature is the prerequisite for an active intervention in the material world aimed at practical use. However, behind it is another immediate [*unmittelbares*] understanding of nature that unconsciously receives the mathematical structures and reproduces them in the *Geist*, and which is available to all the people who are ready for a more intimate, absorbing [*aufnehmenden*] relationship with nature.[319]

In this allegorical explanation of scientific understanding, music and knowledge are brought together through the comparison of the insights gained by the practice of studying nature with the insights gained by creating music. The distinction Heisenberg draws between an intellectual and an immediate way of gaining insight in music and knowledge creation develops a hierarchy. The first level of understanding is gained through the intellectual study of nature, which Heisenberg associated with the practical exploitation of nature that we have encountered in the cultural critique of science and

[319] Heisenberg, 'Gedanken der Antiken Naturphilosophie in der modernen Physik', 132.

modern society (see Sections 5.2 and 5.3). The second level, however, is a somatic experience that he characterises by an immediate connection with the true structures of nature that lie behind perceptible phenomena that are subject to the intellectual study. In the fashion of structural realism, these mathematical structures are the real content of music and of nature. In return, the immediate understanding of this "actual content" of nature and music is reserved for selected individuals. With the restriction of this immediate understanding to selected individuals, the statues of scientist who reaches this complete understanding of nature is heightened. I show in Chapter 7 how Heisenberg's discussion and presentation of gaining scientific insight into nature draws on and reproduces the ideal of the scientist as a Romantic.

The connection between scientific knowledge and music appear in Heisenberg's speech "On the History of the Physical Explanation of Nature" from 1932. In the speech, he explicitly draws on the idea of the *musica universali*s and develops a lineage of it dating back to Plato.

> No other task of science seems more valuable to him [the scientist] than this: to seek out [*suchen*] the enduring [*bleibenden*] laws in the changing of phenomena [*Erscheinungen*]. It is important and characteristic that Plato emphasises precisely this 'formal' side of the explanation of nature, as we sometimes say today. For example, Plato talked once about the Pythagoreans and their study of the oscillations of strings [*Saiten*] and harmonies. The philosopher cares about these experiments because of the numerical relationships behind the harmonies; the phenomenon itself remains an unimportant accessory to him. But the knowledge of nature that can be achieved through the study of its mathematical structures is, according to the philosophers, always only the 'prelude to the melody' that is actually to be learnt, namely the knowledge of the essence of 'things,' to the first stage of knowledge [sic]. In Plato's image, those who forget this are like those prisoners who consider the movement of shadows to be the whole of reality and who will never see the light.[320]

By invoking Plato, Heisenberg legitimises and validates the interpretation of mathematical formulae as the *musica universalis*. Once more, he distinguishes between two levels of scientific study: first the discovery of natural laws, the harmonies

[320] Heisenberg, 'Zur Geschichte der Physikalischen Naturerklärung', 55.

of phenomena, and second, the reaching of an understanding that grasps a phenomenon's essence. Through the refence to Plato's 'allegory of the cave,' Heisenberg develops a hierarchy between the two levels of knowledge production. As a result, the formulation of fundamental law signifies an incomplete understanding, whereas the finding and formulating of a unifying law from which all phenomena (of an area or reality) can be deduced presents the true essence of scientific work.[321] With use of ideas from Neo-Platonism and monism Heisenberg manifests, through the debate of simplicity in physics, the distinction between theoretical and experimental physicists (see also Section 7.1).[322]

6.1.1.2 Symmetry

In the edited lectures *Physics and Philosophy*, Heisenberg reflects further on symmetry as an epistemic value of modern physics. His reflections on symmetry stand within a wider context of debates on, for example, symmetry as the invariance of a structure under a given mathematical transformation (e.g., rotation in space) discussed in modern mathematics, or symmetry as a qualitative notion describing a harmony between the parts and the whole.[323] Within these frameworks, Heisenberg invokes symmetry as a epistemic value in texts from the 1950s onwards to defend his research from the 1920s and 1930s on quantum mechanics.

> All these [counter]proposals have found themselves compelled to sacrifice the essential properties of symmetry of quantum theory [...]. Therefore, we may well suppose that the Copenhagen interpretation cannot be avoided if

[321] See Manfred Stöckler, 'Hat sich Werner Heisenberg zu Recht auf Plato berufen?,' In *Werner Heisenberg Physiker und Philosoph: Verhandlungen der Konferenz "Werner Heisenberg als Physiker und Philosoph in Leipzig" vom 9.-12. Dezember an der Universität Leipzig*, edited by Bodo Geyer, Helge Herwig and Helmut Rechenberg (Berlin: Spektrum Akademisicher Verlag 1993), 335–343.
[322] Christa Jungnickel and Russell McCornmach, *The Second Physicist: On the History of Theoretical Physics in Germany,* (Cham: Springer 2017), 401.
[323] Borrelli, 'Symmetry, Beauty and Belief in High-Energy Physics.'

> these properties of symmetry [...] are held to be a genuine feature of nature; and every experiment yet performed supports this view.[324]

Here, Heisenberg cites symmetry as an epistemic value in defence of the Copenhagen interpretation of quantum mechanics. However, it is not as straight forward as Heisenberg's makes it out to be. The historian Mara Beller showed how the Copenhagen interpretation of quantum physics only became a recognisable reference point through a series of dialogues in the 1950s about the discussions between Heisenberg and Bohr on the interpretation of their research from the early 1930s.[325] While symmetry appears in Heisenberg's texts after the mid-1930s as an epistemic value, it rises to prominence in his research on the *Weltformel* from the 1950s.

In his memoir, symmetry plays a central role in Heisenberg's reflection on the development and assessment of contemporary research. In a combination of Plato and the first words of the Old Testament, "In the beginning was the word," the protagonist presents symmetry as the initial form of the world.

> Perhaps it was possible to divide matter further and further, but in the end, there are no more parts; instead, one transforms energy into matter, and the parts are no longer smaller than the divided. But what was at the beginning? A natural law, mathematics, symmetry? 'In the beginning was symmetry.' That sounded like Plato's philosophy in the 'Timaeus.'[326]

Aesthetic qualities and the framework of a Christianised Plato are used to interpret the new scientific insights about the relationship between matter and energy, in particular, the transition from one to the other.

In the 19th century, another notion of symmetry as mathematical invariance took hold. The ideas of symmetry and symmetry-breaking as a topic in high energy

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[324] Heisenberg, *Physics and Philosophy*, 96.
[325] Mara Beller, *Quantum Dialogue: The Making of a Revolution,* (1999). Moreover, Dan Howared,"Who Invented the ‚Copenhagen Interpretation?' A Study in Mythology," In *Philosophy of Science*, 71, (2004), 669–682 argues that the idea of a consistent Copenhagen interpretation of quantum mechanics was coined by Werner Heisenberg in his Gifford Lecture at St. Andrews in 1955–56 and happily embraced by fellow physicists and philosophers, including David Bohm, Karl Popper, and Paul Feyerabend.
[326] Heisenberg, 'Der Teil und das Ganze,' 185, see later in his memoir a similar claim, 324.

physics in the 1970s show influences of both traditions.[327] Here, Heisenberg's texts contribute to the interference pattern between science and religion on two levels. First, he activates the Platonic idea of form and of symmetry in his interpretations of theories, and second, he combines modern physics with a Christianised Platonism, which becomes once more available through the work of *Naturphilosophen* and Romantics. The idea of symmetry as a harmony between different parts, and of part and the whole,[328] can be observed in his reflection on beauty as an the epistemic value.

6.1.1.3 Beauty

In the manuscript *Philosophy*, Heisenberg reflects on beauty as an epistemic value. In his reflections, he explores and uses beauty as an aesthetic argument for the confirmation of a theory. Heisenberg explicitly establishes beauty (along with fruitfulness) as a genuine epistemic value that even trumps a theory's usefulness and/or its application.

> In any case, the value of a scientific achievement is not measured by the object, i.e., not by the human significance of the material, and certainly not by any 'practical use,' but only by the beauty and the fruitful power of the expressed structures.[329]

The ideal of beauty can also be found in Goethe's *Naturphilosophie* and his critique of a materialist science, both of which Heisenberg explicitly draws from in the manuscript. In 1973, Heisenberg dedicates a whole speech, "The Meaning of Beauty in the Exact Sciences," to beauty, presenting it as an epistemic value. Much like the epistemic values of simplicity and symmetry, Heisenberg traces beauty back to Greek

[327] Borrelli 'Symmetry, Beauty and Belief in High-Energy Physics'; Borrelli 'The Making of an Intrinsic Property'.
[328] Giora Hoan and Bernard Goldstein, *From Summetria to Symmetry: The Making of a Revolutionary Scientific Concept*, (Dordrecht/Heidelberg: Springer 2008).
[329] Heisenberg, 'Der Teil und das Ganze', 290.

antiquity. In particular, the notion of beauty as the agreement of the parts with the whole, presents a central notion across his works, most prominently serving as the title of his memoir from 1969. In the speech from 1973, he traces this notion of beauty back to Plato, developing a legitimacy through legacy. The idea of the congruency of the part and the whole as beautiful has a long history that spans discourses part of philosophy, science, and religion. Heisenberg appreciates this idea of congruency, transported by traditions of *Naturphilosophie* and monism.

> Already in antiquity, two definitions of beauty existed that stood somewhat in opposition to one another [...] One definition describes beauty as the correct agreement of the parts with each other and with the whole [*Ganzen*]. The other one, which goes back to Plotinus and without a reference to the parts, describes the shining through [*das Durchleuchten*] of the eternal brilliance [*ewigen Glanzes*], of the 'One' through the material phenomena.[330]

Along with the notion of beauty as the congruence of the part and the whole, Heisenberg identifies a second concept of beauty: the eternal brilliance shining through the phenomenal world. This notion of beauty is reminiscent of the aesthetic repertoire of the Romantic landscape, notably 'the sacred light,' which guides the viewer and evokes sensations, a sense of longing, for example.[331] Moreover, Heisenberg's discussion and use of this "sacred light" as a quality of true mathematical formulae could be described as a sacralisation of nature. In Section 5.1 on the religious experience, the description of 'shining through' has already come up, and as we will see it appear again in Chapter 7, where it is prominent in Heisenberg's narration of knowledge production as an experience.

The two aspects of congruency and the sensory response associated with beauty are linked in Heisenberg's texts. In the tradition of Romantic aesthetics, Heisenberg presents the identification of a beautiful theory as a combination of

[330] Heisenberg, 'Die Bedeutung des Schönen in der Exakten Naturwissenschaft', 370.
[331] Grieser, 'Imaginationen des Nichtwissens.'

intellectual work and affective experience of the new insight. Heisenberg equates here experience or recognition of nature's beauty with the understanding of nature's phenomena.

> [I]f beauty is recognised as the correspondence of the parts with each other and with the whole, and if, on the other hand, all understanding can only come about through this formal interconnection [*Zusammenhang*], then the experience of the beautiful becomes almost identical to the experience of the understood, or at least sensed [*erahnten*], interconnection [*Zusammenhang*].[332]

In his reflections, Heisenberg further embeds two examples to illustrate his arguments: Kepler's work on the planetary movements and Newton's formulation of mechanical laws. Both examples, he argues, are presented as evidence for the immediate insight into nature, which offers understanding of natural phenomenon that is captured in clear presentations.

> [A] confusing abundance of details was suddenly organised, after years of futile efforts for understanding, when an interconnection emerged that, although abundantly unclear, was ultimately simple in its substance, that immediately convinced through its coherency [*Geschlossenheit*] and abstract beauty.[333]

The role of experience in the production of, in this particular case, a beautiful theory is made explicit in this description: "the soul is startled. It shudders at the sight of the beautiful."[334]

Unlike in the speech from 1973, where he reflects on beauty, Heisenberg invokes beauty in his memoir as an epistemic value in relation to matrix mechanics. In a conversation set at the house of Albert Einstein in 1926, the protagonist, Heisenberg, defends matrix mechanics against the objections of his host. The character Einstein claims that matrix mechanics does not withstand academic rigour: "many and crucial questions remain completely unsolved?"[335] In the defence of the new theory, the

[332] Heisenberg, 'Die Bedeutung des Schönen in der Exakten Naturwissenschaft', 373.
[333] Ibid., 377.
[334] Ibid., 373.
[335] Heisenberg, 'Der Teil und das Ganze', 98.

protagonist invokes beauty as a justification for the theory's validity. A combination of the quality of the formulae and the process of knowledge production.

> I believe, just like You [*Sie*], that the simplicity of natural laws has an objective character that it is not just the result of the economy of thought. If nature leads us to mathematical forms of great simplicity and beauty—by forms I am referring to coherent [*geschlossene*] systems of hypotheses, axioms, etc.—to forms that no one has previously constructed [*ausgedacht*], we cannot help to think [*glauben*] that they are 'true,' that they present [*darstellen*] a genuine feature of nature [*einen echten Zug der Natur darstellen*]. It may be that these forms also cover our relationship to nature, that they include an element [*ein Element*] of thought economy. But the fact that we could never have arrived at these forms ourselves because nature revealed [*vorgehführt*] them to us in the first place suggests that they must be part of reality itself, not just of our thoughts about reality. You [*Sie*] may object that by speaking of simplicity and beauty I rely on [*verwende*] an aesthetic criterion of truth. I must admit that for me, the simplicity and beauty of the mathematical schemes suggested by nature has very great persuasive power. You [*Sie*] must have experienced [*erlebt*] it too, that we are almost startled [*erschreckt*] by the simplicity and coherence [*Geschlossenheit*] of the connections nature suddenly lays out before us and for which we are not prepared at all [...] The simplicity of the mathematical scheme has the further consequence that it ought to be possible to think of many experiments [...] And if the actual experiments should bear out the predictions, there is little doubt but that the theory reflects nature accurately in this particular realm.[336]

The protagonist naturalises the aesthetic qualities of simplicity and beauty of the mathematical formulae by presenting them as qualities given by nature. The objective character of the aesthetic judgments is further emphasised by the explanation that nature leads the researcher to these formulations, which minimise their theory-ladenness.

Moreover, the protagonist suggests an agency of nature as an agency that leads the researcher to the mathematical formulae. We have encountered the topos, in the form of the veil of Isis, of the active, female nature revealing its secrets to the researcher in Section 6.1.1. If we compare the topos invoked in this narration of knowledge production with the topos of the religious experience in Heisenberg's texts (see Section 5.1), we can see that there are clear similarities (e.g., the suddenness,

[336] Ibid., 98f.

the startle, and the guidance located outside of the immanent world). The experience of knowledge serves as a confirmation of the theory of quantum mechanics. While the protagonist defends Heisenberg's work from the 1920s (i.e., matrix mechanics), the use of aesthetic judgments as epistemic values is a characteristic of Heisenberg's research from the 1950s, particularly the *Weltformel*. At the time, Heisenberg invoked symmetry and simplicity in defence of the *Weltformel*, which did not withstand contemporary empirical practices and competed with Einstein's work on a similar theory.[337] Here, the aesthetic judgments are invoked as confirmations for his theory.

The interference between science and religion in the reflection and use of beauty as an epistemic value is further made explicit in the connection of beauty and truth with normative judgments. This connection has a long tradition and can already be found in Plato's work with a Christian reinterpretation in Plotinus' work. In the tradition of pantheistic perspectives of the universe that emanates from the "One," an ideal construction that cannot be captured, and as such is God, remaining greater than the sum of all things in the cosmos.[338] So, when Heisenberg concludes in his speech "On Beauty" that "the central idea is that of the beautiful, the good, in which the divine becomes visible,"[339] he draws on this tradition and, in the context, develops a distinct interference pattern between science and religion.

I showed how Heisenberg reflects on and invokes the aesthetic judgments of simplicity, symmetry, and beauty, which serve as epistemic values in Heisenberg's texts. Beyond their function as epistemic values, the analysis of these three aesthetic judgments shows that they are part of an interference pattern between science and

[337] I'd like to thank Alexander Blum, who pointed out this connection in conversations during my fellowship at the MPI History of Science in Berlin between November 2022 and January 2023. See Blum *Heisenberg's 1958 Weltformel* for an in-depth debate of symmetry in Heisenberg's *Weltformel*, and Borrelli "Symmetry, Beauty and Belief in High-Energy Physics;" Borrelli, 'Poetic Imagination in Scientific Practice'.
[338] William Mander, 'Pantheism,' In *The Stanford Encyclopedia of Philosophy,* (2023).
[339] Heisenberg, 'Die Bedeutung des Schönen in der exakten Naturwissenschaft', 373.

religion. However, in this case and many others of this chapter, the aspect of the interference pattern (whether the communication is religion of science) is not clearly distinct, especially because the traditions they activate (i.e., Neo-Platonism, Pantheism, *Naturphilosophie*, or German Romanticism) are at times part of both. Nonetheless, there are aspects that clearly contribute to the interference. For example, the somatic aspect of the experience of the formulae draws on the topos of the religious experience reinvented by the Romantics. (For further examples, see Sections 7.1 and 7.2).

6.1.2 A New Language

"Poetry" and "poetic language" are recurring notions in Heisenberg's arguments on the epistemological consequences of modern physics. In 1942, Heisenberg dedicates a section to "Language [*Die Sprache*]," in the manuscript "Philosophy." Here, he presents language as a precondition for the scientific study of nature when he describes it as "the form through which human thoughts can be grasp and shared."[340]

In the early 1930s, language was a central topic in Heisenberg's work and, in particular therein, his collaboration with Niels Bohr on the interpretation of quantum theory. While most of the mathematical groundwork for quantum mechanics was laid in the 1920s, much of the interpretations of the new mathematical formulations followed in the decades to come. This is also visible in his popular texts, in which he partially occupied himself with the mismatch between the concepts of Newtonian mechanics and the new knowledge presented by quantum mechanics. This mismatch between the concepts (e.g., objectivity and causality) and knowledge is at the root of

[340] Heisenberg, 'Ordnung der Wirklichkeit (1942),' 222.

Heisenberg's reflection on the use of a "poetic" language through which physicists ought to verbalise the insights of modern physics.

The discussion of poetry as a medium of knowledge production in Heisenberg's texts draws on a central point of *Naturphilosophie*. The Romantics and *Naturphilosophen* proposed and used poetry as a form through which to study and understand nature. Building on the notion of poetry as "the language of the universe," they sought a richer understanding of nature as a whole, which can be observed, for example, in Goethe's literature and study of nature. [341] In Heisenberg's writings, the connection between poetry and knowledge production is present in Heisenberg's speech "The Goethean and the Newtonian Theory of Colour in Light of Modern Physics" from 1941. He invokes the idea of poetry as a viable medium of knowledge production. Unlike, the intellectual study of nature with theories or the practical study of experiments, poetry is presumed to render nature intelligible through an immediate understanding involving the whole bio-somatic apparatus of the researcher.

> [I]t is probably more accurate to assume that all truly great *Naturphilosophen* were also familiar with the sphere of poetry. In any case, it has also been the aspiration of physicists to trace [*nachspüren*] the harmonies of natural phenomena [in *die Harmonien der Naturereignisse*]. Conversely, it would be a mistake [*Irrtum*] to think that the poet Goethe was more interested in evoking a vivid impression [*lebendige Eindruck*] of the world than in gathering actual knowledge [*wirkliche Erkenntnis*]. Already, all truly great poetry conveys real insight into areas of the world that are otherwise difficult to recognise [*erkennenbar*], and even more so a work such as the Theory of Colours is intended to convey new knowledge and is written with every claim to scientific accuracy.[342]

Beyond that, the sensing of nature is presented as a way to gain genuine understanding of difficult subjects. As such, the study of nature becomes a method of uncovering the secrets of nature.

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[341] von Stuckrad, *The Scientification of Religion*, 454.
[342] Werner Heisenberg, 'Die Goethe'sche und die Newton'sche Farbenlehre im Lichte der Modern Physik', 152.

Furthermore, the connection between science and poetry is developed on the level of the researcher. Goethe's literary and scientific work play a central role in Heisenberg's interpretation of poetry as a tool for research and the identification of the vitality of nature. In particular, Goethe's critique of the materialist (i.e., positivist) approaches in modern science, because of the renunciation of the vitality of nature, features as early as 1932 in Heisenberg's writings. In the speech from 1932 "On the History of the Physical Explanation of Nature," Heisenberg references Goethe's *Theory of Colour* and his critique of a materialist science, which he associates, just like Goethe, with Newtons optics.

> This renunciation of liveliness [*Lebendigkeit*] and immediacy [*Unmittelbarkeit*], that has been the prerequisite for the progress of natural science since Newton, also forms the real reason for the bitter battle [*Kampf*] that Goethe waged in his *Theory of Colour* against Newton's physical optics. It would be superficial to forget this battle as unimportant; there's a good reason why one of the most enlightened men [Menschen] put all his energy into fighting against [*kämpfen*] the progress of Newtonian optics. If Goethe can be accused of anything, it is only a lack of the ultimate consequence; he should not have fought against Newton's *view*s, but should have rather stated that all of Newton's physics–optics, mechanics, and the law of gravitation–came from the devil [*vom Teufel abstammt*].[sic!] Conversely, it is a clear sign of the power and inner consequence of the abstract science that it has always continued to develop in the same direction, despite all objections.[343]

While Heisenberg acknowledges the advancement of modern science, his critique focusses on the observable material of the world. In the tradition of Goethe's *Naturphilosophie*, Heisenberg calls for a phenomenological approach to nature, which seeks to offer a holistic view of a phenomenon like light. Focused on the observation of visible phenomena, Goethe situated his theory of colour in opposition to Newton's study on the mathematical description of light. Goethe's critique of Newtonian mechanics is explicit in Heisenberg's objection of Newtonian physics, in particular his laws of gravity and, by extension, the method of scientific research. However, Heisenberg's agreement with Goethe's call to recognise the liveliness of nature and

[343] Heisenberg, 'Zur Geschichte der Physikalischen Naturerklärung', 58f. italic in the original.

study it through immediate experience does not lead to a full rejection of Newtonian physics; he highlights the importance of abstraction and distance from the immediate experience.

In the manuscript *Philosophy*, Heisenberg delves into the opposition between these two approaches to studying nature through the problem of using language. He explicitly discusses the opposition between the clear and precise language of modern science and poetic language (or poetry). Similar to the critiques of *Naturphilosophers*, Heisenberg claims that mathematics and the precise language of modern science are characterised by a renunciation of the vitality of nature.

> The words of such an artificial language [*Kunstsprache*], in contrast to the words of ordinary language, only refer to very specific areas of interconnections [*Zusammenhangsbereiche*]. The part of reality, depicted by the artificial language, that is 'essential' for the adopted scientific standpoint, may appear unimportant from other points of view. This representation of a part of reality, which was previously described as 'static' is thus unavoidably linked to a heavy [s*chwerwiegend*] renunciation [*Verzicht*]: the renunciation of the infinitely manifold relatedness of words and concepts, which only awakens in us the feeling of having understood something of the infinite abundance [*Fülle*] of reality.[344]

The description of the language of physics building on Newtonian mechanics is thus characterised by the renunciation of the abundance of reality to achieve an artificial language, leading to a static language. Through abstraction, worlds are only artificial, only meaningful in certain settings. This static language stands in opposition to a language that is, like poetry, characterised by abundance. He suggests that only this abundance makes understanding possible through feelings rather than through intellect. The ambiguity of words taps into the emotional and somatic aspect of understanding, evoking the feeling of understanding.

[344] Heisenberg, 'Ordnung der Wirklichkeit (1942)', 224.

The idea of nature as an organic, active entity is explicit in Heisenberg's explanation about dynamic language.

> The 'static' can only be contrasted with another kind of representation of reality, which is only made possible by the infinite multiplicity of words and which can be described as 'dynamic.' In it, the expressed thought should not be a potentially true representation of reality, but it should form the seed [*Keim*] for further lines of thought; it is not the precision but the fruitfulness [*Fruchtbarkeit*] of the concepts that matter. [...] the fullness of content of the space traversed by the thoughts subsequently creates a faithful image of the intended realm of reality. This type of representation is based on the vitality of the word.[345]

The vitalist idea of nature can be observed in the organic vocabulary, relying on terms like "seeds" and "fruitfulness" used to describe the language, and ultimately culminates in the organic idea of nature, *natura naturans*. Heisenberg claims that the dynamic language not only facilitates a deeper understanding of nature but also offers a more accurate vocabulary to represent living nature. Because of its vitality, the ideas expressed in the language outgrow their initial spaces and context.

Heisenberg's explicit reference to and praise of poetry and Goethe *Naturphilosophie* contributes to the interference between science and religion insofar as he suggest a medium for knowledge production that transcends the entwined practices of observation, quantification, and theorising of the material nature.[346] Later in the manuscript *Philosophy*, Heisenberg suggests that it is the formal aspect of the poetry that makes it a suitable form to speak about the mathematical structures at the core of theoretical physics.

> Even poetry seeks to convey knowledge of reality [*Erkenntnis der Wirklichkeit*]. Its representation always bears dynamic character [...] This binding of the concepts in a formal—in the most general sense, mathematical— connection is what poetry has in common with the completed [*vollendet*] forms of the representation labelled as 'static.' Poetry stands, so to speak, at the point where the extremes touch [*berühren*]: on the one hand,

[345] Ibid.
[346] Walter D. Wetzls, 'Johann Wilhelm Ritter: Romantic Physics in Germany,' *In Romanticism and the Sciences*, edited by Andrew Cunningham and Nicholas Jardine (1990), 199–212, 205; Dennis L. Sepper, 'Goethe, Colour and the Science of Seeing,' In *Romanticism and the Sciences*, edited by Andrew Cunningham and Nicholas Jardine (1990), 189–198, 189.

> the thinking that is purely determined by its content and fully using the vitality of the word, and on the other hand, the relationship between concepts developed through a strictly mathematical scheme.[347]

In the tradition of the Romantics, Heisenberg presents poetry as a form of knowledge production. It is not only the (mathematical) structure but also the ambiguity of poetry that is associated with the potential for a genuine study and an immediate understanding of nature. Consequently, the reflection on the benefits of a poetic language contributes to development of an interference pattern between science and religion, as it pleads for a language that stands in the *longue durée* of Romanticism and the immediate connection to nature through experience rather than for a propositional study based on experiments and logic.

In the manuscript *Philosophy*, this immediate understanding of nature through the senses that Goethe associated with poetry is made explicit in a discussion of the potential of poetry for contemporary physics. In particular, the notion of poetry transcends everyday language because its meaning is not confined to individual words; rather, it emerges from the interplay of context and the ambiguity of the word— all the while using a formal structure.

> The poet can express thoughts that can no longer be expressed in ordinary language precisely because the words receive a new meaning through the context in which they stand, through the resonance [*Mitschwingen*] of other ideas, through the poetic form of the sentence.[348]

In turn, the logic of "ordinary language" used by scientists is presented as restrictive.

Heisenberg suggests that it is the interplay of ambiguity and formal structure poetry that holds the potential for knowledge production.

> That is why every genuine philosophy stands on the threshold between science and poetry. The great philosophers have always been aware of the 'floating' character of all knowledge [...] also why the deepest knowledge is finally expressed in a parable.[349]

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[347] Ibid., 225.
[348] Heisenberg, 'Ordnung der Wirklichkeit (1942)', 223.
[349] Ibid., 288f..

What is further noteworthy of Heisenberg's reflection on poetry is the universalising claim about knowledge. Similar to his claims about the religious experience (see Section 5.1), he suggests that ordinary language suspends an understanding of the most fundamental knowledge. The production of knowledge is, in this case, no longer the result of cognitive work but of the psychosomatic experience of understanding.

At the same time, Heisenberg's claims about poetic language has consequences for the ideal of scientists. The idea of poetry as a medium of knowledge production is entwined with the ideal of the researcher as a man with an appropriate amount of sensitivity, a form of genius with an immediate connection to nature.[350] In the memoir, the protagonist associates this ability of the physicist to sense and thus understand the workings of nature but to not present it clearly and relying on parables to make it explicit.

> Quantum theory is such a wonderful example of how it is possible to understand a subject with complete clarity and yet at the same time know that one can only speak of it in images and parables.[351]

The concrete example of how poetry may inform the work of physicists brings quantum mechanics and the Romantic concept of poetry together. For the interference pattern between science and religion, poetry is a mode of gaining insight into nature and ultimately making knowledge production an experiential practice.

A decade earlier, in *Physics and Philosophy*, Heisenberg suggests that the use of poetic language by physicists is a consequence of quantum physics, particularly the uncertainty principle.

> [I]nterpretation of quantum theory has encouraged the physicist to use an ambiguous rather than an unambiguous language, to use the classical concept in a somewhat vague manner in conformity with the principle of

[350] Schmidt, *Die Geschichte des Genie–Gedankens,* 10–30.
[351] Heisenberg, 'Der Teil und das Ganze', 285.

> uncertainty, to apply alternatively different classical concepts which would lead to contradictions if used simultaneously.[352]

From an aesthetic perspective, the two languages hold different qualities—one clearly useful for definite descriptions, and the other one fruitful, able to represent the creative aspects of nature.

This claim builds on the observation that the existing language, coined by Newtonian mechanics, no longer fits the concepts and insights gained by quantum mechanics, where "common concepts cannot be applied to the structure of the atoms."[353] While the precise language used by classical mechanics continues to be valuable, it does not capture the insights of particle physics and thus leads the formerly precise language to become metaphorical: "This use of language is in many ways quite satisfactory, since it reminds us of a similar use of the language in daily life or in poetry."[354] He concludes that the language used for classical mechanics cannot be adapted to meet the new insights, "We must keep in mind this limited range of applicability of the concepts of classical mechanics while using them, but we cannot and should not try to improve them."[355] Rather than an cognitive creation of a new language,[356] Heisenberg suggest that a suitable language will emerge by itself: "One should simply wait for the development of the language which adjusts itself after some time to the new situation."[357] In the meantime, physics relies on parables and allegories to speak about the new theories formulated using the abstract and precise language of mathematics.

Heisenberg's discussion of poetry is an important aspect of the role of religion in his writings. The call for poetry as a means for knowledge production activates ideals

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[352] Ibid., 122.
[353] Heisenberg, *Physics and Philosophy*, 121.
[354] Ibid., 123.
[355] Ibid., 14.
[356] Neurath, 'Unified Science and its Encyclopaedia.'
[357] Heisenberg, *Physics and Philosophy*, 119.

of *Naturphilosophie* and, in particular, the interference between science and religion. With his presentation of poetry as a practice and form of knowledge production, knowledge production is presented as involving feelings and the experience of an immediate insight. The reference to poetic language is part of the epistemological interpretation of quantum mechanics. I showed that Heisenberg suggests that poetry presents an immediate access to nature and complete knowledge. Furthermore, in the context of these reflection on the language, we can observe how Heisenberg actualises the concept of the *natura naturans*. As a result, he develops an alternative to materialist science, built on classical mechanics and the observer-independent ideal of objectivity. The call for poetry as a form and practice for knowledge production is tied to the challenges of making sense and expressing the new knowledge of quantum mechanics. While I looked at the way this contributes to the interference pattern between science and religion (analysed in Section 5.3.2), the use of a poetic language in and for modern physics plays a central role in Heisenberg's renegotiation of the complementary relationship between science and religion.

6.2 Conclusion

In 1931, two years before winning the Nobel Prize for Physics, Heisenberg published an article, "Problems of modern Physics [*Probleme der modernen Physik*]" (1932), in the German newspaper *Berliner Tageblatt*. In the article, he explained how quantum mechanics changed the epistemological foundations of the study of the atom and, more broadly, of contemporary science. One claim he makes in the article is that quantum mechanics changed the relationship between physics and other academic disciplines, such as philosophy, chemistry, and astronomy.

> In the last years, physicists were forced to do philosophy, in particular to conduct some epistemology [...] The research of physics branching into the area of philosophy has come to an end in the last two years.[358]

I showed in this chapter that Heisenberg combines different traditions, such as pantheism and Neo-Platonism, for his wider epistemological and ontological interpretations of modern physics. The impulse for these interpretations in his texts is the interpretative opening presented by quantum mechanics paired with a critique of a positivistic science associated with Newtonian mechanics. This opening leads to an imagination of an alternative science that is characterised by the combination of three concepts and ideas transported by *naturphilosophische* and Romantic studies of nature. I found that the first concept of "unity" or "unification" is related to four problems: the structure of scientific disciplines; the interpretation of nature as a whole building on the idea of nature as *natura naturans*; the pursuit of one unifying theory; and the international understanding among cultures. In four cases, the observation or pursuit of unity serves a solution for the epistemological and social problems Heisenberg identifies.

For the second idea, I found that Heisenberg's use of and reflection on aesthetic judgments (i.e., simplicity, symmetry, and beauty) is tied to the problem of (seemingly) underdetermined theories of modern physics (i.e., quantum mechanics and unified field theory). As a result, these aesthetic judgments serve as epistemic values to confirm the theories. Lastly, Heisenberg's reflection on the potential of poetry for science is equally tied to a problem, namely, the discrepancy between the new theories and the conceptual framework of classical mechanics. Moreover, the potential Heisenberg identifies with poetry exceeds the new medium for knowledge production that facilitates an immediate understanding of the whole of nature.[359] Consequently,

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[358] Heisenberg, 'Probleme der modernen Physik', 49.
[359] Keren Gorodeisky, '19th Century Romantic Aesthetics', In *The Stanford Encyclopedia of Philosophy*, (2016); von Stuckrad 'Naturwissenschaft und Religion.'

Heisenberg's employment of Neo-Platonic ideals, Romantic aesthetics, or pantheistic *Naturphilosophie* contributes to observable interference patterns between science and religion, where religion serves as an interpretative framework for the epistemological void left by the newly formulated quantum mechanics.

So, **while** Heisenberg suggests in the article from 1932 that the philosophical work surrounding modern physics will soon come to an end, my analysis demonstrated that the article only references the philosophical work Heisenberg would go on to engage after 1940.

Chapter 7 Religion and Presentations of Knowledge Production

A central theme of Heisenberg's popular writings is the production of (new) knowledge. The discussion on and presentation of knowledge production shapes his reflection on science initiated by modern physics. In his texts, Heisenberg distinguishes between two main practices of knowledge production—understanding and predicting—which he relates to two traditions of physics: respectively, theoretical and experimental. By focusing on the arguments and the aesthetic repertoires involved in Heisenberg's reflection on science, I show how he develops a hierarchy between understanding as the main aim of science and predicting and problem solving as a less important part of knowledge production.

With the focus on religion, I analyse in this chapter how Heisenberg's discussion and presentation of knowledge production use, actualise, and change ideals and aesthetic repertoires of *Naturphilosophie* and Romanticism. Moreover, I incorporate the analytical category of scientific masculinity to study how the ideal of knowledge production presented in the texts constructs and presents theoretical physics as a male discipline, dominated by the physicist who best embodies the Romantic genius.

In Section 7.1, I discuss the presentation of understanding of nature as the main aim of science. By taking a closer look at the aesthetic repertoire, specifically the allegories and description of psycho-somatic shifts accompanying the presentation of both practices, I show that the texts develop a hierarchy between understanding and predicting. I then continue the analysis, in Section 7.2, with a focus on the aesthetic repertoire of Heisenberg's texts. This focus shows how the narration of knowledge production is coupled with particular topoi of encounters of nature. Standing in the tradition of the (religious) experience at the centre of the Romantic religion (see Section 5.1), the topoi of encountering nature (e.g., through mountaineering, *terra incognita*,

or the experience of nature) draw on the concept of a *natura naturans* (see Section 6.1.3) and ultimately present knowledge production as an immediate experience of the creative forces of nature and insight into the mathematical structures governing natural phenomena. Moreover, these topoi are focal for the construction of the physicist's masculinity as an active man (climbing mountains and discovering new lands) who is at the same time sensitive enough to experience nature.

In Section 7.3, I turn to analyse the presentation of the history and institutions of knowledge in Heisenberg's texts. In emphasising how the development of physics is presented in Heisenberg's texts, I show how physics is constructed as a primarily male discipline. Consequently, the use of the concept and aesthetic repertoire of immediate and absolute grasp of nature in the reflection and presentation of knowledge production proves to be an important pattern of interpretation for science communication and the *imaginaire* of the physicist as a Romantic genius.

7.1 'Understanding:' Discussions on Knowledge Production

"Understanding [*verstehen*]" holds a central place in the reflection on scientific practices in Heisenberg's texts. While "understanding" becomes only a key term in the book *Physics and Philosophy* from 1956*,* similar claims and ideas appear in Heisenberg's texts as early as the 1940s.

In Chapter 6, I showed that the grasp of the simple structure underlying natural phenomena is a central claim in these documents. In this section, I show that this grasp of the whole of nature with simple formulae is focal for Heisenberg's description of the aim of science as understanding nature. Beyond these claims of what is understanding as a practice of knowledge production,[360] understanding is explicitly juxtaposed with

[360] See for an Integrated History and Philosophy of the concept and idea of understanding in science, Henk W de Regt, *Understanding Scientific Understanding* (Oxford: Oxford University Press 2017).

the practice of "predicting [*berechnen*]" and experimenting, in Heisenberg's texts. These juxtapositions make clear that understanding is not only a cognitive practice of knowledge production but is further a somatic experience, unlike predicting and experimenting.

In this section, I focus on the reflection of understanding as a central practice of knowledge production that is set in opposition to predicting. In so doing, I show how Heisenberg draws on ideas and concepts that stand in the tradition of *Naturphilosophie*. For example, at the turn of the 19th century, *Naturphilosoph*er, such as von Goethe pursued the understanding of a phenomena in whole, which they set in opposition to the materialist pursuit of the empiricists at the heart of the Enlightenment.[361] This opposition between the two practices and research traditions translates further into the juxtaposition of theoretical and experimental physics, a dichotomy that continues to structure contemporary physics. In Heisenberg's texts, the link between the two distinctions guides not only the critique of the materialist science encountered in Sections 5.2.3 and 6.1, but also a reflection on the true practice of physics.

In the book *Physics and Philosophy*, the practice of physics is first presented as a combination of experimental work and theorising on the basis of the experiments using a distinct, but unspecified language.

> Our scientific work in physics consists in asking questions about nature in the language that we possess and trying to get an answer from experiments by the means that are at our disposal.[362]

The work of physics is a dynamic relationship between investigative questions about natural phenomena and experimentation. Both are conducted with the framework of the existing language and experimental tools.

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[361] Keren Gorodeisky, '19th Century Romantic Aesthetics'.
[362] Heisenberg, *Physics and Philosophy*, 25.

Two years later, in the speech "The Abstraction in Modern Science" from 1960, both the experimental and theoretical approaches are combined to fulfil the ambition of science.

> Thereby, the force fields can be transformed into one another; their inner interconnection [*Zusammenhang*] can be recognised immediately [*unmittebar*] in the experiment. Then, it only remains for the physicist to formulate the laws of nature, according to which the transformation of elementary particles takes place [...] But for our considerations the details are not important; in principle, the interrelation [*Zusammenhang*] between the various physical areas [*physikalischen Bereichen*] seems to have been clarified by the experiments of the last ten years; we believe that we can recognise [*erkennen*] the outlines of the uniform physical structure of nature.[363]

The goal of science is to recognise the inner workings of a phenomena, exemplified in the research activities of contemporary physicists as part of the investigations of particles. To achieve this understanding, the formulation of the laws is preceded by experiments. In the case of forces, the interconnections were easily recognised in the experiments, encouraging the theoretician to work on the formulation of the laws. The experimentalist work paved the way to understand different areas of physics, because based on the results from the experimentalist, the outlines for a new theoretical structure were visible, but had yet to be formulated.

The idea of the knowledge production in physics as an integration of experimental and theoretical work can also be observed in the question-and-answer section of the speech "Theory, Criticism, and a Philosophy" from 1968. Heisenberg describes the integration of empirical and theoretical work as a pivotal step to the formulation of general laws. The integration is accompanied by the challenge of specialisation.

> I can only speak about that prescription which I have always used. This was that one should not stick too much to one special group of experiments one should rather try to keep in touch with all the developments in all the relevant

[363] Heisenberg, 'Die Abstraktion in der modernen Naturwissenschaft', 320.

> experiments so that one should always have the whole pictures in mind before one tries to fix a theory in mathematics or other languages.[364]

Here the aim is to get a picture of the whole by paying attention to different experiments, which presents the foundation for a theory formulated in mathematics. The proposal to integrate a variety of data in order to formulate a new theory, follows the idea of an inner unity. This unity can be described through mathematical formulae. To succeed in that mission, the theoretician has to pay attention to developments in experimental physics.

In the memoir we can observe the need for the confirmation of theories by experimentation. The character Einstein points to the theory-burden of observation.

> Only the theory decides what can be observed [...] Only the theory, that is the knowledge of the laws of nature, allows us to deduce the underlying process from the sensory perception [*sinnliche Eindruck*].[365]

The character suggests that any observation is burdened by theory, the observation and results drawn from it depend on the theoretical premise of the experiment. Furthermore, not only do the observations depend on the theory, but so too does the deduction of new knowledge through experimentation. On the other hand, the extent of the interplay between theory and experiment becomes evident a couple of pages later. Einstein insists on the confirmation of a theory through experimentation, "'The control through the experiment' Einstein suggests, 'is naturally a trivial condition that a theory is correct."[366]

In the memoir, it is the character Wolfgang Pauli who suggests in a rhetorical question that the interaction between experimental and theoretical work are crucial for the advancement of science.

> Do you mean that physics does not only include experimenting and measuring, on one hand, and an apparatus of mathematical formulae, on the

[364] Heisenberg, 'Theory, Criticism, and a Philosophy', 438.
[365] Heisenberg, 'Der Teil und das Ganze,' 92.
[366] Ibid., 99f.

> other hand, but also that at the juncture [*Nahtstelle*] of both real philosophy has to be practiced?[367]

The reflection on beauty in the speech "The Meaning of Beauty" from 1974 (see Chapter 5) is also tied to the distinction between an empirical and a theoretical mode of knowledge production. The argument suggests that a balance between the two modes is most productive for the advancement of science. However, the description of this balance activates the ideas of vitalism as well as the distinction between the meticulous work and creative practices.

> the contrast between the empiricist, who first creates the preconditions for an understanding of nature through careful and conscientious [*gewissenhaft*] painstaking work [*Kleinarbeit*], and the theorist, who designs [*entwerfen*] mathematical images [*Bilder*] according to which he orders nature and tries to understand it—mathematical images, which prove to be the ideas, underlying the natural events [*Naturgeschehen*] not only because of the correct representation of experience but above all through their simplicity and beauty [...] The pure mathematical speculation becomes infertile [*unfruchtbar*] because it doesn't find its way back from the play with the abundance [*Fülle*] of possible forms to the few forms after which nature is really built. The pure empiricism becomes infertile because it suffocates [*ersticken*] in endless tables with no inner coherency [*Zusammenhang*]. Only through the tension, through the play between the abundance of facts and the potentially suitable mathematical forms, can the deciding advances arise.[368]

The empirical work is characterised by precision and detail-orientation. Presented as the legwork of the theoretician, it is at the same time a precondition, and only one step towards the real work. Standing in opposition, the theoretical work is presented as a creative task of designing images and ordering phenomena, which leads to the understanding of a phenomena. This understanding touches on the true ideas, which underlie the phenomena studied by the empiricist. The creative aspect is emphasised with the reference to aesthetic values of beauty and simplicity, which confirm the correctness of the mathematical laws, or images of the theoretician. The theoretician

[367] Ibid., 283.
[368] Heisenberg, 'Die Bedeutung des Schönen in der exakten Naturwissenschaft', 374f..

works best when ordering the individual phenomena to one (or just a few) general laws. This elevates the empiricist's work to another level.

Along with the arguments on interdependence of experimental and theoretical work, Heisenberg's texts also develop a hierarchy between these two practices: with the process of understanding on one hand, and predicting, explaining, and applying on the other. It should not come as a surprise that understanding and the formulation of mathematical theories is presented as the main practice in the texts of theoretical physicists. In the memoir, it is a combination of somatic states and allegory that reinforces a hierarchy between the process of understanding and predicting or the theoretical and experimental work respectively.

In the chapter, "The Concept of 'Understanding' in Modern Physics [*Der Begriff 'Verstehen' in der Modernen Physik*] (1920 until 1922)," the character Wolfgang Pauli describes understanding as involving both, somatic changes along with the cognitive work of understanding itself.

> Understanding' must mean quite generally: having ideas, concepts with which one can recognise a great abundance of phenomena as uniformly interrelated [*zusammenhängend*] and that means to 'grasp [*begreifen*]' them. Our thinking calms down [*berruhigt sich*] when we realised that a particular, seemingly confusing situation [*Situation*] is only a special case of something more general that can be formulated in a simpler way. The reduction of the colourful diversity [*bunte Vielfalt*] to the general and the simple, or let's say in the terms of your Greeks, the 'many' to the 'one', is what we describe with 'understanding'[369]

On the semantic level, understanding is presented as a henological reduction of "the many" to "the one" simplified theory, invoking the pantheistic idea of nature as well as the monism we came across in Section 6.1. Along with the epistemological arguments and ontological claims, understanding is associated with a somatic shift, of calming

[369] Heisenberg, 'Der Teil und das Ganze,' 53.

down. This shift reinforces the reduction of a “confusing state” and “colourful diversity” to the simple and general.

The somatic aspect of understanding can be further observed in the protagonist's explanation of his understanding of the theory of relativity, “You could say I understand the theory with my brain but not with my heart.”[370] Here, the protagonist suggests that full understanding involves the body and cannot be reached with the cognitive faculties alone. He continues to explain that understanding involves a somatic experience, “we get the feeling that we have ‘understood’ [the unified connection].”[371] As such, the process of understanding nature is affective and not a purely cognitive work.

In another conversation with the character Einstein, the protagonist gives a more specific account of the feeling that is involved in understanding and which again once more in the differentiation between the recognition of simple laws and the solving of mathematical problems.

> The feeling [*Gefühl*] that comes over us at such a sight is yet completely different from the joy [*Freude*] we feel when we think that we completed a task of (physical or non-physical) craftsmanship [*Handwerksarbei*t] particularly well.[372]

Here two different emotions are involved with the two kinds of work. The feeling of the sight of a simple formulation is accompanied by a feeling that overcomes the physicists, the emotion of joy for solving a calculation has a limited scope unclear here. Similar to the religious experience (see Section 5.1) the feeling is characterised as a different kind, almost an emotion *sui generis* that overcomes the scientists. Joy on the other hand is associated with an active completion of a piece of work. This active work of the scientists is reinforced with its association with craftsmanship. This association

[370] Ibid., 48.
[371] Ibid., 52f.
[372] Ibid., 99.

of physics with craftsmanship appears already in the manuscript *Philosophy* from 1941. Heisenberg uses a similar conceptual pair of experimental and mathematical work. Similarly, the experimental work is characterised as "the specialised craftsmanship [*handwerkliches Können]*, the virtuoso." The description of the theoretician's work of formulating mathematical laws invokes the idea of an encounter with nature, a central term of *Naturphilosophie*. It is the theoretician who "traces [*nachfühlen*] the detail in a tender way to recognise the finest traits of nature in one small area and structures it systematically."[373] The work of the theoretician combines the sensual practice of tracing characters of nature.

The hierarchy between the tracing of nature by the theoretician and craftsmanship of the empiricists is reinforced with the uses of the allegory by Friedrich Schiller, "When kings go a-building, waggoners have more work." It is the character, Arnold Sommerfeld, a theoretical physicist and the protagonist's supervisor, who links the allegory to the theoretician; and experimentalist Sommerfeld who encourages the protagonist to pursue theoretical physics, "from what you have told me, I take it that you are much keener on theory."[374] However, he suggests that Heisenberg has first to learn the craftsmanship of mathematics and experimenting with the note that "[a]t first, we are all waggoners!"[375] The protagonist associates the work of the kings with the theoretical physicists, such as Bohr and Einstein, whose work produced "petty problems" that are solved by the waggoners through diligent work of predicting and experimenting. The idea of predicting being secondary to theoretical work is reiterated in the statement by the character, Wolfgang, "[t]he ability to predict is often the consequence of understanding."[376]

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[373] Heisenberg, 'Die Einheit des Naturwissenschaftlichen Weltbildes', 167.
[374] Heisenberg, 'Der Teil und das Ganze,' 31.
[375] Ibid., 32.
[376] Ibid., 53.

Despite his keen interest in theoretical work, Sommerfeld suggests that the protagonist ought to focus first on detailed problems before pursuing his interest in more theoretical work. In his explanation, Sommerfeld distinguishes once more the two forms of research, "even if you study theory, you will have to pay particular attention to what may appear as trivial little tasks."[377] The study and solving of "many petty problems" precede the theoretical work because their solutions "only present in their entirety [*Gesammtheit*] an image of the newly explored area."[378] Heisenberg mentions that he used to build devices during his adolescence but points out that he struggled with the necessary diligence to conduct "precise measurements."[379] He rather emphasises his conviction for the theoretical work, "But I'm possibly more interested in the philosophical questions, which lie behind than the single petty problems."[380] To encourage Heisenberg, Sommerfeld reassures the protagonist that he will enjoy the solving of the petty problems, "you will get pleasure from performing minor tasks carefully and conscientiously and, let's hope, from achieving decent result."[381] Similar to the example discussed earlier, the solving of detailed problems is associated with pleasure, with the problems being characterised as minor tasks.

[377] Ibid., 31.
[378] Ibid., 32.
[379] Ibid., 31. The perception of Heisenberg's relationship to experimental work has been formed by two anecdots. The first anectode tells the story of Heisenberg's disinterest in experimental physics. Heisenberg coined the anecdote himself for example in an interview with Thomas Kuhn from 1962/3 in which he recounts his poor results in the experimental side of his doctoral studies and exam conducted under Wilhelm Wien. Heisenberg, Thomas Kuhn and John Heilbron, Werner Heisenberg – Session 1, November 30, 1962, In *Niels Bohr Library and Archive*s. For an analysis of these interviews see te Hessen, *Revolutionäre im Interview.* His limited interest and training in the experimental work however did not keep him from working on the German nuclear weapons program. The second anecdote was coined by Heisenberg's biographers and which juxtaposes the first one. Becker, for example uses a picture in which Heisenberg sits in a vehicle next to his brother and his nephew. The vehicle is serving the biographers as a confirmation for Heisenberg's early interest and talent in (theoretical) physics. Considering the protagonists claim that he had neither talent nor interest in the experimental side of physics, it is evident that the narrative is a construction of the biographers, Becker, *Die Gruppe Heisenberg,* 8.
[380] Ibid., 32.
[381] Ibid., 32.

In the speech "Scientific and Religious Truth," the hierarchy between the two kinds of work is also present, but with a different terminology.

> Many philosophers and theologian had talked a lot about the great interconnection [*grossen Zusammenhang*] there was little new to be said [...] But the details of natural phenomena [*Naturgeschehen*] had been barely researched. This was work to which many lesser spirits [*kleinere Geister*] could contribute and—there was also the consideration that knowledge of details had some practical use.[382]

I showed that the juxtaposition of the two research practices of understanding and predicting or experimenting has two sides. On the one hand the texts repeatedly suggest that the two practices complement one another in the process of knowledge creation. On the other hand, the texts develop a clear hierarchy between understanding and predicting. The hierarchy is developed mostly by the aesthetic repertoire. It is the somatic changes that accompany both practices of knowledge production that sets them apart beyond the different knowledge they produce. The somatic change of understanding is more profound and shows similarity with the religious experience (see Section 5.1) than the joy associated with calculating and experimenting. Moreover, Heisenberg's association of the theoretical physicists, who seeks a deep understanding of nature with kings and the association of the experimentalist and problem solving with waggoner and lesser spirits clearly develops theoretical physicist as the supreme discipline, or like the German saying 'the discipline of the king [*Königsdiziplin*].'

7.2 'Encounters with Nature': Presentation of Knowledge Production

The aesthetic repertoire of encounters with nature plays a central role in the narration of knowledge production in Heisenberg's popular writings. These encounters with

[382] Heisenberg, 'Naturwissenschaftliche und Religiöse Wahrheit', 425.

nature show great resemblance with the aesthetic repertoire of the (religious) experience seen in Section 5.1. These encounters are present in the topoi of mountaineering, the *terra incognita*, or the experience of knowledge. Encounters with nature as forms of knowledge production and perceiving nature are crucial to the formation and self-fashioning of Romanticism and *Naturphilosophie*. The different encounters of nature stand in a *longue durée* of the religious experience coined by the Romantics.

In this section, I focus on four topoi of the aesthetic repertoire of the presentation of production of knowledge. First, the topos of mountaineering as a domination of nature draws attention to the laborious work involved in the encounter with nature and the self-fashioning of the mountaineer as a man who faces and survives danger. Closely entwined with the topos of mountaineering is the second topos of the *terra incognita.*[383] The *terra incognita* describes the imagination of an empty land that is free to be discovered and conquered.

While these two topoi activate the idea of nature as a place to be dominated, the third topos of the experience of nature imagines and presents the encounter with nature as an epiphany of the creative forces of nature (described in Section 6.1.3). I will show, through the link of knowledge production with the topos of the experience of knowledge in Heisenberg's texts, that the production of new knowledge (e.g., matrix mechanics) becomes an experience of knowledge. In the fashion of the Romantics, the encounter with nature, in particular the attempt to dominate nature as is the case in mountaineering, mirrors the internal conflict of the mountaineer (or, in this case, the

[383] I chose to translate "*unendliche Neuland*" as "*terra incognita*" rather than as the more common "infinite virgin territory" or "virgin soil," because the German original does not have any sexual connotation akin to the metaphor of the virgin. Heisenberg rarely uses sexual metaphors, apart from the distinction "fertile [*fruchtbar*]" and" infertile [*unfruchtbar*]" (Heisenberg, 'Die Bedeutung des Schönen in der exakten Naturwissenschaft,' 374f.). Furthermore, the original does not have distinct connotations of ownership or relationship to a sovereign state, whereas the term territory does.

physicist). This conflict, and its vanquishment, is the fourth topos. In Heisenberg's texts, the conflict is mirrored by the physical exhaustion and the battle against illness. As I will show, this topos of exhaustion is entwined with the topos of the caring wife, and as such, both breaks and sustains social ideals and structures of knowledge production.

The analysis of these four topoi shows how an aesthetic repertoire standing in the tradition of the Romantic religion shapes the narratives of knowledge production along with the scientific masculinity of the Romantic genius.

7.2.1 Mountaineering

The first link between mountaineering and knowledge production can be found in the last paragraph of the speech "Goethean and Newtonian Theory of Colour in Light of Modern Physics" from 1941. In this paragraph, Heisenberg compares the mountaineer's ambition and success in climbing the mountain top with the scientist's aim and work to seek out the mathematical structures of nature (see Sections 6.1.3 and 6.2.1). In the tradition of mountaineering as a form of dominating and controlling the power of nature, the scientists much like the wanderer overcomes the difficulties of his trait to reach new heights.

> But we might compare the natural scientist who leaves the realm of living observation in order to understand the great interconnections [*Zusammenhängen*] with a mountaineer who wants to conquer the highest peak of a massive mountain range in order to overlook the land below him in all its interconnections [*Zusammenhängen*]. The mountaineer, too, must leave the fertile valleys inhabited by people. The higher he climbs, the wider the land opens up to his gaze, but the sparser the life that surrounds him becomes. At last, he reaches a blindingly clear region of ice and snow, where all life has died out and where he himself can only breathe with great difficulty. It is only through this region that the path leads to the summit. Yet up there, in the moment when the whole land lies spread out beneath him in its fullest clarity, he is perhaps not too far from the living realm. We understand when earlier times perceived those lifeless regions only as a dreadful wasteland, when entering them appeared to be a violation of the

> higher power, which were likely to take bitter revenge on anyone who dared to approach them. Goethe, too, felt the hurtfulness of natural science's approach. But we may be sure that the poet Goethe was also entirely familiar with the ultimate and purest clarity to which this science aspires.[384]

At the beginning of the paragraph, Heisenberg links the work of the natural scientists and the practice of the mountaineer through the comparison that both follow the ambition to gain new insight. The scientist aims to understand and to see the great interconnection of nature, whilst the mountaineer seeks the interconnection of geography by overlooking the land. In order to reach the interconnection both have to leave the realm of the living behind. It is only through the laborious ascent that the mountaineer reaches the summit and with it greater insight.[385] The labour and embodied experience of the ascent is made tangible with the description of the danger of the sparse land is placed in opposition to the vitality of the valley that the mountaineer leaves behind in order to gain a new perspective of it. The aesthetic registers of clear ice and snow reinforce the bio-somatic experience of the difficulty to breath. The combination of the absence of live and the experience of suffocation gives form to the danger involved in the ascent that is further intensified by the potential of the revenge of a higher power. Once the summit is reached the mountaineer is rewarded with a new perspective of the landscape, the fullest clarity over the valleys. For the Romantics, this view represented more than a new perspective it further presented the possibility "of transforming the self and the selves relation with the world."[386] As for the scientists, the comparison with the mountaineer asserts the masculine identity of the scientist as a man of action who is able and willing to overcome danger for the pursuit of new knowledge. In order to attain new knowledge,

[384] Heisenberg, 'Die Goethe'sche und die Newton'sche Farbenlehre,' 160.
[385] Simon Bainbridge, *Mountaineering and British Romanticism. The Literary Cultures of Climbing 1770–1836*, (Oxford: Oxford University Press 2020), 117.
[386] Ibid., 117.

the physicists, much like the mountaineer, transgress "the border of bodily exhaustion," the laborious ascent and inner struggles to reach now hights.[387]

The paragraph closes by bringing the mountaineer's success back together with the scientist's success to gain new and clearer insight into the natural or nature. Consequently, the topos of mountaineering draws attention to the embodied experience of knowledge production while presenting the scientists success to gain new knowledge as a domination of nature.

7.2.2 *Terra incognita*

The scientist and the mountaineer encountering and dominating nature is closely related to the topos of the terra incognita, the unknown land. In Heisenberg's texts, the terra incognita is linked to the areas and phenomena of nature that have yet to be rendered intelligible by the scientist. In the topos of mountaineering, the terra incognita appears as the wasteland, the lifeless regions that have to be overcome reach the top and gain a new perspective of fruitful lands below. Beyond the topos of mountaineering, the *terra incognita* is explicitly related to imperial practices. In the speech "Goethean and Newtonian Theory of Colour", Heisenberg draws a connection between the scientists like him who were involved in the formulation of modern physics, and men who conquered lands.

> The march [*Fahrt*] to foreign lands and treasures can only come to its natural end once all countries have been explored [*erforscht*] and their treasures distributed [...] Similarly, science and technology will develop in our time. Just as no border posts [*Grenzstein*] could hinder the march into foreign lands, the path of technology will not be held back by external obstacles. Only nature itself can stop this active advance into its most remote areas by demonstrating to us that the land to be conquered [*zu erobernde Land*] is not infinite. It is perhaps the most important feature of modern physics that it helps us to see clearly the limits of our active engagement with nature.[388]

[387] Von Stuckrad, 'Mountaineering,' 1119.
[388] Heisenberg, 'Die Goethe'sche und die Newton'sche Farbenlehre,' 156.

The paragraph connects science and technology with the imperial practice of conquering lands and colonial practices of exploiting resources. Like the imperial endeavour, the scientist's domination of nature cannot be held back by ethical and social values (see Section 5.3) but rather by the limitation of nature and resources. Unlike foreign lands, which were an imagined *terra incognita* to conquerors and explorers, Heisenberg attests that nature is in fact a creative force that can stop the advancement of scientists. From this personification of nature, Heisenberg concludes that modern physics must recognise the creative force of nature, and with it the limits of the scientist's ability to dominate nature.

In the speech "The Unity," Heisenberg presents the achievement of the early modern scientists as the discovery of the *terra incognita* of nature and with it the potential to render the infinite territory intelligible and ultimately dominate it.

> Unlike Kepler, the natural scientist of the early eighteenth century is no longer close to the goal of grasping the divine plan of creation and bowing in reverence before the unveiled sanctuary, but he stands at the gate [*Eingangstor*] to an infinite new territory whose boundaries are nowhere to be seen[389]

The practices of modern science stand at the beginning of this new land. No longer the sanctuary of early modern scholars, nature is interpreted as the playground of the scientists. While Kepler's study of nature focused on the visible movements of the celestial objects, the phenomena studied by modern physicists were only visible through technological mediation. This translates into the Heisenberg's interpretation of modern physics as the pursuit of an infinite land that is set in opposition to an inquiry into nature shaped by pursuit of God's plan.

The link between scientific and imperial practices is even more explicit in the memoir's chapter "Departure for the New Land (1926–1927)." Here the research and

[389] Heisenberg, 'Die Einheit des Naturwissenschaftlichen Weltbildes,' 165.

achievements of modern physicists is associated with the exploration of Christopher Columbus.

> If I were asked what Christopher Columbus' greatest achievement was in discovering America, [...] His most remarkable feat was the decision to leave the known regions of the world and to sail westward far beyond the point from which his provisions could have got him back home again.
>
> In science, too, it is impossible to open up new territory unless one is prepared to leave the safe anchorage of established doctrine and run the risk of a hasardous leap forward.[390]

The idea of the *terra incognita* served men such as Columbus and empires like Spain in their ambitions to claim land, despite it being populated by natives. The link between scientists and these overtly imperial endeavours develops the image of the scientist as a masculine hero, a man of action, who successfully overcomes the odds, dears to leave the known land, and makes nature his own. Scientific practice here becomes a question of dominating nature, with the ideal of nature as an artefact in the tradition of the *natura naturata*.

7.2.3 Experience of Nature

Another central mode of encountering nature through mountaineering and beyond is given form in the experience of nature. Unlike the topos of domination, the experience of nature includes descriptions of the meeting with nature as an epiphany of nature's sacred dimensions. While we have come across reflections on knowledge production as the sight of the one structure of nature in Section 6.1, in this section, I focus on the aesthetic repertoire involved in the presentation of such moments of knowledge production in the texts. In these cases, knowledge production comes together with the

[390] Heisenberg, 'Der Teil und das Ganze', 101.

religious experience in the tradition of the modern aesthetic religion coined by the Romantics, like Schleiermacher (see Section 5.1).

The first example of such an experience of knowledge can be found in the chapter "Quantum Mechanics and a Talk with Einstein (1925–1926)." In the chapter, the protagonist recounts a central moment of his research in the formulation of quantum mechanics activities the encounter of nature as a revelation to which we may also refer to as a "breakthrough." This breakthrough set during a research leave to the island of Helgoland in the early summer of 1925 is repeatedly linked to a hike in the Austrian mountains during the fall of 1924. The hike is recounted as an encounter with nature, activating the topos of experiencing nature as depicted by the painting "The Wanderer over the Sea of Fog" (c 1818) by Casper David Friedrich where the clear view of the landscape remains withdrawn from the observer by the fog. Throughout the chapter this hike is linked to the research the protagonist is conducting and leads to the formulation of matrix mechanics. In the opening paragraph of the chapter, the link between the two storylines is.

> If I think back on the state of atomic theory in those months, I always remember a mountain walk with some friends from the Youth Movement, probably in the late autumn of 1924.[391]

Following the introduction of the chapter's subject and linking the hike and his research in quantum physics, the protagonist goes on to recount the hike in detail. The combination of aesthetic qualities like "gloomy weather" with somatic responses like feeling "anxious" makes the hike an affective experience, at the end of which the living beauty of nature is revealed behind the clouds to initiate a feeling of connectives.

> In the valley the weather was gloomy, the mountains were veiled in clouds, and during the climb, the mist begun to close in on us. After a while, we ended up in a confused jumble of rocks and slopes with no sight of the track. We

[391] Heisenberg, 'Der Teil und das Ganze,' 86. The notes of a fellow scout, Eberhard Rüdel, confirms the hike, including the rainy weather and the sunshine at the top, in Becker, *Die Gruppe Heisenberg,* 339f..

> tried to gain some height, though we felt rather anxious if we would find our way back in case anything went wrong. All at once the mist became so dense that we lost sight of one another completely and could keep in touch only by shouting. At the same time, it grew brighter overhead, and the light suddenly changed colour. We were obviously under a field of moving wafts of mist. Then, quite suddenly, we could see the edge of a steep rock face, straight ahead of us, bathed in bright sunlight. The next moment the fog had closed up again, but we had seen enough to take our bearings from the map. After a further ten minutes of hard climbing, we were standing in the sun on a saddle [*Sattlehöhe*] above the sea of fog [*über dem Nebelmeer*]. To the south we could see the peaks of the Sonnwend Mountains and beyond them, in full clarity, the snowy tops of the Central Alps, leaving no doubts about the further ascent.[392]

The group starts their climb of the Guffert mountain in the valley. In the valley the weather is gloomy, cloudy, and misty. During their ascent the mist grows closer, veiling everything and making orientation by eye difficult. The obscurity is emphasised by the need to navigate by sound and accompanied by the feeling of anxiety. Despite the difficulty, the group continues to ascend. The ascent is accompanied with light coming from above. This state is interrupted by the sudden parting of the fog revealing a steep cliff lit by the sun, which despite disappearing again offers guidance. The group rises out from the fog to the middle of a saddle pass. They can see where they came from, overlooking the fog and the Alps. Standing in the sunlight the view is clear, in opposition to the mist of the ascent. Romantic authors in particular describe encounters with mountains as an epiphany of the sacred dimension of nature, its living beauty condensed in the *natura naturans.*[393] In many cases, the revelation of the sacred dimension of nature is accompanied with the description of how overlooking the land from above offers a new perspective. This topos has been put on canvas by Friedrich and since the painting "Wanderer over the sea of fog" became a paradigmatic image of the Romantic longing for the infinite. In the painting the central figure of the wanderer orders and mediates the view over the landscape. With his back to the

[392] Heisenberg, 'Der Teil und das Ganze,' 86f.
[393] Joan Steigerwald, 'Romanticism in European History,' In *The Encyclopedia of Religion and Nature*, ed Bron Raymond Taylor and Jeffrey Kaplan, (London: Thoemmes Continuum 2005), 1419–1422.

observer, the wanderer reminds us of the sublime and the longing for unity with the infinite. The landscape is partly veiled by the fog which heightens the role of the imagination and renders the scene insubstantial by eradicating the connection with the ground. As we have seen in Section 5.1, for Schleiermacher religion is interpreted through experience and in particular the experience of the infinite.

The scene of the experience of nature is followed by an interlude about the protagonist's research. In the interlude, the protagonist goes on to relate the experience of being lost in the fog but on the ascent to the state of his research before he left for Helgoland.

> Apparently, in the winter of 1924-1925, particle physics had already reached the area, where the fog impenetrably thick [*undurchdringlich dicht*], in the area where it, so to speak, already started to get brighter above us. The differences in brightness heralded the possibility of decisive insights [*Durchblicke*].[394]

Through the link, the state of modern physics is illustrated. It becomes relatable to a reader who has no knowledge and understanding of the detailed problems of quantum mechanics. Rather, it becomes evident that the physicists struggled to orientate themselves. The protagonist describes the state of his research by drawing on the aesthetic repertoire of the hike, "I ended up in an impenetrable thicket of complicated mathematical formulas, with no way out."[395] In this paragraph the protagonist links particle physics, the hike in the Alps, and the trip to Helgoland. For a detailed discussion of the link between knowledge production and the topos of exhaustion with Helgoland see the Section 7.2.4.

The account of the stay on the island of Helgoland on the coast of Germany is the central moment of knowledge production in the memoir. Like the physicists, the

[394] Heisenberg, 'Der Teil und das Ganze,' 87
[395] Ibid., 87.

protagonist Heisenberg sought out the island to cure his hay fever.[396] The work the protagonist conducts during this stay leads to the seminal papers on matrix mechanics. Here the topoi of the experience of nature are entwined with the production of knowledge to become the experience of knowledge.

> At the end of May 1925 [...] I wanted to travel to Helgoland [...] Apart from daily walks and long swims, there was nothing in Helgoland to distract me from my problem, and so I made much swifter progress than I would have done in Göttingen. A few days were enough to jettison all the mathematical ballast [...] and to arrive at a simple formulation of my problem. When the first term confirmed the energy principle, I was agitated [...]. Since the results presented themselves without any effort, I could no longer doubt the mathematical consistency and coherence of the indicated quantum mechanics. At first, I was deeply startled [*zutiefst erschrocken*]. I had the feeling that through the surface of atomic phenomena [...], I was looking at an underlying ground [*Grund*] of strange inner beauty. I felt almost giddy at the thought of the wealth of mathematical structures, I now had to pursue. I was far too excited to sleep. So, I left the house at dawn and headed to the southern tip of the Oberland, where a lone rock jutting out into the sea had always whetted my desire for climbing. I managed to climb the tower without too much trouble and awaited the sunrise on its top.
>
> What I saw during that night in Helgoland was admittedly not very much more than the sunlit rock edge I had glimpsed at in the autumn of 1924.[397]

The passage about the breakthrough in Helgoland stretches over two pages in which we can find different narrative registers. Starting with the descriptions of the circumstances and his mode of working, the protagonist goes on to explain the mathematical problem he is trying to solve which then turns into a figure of sensation which culminates in the momentary experience of knowledge, in particular mathematical structures.

The change of registers to sensation stands in the tradition of the "modern aesthetic religion" for which Schleiermacher paved the way with his re-definition of

[396] Heisenberg's escape to Helgoland to recover from a hay fever attack in June of 1925 is documented in letters to his mother. The letters further document severe hay fever attacks over the year and the different treatments Heisenberg sought. Heisenberg writes to his mother on June 5th,.1924 "I have neutralized my hay fever with aspirin" or a day later June 6th, 1924 "in this dreadfully beautiful weather, I'm eking out my miserable existence on aspirin, cocaine and similar stuff" both are edited in Hirsch-Heisenberg, *Liebe Eltern!*, 74–75.
[397] Heisenberg, 'Der Teil und das Ganze,' 89ff.

religion as “sensing and feeling” and an “intuition of the universe.” The somatic changes and affective language of this passage presents the moment of knowledge production as one of “overwhelming sensations.”[398] The topoi of the experience of nature turns here into the experience of knowledge, serving here as confirmation for the validity of his work. In the conversation with Einstein, the protagonist describes the experience in the following way “nature leads us to mathematical forms of great simplicity and beauty.”[399] Here the combination of sensations, such as effortlessness and immediacy as well as aesthetic judgments of beauty and location of the theories present non-epistemic values of knowledge production.[400] The experience develops a correspondence between the hidden forces of nature, here the beautiful ground and mathematical formula, on one side and the imaginative genius within the human, that come through in the absence of worldly distractions. Similar to the experience of nature in the mountains, the encounter with nature is framed by the longing for unity with the infinite. Set in train by the sight from the balcony and the awaiting of the sunrise the longing for unity is an individual experience.

The protagonist's contribution to the formulation of quantum mechanics is presented as a highly individual experience of immediate cognition, through the reference to an aesthetic repertoire of sensory changes and aestheticisation of nature. Heisenberg’s narration of his breakthrough includes bio-somatic modes of feeling “startled,” “dizzy,” or “too excited to sleep”, accompanied by aesthetic judgments of “beauty” and “simplicity” or the breakthrough of the surface of atomic phenomena. Furthermore, Heisenberg parallels cognition with the experience of nature. In addition

[398] Grieser, ‘Blue Brains,‘ 258.
[399] Heisenberg, ‘Der Teil und das Ganze‘, 98–99.
[400] Roony, ‘The Borderlands Between Epistemic and Non-Epistemic Values,’; The aesthetisation of the mathematical formulae gives a form to the structural realism observed in Heisenberg’s texts, see Camilleri, *Heisenberg and the Interpretation of Quantum Mechanics*.

a rhetorical shift from bodily agony, stagnation, and high contemplation to the effortless calculation of results is reinforced by another anecdote. Too excited to sleep after he reaches a solution to the mathematical problems at three in the morning, Heisenberg recounts how he painlessly climbs a lone rock jutting out into the sea, to await the sunrise. In his eyes, the effortless calculation and unveiled beauty of the "simple" formulation vouch for the accuracy of quantum mechanics, while conveying the immediacy of cognition.[401] Similarly, the final result casts any doubts aside of the "construction of a closed and mathematically sound structure" of modern physics.[402] Ultimately, he ties the hyper-subjective cognition back to the social certification of academic knowledge, when illustrating the intensive work back in Göttingen of editing his initial calculation for publication.[403] Through this narrative structure, Heisenberg embeds his perception and achievements in a Romantic aesthetic and the paradigmatic topos of overlooking the sea of fog.

The individuality of this moment of knowledge production stands in contrast to the premise of the memoir that "science is created in conversations."[404] The premise of science as a collaborative practice is emphasised by the presentation of the memoir as conversations. This ideal however does not apply to Heisenberg's breakthrough in quantum mechanics. While the experience of knowledge stretches over two pages, the collaboration between Heisenberg, Max Born, and Pascal Jordan that lead to the publication of the three seminal papers is explicitly excluded: "Of the extremely intensive work which kept us breathless for a few months I won't report."[405] The focus of the individual experience of knowledge as the key moment of knowledge production

[401] Heisenberg, 'Der Teil und das Ganze,' 89.
[402] Ibid., 90.
[403] Ibid., 89.
[404] Ibid., 9.
[405] Ibid., 90.

is key for the ideal of the Romantic genius. The German Physics Society and the Max Planck Institute for Theoretical Physics erected a stone in June 2000 on Helgoland to commemorate Heisenberg's breakthrough in modern physics.[406]

The experience of the sunrise appears already in a speech from 1967, titled "Goethe's Image of Nature and the Technical-Scientific World." Here Heisenberg offers an interpretation of von Goethe's poetry, in particular the experience of the sunrise not only as a religious experience but further as a part of knowledge creation.

> It was not the experience of nature by the individual, as much as it had filled him as a young man, that was important to the older Goethe, but rather the divine order that is recognisable in this experience. For Goethe, it is not just a poetic metaphor when, for example, in the poem 'Understanding Old Persian Faith,' the believer is moved by the sight of the sun rising over the mountains to 'recognise God on his throne [...]' Goethe believed that the scientific method must also adapt to this subject of the experience of nature, and thus the search for the primordial phenomenon [*Urphänomen*] is to be understood as research [*Forschen*] into the structure underlying the phenomenon, which is set by God.[407]

In the paragraph, Heisenberg refers to von Goethe and verse from the East-Western Diwan. Heisenberg reflects on the link von Goethe develops between the experience of nature and the method used to study nature. The experience is made out as a central aspect of research. Here Heisenberg uses and combines von Goethe's work with Schleiermacher's concept of religion as the experience of the infinite. First, it is linked to the structural realism in Heisenberg's work, the idea of a structure that underlies the phenomena (see Sections 6.1.3 and 6.2.1). Second, the experience of the sun rising over the mountain is presented as the recognition of God. Within the linkage between the experience of nature and the method of science, the sight of the sunlight mountains is part of the process of knowledge production, as presented in the memoir.

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[406] The Inscription states "In June 1925, here on Helgoland, the 23-year-old Werner Heisenberg made the breakthrough in the formulation of quantum mechanics, the fundamental theory of the laws of nature [*Grundlegenden Theorie der Naturgesetze*] in the atomic realm that has profoundly [*tiefgehend*] influenced human thinking far beyond physic."
[407] Heisenberg, 'Das Naturbild Goethes und die Technisch-Naturwissenschaftliche Welt', 402f.

The presentation of the formulation of quantum mechanics as an experience of knowledge stands in contrast to the descriptive narration of the same event in the book *Physics and Philosophy*. Unlike the hyper-individual experience in the memoir, Heisenberg recounts the formulation of matrix mechanics as an impersonal development with the focus on the technical details.

> The precise mathematical formulation of quantum theory finally emerged from two different developments. The one started from Bohr's principle of correspondence [...] The idea suggested itself that one should write down the mechanical laws [...] as equations for the frequencies and amplitude of their Fourier expansion [...] This plan could actually be carried out in the summer of 1925 it led to a mathematical formalism called matrix mechanics or, more generally, quantum mechanics.[408]

In this presentation, Heisenberg's role in the formulation of the matrix mechanics is absent. Furthermore, the focus on the technical details presents it as a cognitive work, a plan that was followed and through which the results were reached suggesting a clear path by which new knowledge is produced, in the absence of the exhaustion and excitement he experienced.

These two narratives tell a different story about how ground-breaking; Nobel-prize winning knowledge is produced. As I will show in Section 8.4, it is the experience of the matrix mechanics that shaped the scientific persona of Heisenberg as well as the actualised scientific masculinity of the Romantic genius for theoretical physicists in the late 20th century. The topos of immediate experience and sensibility towards the natural world are heightened by the commitment to the ideals of science regardless of the sacrifices.[409] The link between the experience of nature and the production of knowledge is an important topos of the scientists relationship with nature as a means to witness the transcendence.[410] Heisenberg's immediate cognition of the beauty and

[408] Heisenberg, *Physics and Philosophy,* 9.
[409] Jan Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820,* (Chicago: University of Chicago Press 1992), 19.
[410] Hampton, *Romanticism and the Re-Invention of Modern Religion*, 7.

mathematical structures of nature collapses the subject-object difference[411] upheld by classical mechanics.[412] This translates to his scientific persona, as Carson argues the collapse between subjective and objective helped to popularise Heisenberg's writings and persona. His "bourgeois sensibilities" and presentation of "private roots" appealed to a post-War audience, which was sceptical of both "inhuman scientists"[413] and "the aristocratic ideal of masculinity."[414] Heisenberg balanced the subjective angles with a self-restrained corporality and professorial voice, which vouched for the objective character of his speeches.[415] This collapse of the subjective and objective is at the centre of the experience of knowledge. The experience of knowledge combines the religious experience (see Section 5.1) with the idea of the *natura naturans* (see Chapter 6) which leads to a sacralisation of nature as well as the presentation of knowledge production as an experience of knowledge.

7.2.4 Exhausted by Research

The topoi of knowledge production as encounters with nature are also a means to overcome not only the cognitive but also the psychosomatic limits of a person. As such knowledge production, much like mountaineering, means to transgress bodily exhaustion in order to gain a fuller understanding of nature and one's capacities.[416] In the memoir, I identified find three moments where bodily exhaustion, in the form of illness, accompanies the process of coming to knowledge. In all three cases of exhaustion from intensive research, the exhausted physicists are shepherded by

[411] Johnston, 'A Historiography of Aesthetics in a Western Context', In *The Bloomsbury Handbook of the Cultural and Cognitive Aesthetics of Religion*, edited by Anne Koch and Katharina Wilkens, (London: Bloomsbury 2019), 13–22, 78.
[412] Daston and Galison, *Objectivity*.
[413] Carson, *Heisenberg in the Atomic Age*, 143.
[414] Mosse, *The Image of Man*, 7.
[415] Carson, *Heisenberg in the Atomic Age*, 143; Coen, *Vienna in the Age of Uncertainty*, 352.
[416] Von Stuckrad, 'Mountaineering,' 1119.

women and wives. As such they show the presence of women in the production of knowledge, however only in the role of assistance.

The breakthrough on Helgoland discussed in the last section is facilitated by the protagonist experiencing an attack of hay fever during his time as an assistant of Born at the University of Göttingen, where he is struggling with the mathematics of a physics problem[417] because of which he leaves for the island Helgoland in the North Sea.

> My work was advanced rather than retarded by an unfortunate personal setback. Toward the end of May 1925, I fell so ill with hay fever that I had to ask Born for fourteen days' leave. I wanted to go to Heligoland, where I hoped to recover quickly in the bracing sea air, far away from blossoms and meadows. On my arrival I must have looked quite a sight with my swollen face; because upon taking a look at me, my landlady [*Hauswirtin*], concluded that I had been in a fight and promised to nurse me through the aftereffects.[418]

Hay fever is an allergic reaction to pollen, thus occurring mostly in spring and early summer, causing cold-like symptoms such as runny nose, sneezing, fatigue, or swollen skin under the eyes. The physical agony of the hay fever is presented as a blessing for his intellectual work, as the physical symptoms justify him taking a break from Gottingen and his academic duties to escape the pollen. He seeks recovery on an island with fresh air and a landlady who offers her support based on his swollen face. Once indicated, the landlady's role in supporting his recovery does not recur in the chapter. The exhaustion, physical agony becomes a catalyst for Heisenberg's breakthrough. In the absence of the city and the symptoms, under the care of a landlady the research advances seemingly by itself.

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[417] Heisenberg's escape to Helgoland to recover from a hay fever attack in June of 1925 is documented in letters to his mother, along with severe hay fever attacks over the year and different treatments, "For today, I have neutralized my hay fever with aspirin" (Heisenberg to his mother 5.6.1924) or "in this dreadfully beautiful weather, I'm eking out my miserable existence on aspirin, cocaine and similar stuff" (Heisenberg to his mother 6.6.1924 in Hirsch-Heisenberg, *Liebe Eltern*, 74f.)
[418] Heisenberg, 'Der Teil und das Ganze,' 88.

The second case of exhaustion and care follows in the chapter "Departure for the New Land (1926–1927)." Following Heisenberg's and Bohr's publication of seminal papers on the interpretation of quantum mechanics in 1926 and 1927, the character Bohr has intensive discussions with Erwin Schrödinger. Set in Copenhagen, in these discussions Bohr defended his interpretation of quantum mechanics against Schrödinger's objections. In the midst of the discussions Schrödinger falls ill.

> The discussion went on for many hours of the day and night without an agreement being reached. After a few days, Schrödinger fell ill [...] Mrs Bohr nursed him and brought tea and cake, but Niels Bohr sat on the edge of the bed and spoke to Schrödinger.[419]

The intensive discussions between the two characters results in Erwin Schrödinger's exhaustion. This exhaustion is embodied through him falling ill. Despite Schrödinger's exhaustion, Bohr continues the conversations. With Schrödinger lying in bed and Bohr sitting on the edge of the bed, the conversations become one sided, with Bohr speaking to, rather than with Schrödinger. Throughout all of this, Margarethe Bohr takes care of her husband's visitor. Like the conversations between the physicists, the conversation between Erwin Schrödinger and Niels Bohr does not result in a breakthrough like Heisenberg's exhaustion.

The most prominent scene of bodily exhaustion in the memoir features once more the protagonist. During his collaborative work on the *Weltformel* with Wolfgang Pauli in the 1950s, the protagonist falls ill. While being nursed by his wife, Heisenberg continues to work. Here the scene of exhaustion and caring is combined with military metaphors.

> At the same time, my health deteriorated once again, to the extent that the doctor advised me to leave Göttingen and to let Elisabeth look after me, in Ascona on Lake Maggiore, until I had fully recovered. My correspondence with Wolfgang from Ascona remains a most painful memory. Both sides fought remorselessly and struggled with the utmost mathematical efforts for clarity. At first, my proof was not yet fully clear and Wolfgang could not see what I

[419] Ibid., 109.

> was getting at [...]. But I could not give in here, and although my illness kept flaring up and causing dizzy spells and depression, I wanted to penetrate to complete clarity. Finally, after almost six weeks of extreme exertion, I managed to break through Wolfgang's defence [...] On the way back from Ascona, I had to get a thorough check-up at the university clinic in Zurich. I took the opportunity to meet with Wolfgang, which went very peacefully, so that in the end all Wolfgang could say was 'boring agreement'. This brought the 'Battle of Ascona', as we later jokingly referred to our correspondence, to a close and it was decided.[420]

The paragraph links Heisenberg's wellbeing with his research on what will be known as the *Weltformel*. The severity of his physical state is emphasised by the doctor's order to take a break at the lake. Under his wife's care the protagonist is able to continue his research despite his ill health. The research and his health are intractably linked. With the lack of progress leading to his mental and physical state deteriorating, Heisenberg struggles to share his vision in the letters to Pauli. Heisenberg's pursuit of mathematical clarity is presented in opposition to dizzy spells and depression he experiences. The protagonist's recovery and his research are paralleled, with both becoming a fight. It is one of the few occasions that Heisenberg uses a military language. The breakthrough in research becomes a breakthrough in the defences of Pauli, which culminates in a harmonious reconciliation and a follow up at the doctor's.

The three moments present knowledge production as a transgression of the border of the body and uphold the *bürgerliche* role model of the caring wife. As such the scenes present the physicist as a person who goes through any length, even putting his health at risk, to gain new knowledge. With the female characters taking over the roles of carer, they pave the way for the physicist's recovery and thus their research. Although they play a part in the process of knowledge production, their role and work become an invisible precondition for the 'real' work of the physicist.

[420] Ibid., 306.

7.3 Histories of Modern Physics

Historical narratives are central to Heisenberg's reflections on religion and his discussion of science. In the introduction to the book *Physics and Philosophy*, he claims that history is a suitable medium through which to present physics, particularly the new knowledge of modern physics, to a lay audience.

> The best way to enter into the problems of modern physics may be a historical descriptions of the development of quantum theory [...] it is in quantum mechanics that the most fundamental changes with respect to the concept of reality have taken place [...] The change into the concept of reality manifesting itself in quantum theory is not simply a continuation of the past; it seems to be a real break in the structure of modern science.[421]

As such, historical narratives become media through which to present the development of physics and to establish the radical novelty of quantum mechanics. While I showed in Section 5.3.1 how Heisenberg uses history to bust the myth of conflict between science and religion, I focus in this chapter on how history further serves as a strategy to develop the legitimacy of theories in addition to the scientific authority of their author, Werner Heisenberg.

First, I discuss the presentation of the history of physics as a genealogy dating back to antiquity. The narrative strategy of the genealogy is prevalent in the book *Physics and Philosophy,* where Heisenberg continuously relates problems and achievements of modern physics to philosophical works from antiquity. These links between contemporary research and past work legitimise contemporary research, suggest a sense of destiny, and present recent achievements as progress.[422] Furthermore, such genealogies are important devices in establishing and maintaining the ideal of physics as a discipline of and for great men.

[421] Heisenberg, *Physics and Philosophy*, 2.
[422] On the device of the narrative strategy of history, see Kostas, 'Onwards facing backwards.'

Second, I analyse how Heisenberg uses the topos of the Socratic dialogue to tell the recent history of modern physics (1919–1960) in his memoir. The conversations that unfold in the memoir, taking place between the protagonist, Heisenberg, and various other characters like his colleague, Wolfgang Pauli, suggest an intimate knowledge of modern physics and manifest a masculine ideal of physics. These dialogues are undertaken in different places, such as on hikes or in lectures, and use affective language, with descriptions of the scenery and the protagonist's somatic responses. Serving as a narrative strategy, these dialogues establish Heisenberg's authority as a physicist by focusing on his active engagement in the production of the new knowledge of modern physics. With the analytical concept of scientific masculinity, the interesting aspect of such histories is how they develop and maintain physics as an all-male space that fosters distinct masculinities. Consequently, these narratives shape the cultural *imaginaire* of theoretical physics as a masculine discipline and the theoretical physicist as a genius.

7.3.1 Genealogies

Up until now, we have come across the use of histories as a way to myth-bust the conflict thesis (see Section 5.3.1) or develop a legitimacy for aesthetic judgments, such as beauty (see Section 6.2.1). In these examples, Heisenberg develops an explicit genealogy of science or physics dating back to early modernity and even to antiquity. In this section, I show that the developed genealogy develops a legitimacy for his wider interpretations of modern science (see Chapter 6 and Section 7.1).

In 1932, Heisenberg gave a speech titled "On the History of the Physical Explanation of Nature" at a public session of the Saxonian Academy of Science in Leipzig. As the title announces, the text focuses on the historical development of

physics and opens with a reference to antiquity. The story told in the speech draws a line between contemporary research and the work of the ancient philosophers, Leucippus and Democritus.

> The exact natural science [*exakte Naturwissenschaft*] of the last 30 years has been coined by the fact [*erhält dadruch ihr besonderes Gepräge*] that its various branches [*Zweige*], Astronomy, physics, and chemistry can be traced back to their common root [*gemeinsame Wurzel*] in atomic physics and that, to a certain extent, many of the wishes with which Leucippus and Democritus approached the study of nature have been fulfilled.[423]

Heisenberg presents the research in particle physics as the emancipation of ancient *Naturphilosophie* as well as the impulse for the renegotiation of the connections between different disciplines, as discussed in Section 5.1. By connecting the the advancement of modern physics with 'the wishes' of ancient philosophers, Heisenberg legitimises his research with the historicity of the questions. Furthermore, the presentation of solutions to these questions become even greater achievements because of the time it took to solve them.

The genealogy presented in the speech, beginning with Leucippus and Democritus, continues with the investigations into matter led by the philosophers Thales, Parmenides, Empedocles, and Anaxagoras.[424] Heisenberg then turns to opposing works on space by Plato and Aristotle,[425] which builds the foundation for the next step in his history of physics: the departure from Aristotle to Plato in early modernity. It is Galileo' s work on gravity and planetary movement that marks the beginning of early modern research. Followed by the studies of Copernicus and Newton, Heisenberg suggests that the novelty of Galileo's work was its focus on abstract conditions, for example, the fall of bodies in a vacuum. With his focus on the mathematical laws describing natural phenomena, Galileo presents a turn towards

[423] Heisenberg, 'Zur Geschichte der Physikalischen Naturerklärung', 50.
[424] Ibid., 52.
[425] Ibid., 53.

Plato: “The starting point of Galileo’s physics is abstract and stands in the tradition that Plato sketched for science.”[426]

It is thus demonstrated that, according to Heisenberg, the formulation of laws describing natural phenomena is the main work of science. In the genealogy, Copernicus and Newton are presented as the reference point for the formulation of simple laws, which were said to govern physical phenomena and thus are the standard of a physicist’s work.[427] This ambition, to find and formulate simple laws, shaped the presentation of the practice of science after the Second World War, as I have shown above (see Section 5.3).

Yet another competition marks the next step of the development of science, that between Newton’s and von Goethe’s research on optics (for an in-depth discussion of this competition in Heisenberg’s texts, see Section 5.2). Maxwell’s work on optics, together with Newton's work on mechanics, are presented as marking the end of the respective fields and, together with chemistry, the beginning of revisiting the “problem of matter” encountered in antiquity: “to tackle this problem, which the Greeks had begun to solve, anew with the newly acquired tools.[428] The genealogy of physics ends with Niels Bohr’s contribution to the contemporary state of particle physics.

Similar genealogies shape the narrative of Heisenberg’s texts over the next forty years. In the Romano Guardini Prize speech from 1973, called “Scientific and Religious Truth,” the introductory paragraph is followed by a historical outline of early modern science, starting with “the discoveries of Copernicus, Galileo, Kepler, Newton.”[429] It is not so much the research of these four men that Heisenberg credits with the development of modern science, but their ingenuity in drawing on the work of Aristotle,

[426] Ibid., 56.
[427] Ibid., 57.
[428] Ibid., 59.
[429] Heisenberg, ‘Naturwissenschaftliche und Religiöse Wahrheit’, 423.

Plato or Ptolemean.[430] It is the work of Kepler and Galileo that Heisenberg discusses in further detail: Kepler's reflection on the process of knowledge creation and Galileo's entanglement with the inquisition (see Section 5.3.1).

Overall, the history of science presented in the speech develops a genealogy of theories and scholars dating all the way back to antiquity. Such genealogies are powerful narratives in shaping the idea of a discipline and establishing a tradition. With the history of physics presented as a long line of male actors, the institutions and the canon are materialising physics as a "masculine discipline."[431] Furthermore, by placing contemporary research in a history, the new theories, such as quantum mechanics or the *Weltformel,* are bestowed with the legitimacy of the genealogy. This legitimacy results from the inevitability suggested by these histories, which leave out failed research and alternative theories.[432] Ultimately, they serve as a powerful tool to legitimise the status quo and imagine the future of the discipline.

7.3.2 Socratic Dialogues

The topos of the Socratic dialogue structures Heisenberg's memoir. Announced in the memoir's subtitle "Conversations in the Area Particle Physics [*Gespräche im Umkreis der Atomphysik*]," narrative form of conversations stands in the tradition of Socratic dialogue. Written by Plato in the fourth century BCE, the Socratic dialogue denotes a corpus of philosophical writings about moral and philosophical problems. The writing coined the genre of conversational prose, in which different characters and the protagonist discuss various topics. Over the last two millennia, Plato's account of the

[430] Ibid., 424.
[431] Schnicke, *Die männliche Disziplin*.
[432] Tampakis, 'Onwards Facing Backwards.'

Socratic dialogue has left a mark on the intellectual history of the West,[433] as demonstrated here by Heisenberg's memoir.

Unlike many of Heisenberg's more descriptive texts that omit the author's role in formulating quantum mechanics, the memoir revolves around the authors partaking in the development of modern physics: "[t]his book is about the development of nuclear physics over the last 50 years as experienced by the author."[434] With the announcement that the memoir recounts the authors experience, Heisenberg insinuates an intimate knowledge of modern physics and its recent history. Strung together without character development, the author, who is also the narrator and the protagonist, recounts individual events that are set in different places and times, e.g., on hikes or in lecture halls and decades of the 20th century. Every conversation begins with a depiction of the setting and, together with the dialogues, forms a portrait of the academic and *bildungsbürgerliche* milieux the author, Heisenberg, was a part of.

To study the role of the memoir in the construction of Heisenberg's scientific persona and his masculinity as a Romantic genius, I suggest we try to understand the book as a piece of autofiction,[435] which opens up the text to a "double reading" useful for dissecting the fictional and factual elements of Heisenberg's accounts as well as recognising transition between the elements. Until now, biographers, historians, and philosophers used these conversations to illustrate historical events or Heisenberg's genius. The double reading recognises how the memoir constructs Heisenberg's scientific persona and with it a distinct masculinity of the theoretical physicist as a Romantic genius. The protagonist's conversations with different characters are pivotal for these constructions as well as the transition between factual and fictional. Along

[433] Richard Kraut, 'Plato,' In *The Stanford Encyclopedia of Philosophy,* (2022).
[434] Heisenberg, 'Der Teil und das Ganze,' 9.
[435] Stefan Iversen, 'Transgressive Narration: The Case of Autofiction,' In *Narrative Factuality a Handbook*, edited by Monika Fludernik and Marie-Laure Ryan, (Berlin/Boston: de Gruyter 2020), 555–564.

with the protagonist, the characters, such as Arnold Sommerfeld, are modelled after historical figures[436] that played a more or less intimate role in the author's biography. While most of the conversations and events in the memoir coincide with historical data, the double reading forces us to analyse the protagonist, the characters, and the events as fictionalised versions of history that, in return, shape the view on historical actors and events.

In the introduction, Heisenberg makes it explicit that the memoir is not a verbatim recount of the recent history of modern physics. He opens the introduction with a quote from the "Pericles's Funeral Oration" by the antique historian Thucydides that points towards the limitations of remembering historical events. This is further reiterated with the disclaimer about the limits of the author's memory: "I have found it impossible to remember their exact wording. Hence I have made each orator speak as, in my opinion, he would have done in the circumstances."[437] In light of the quote, the introduction indicates that the conversations are not literal accounts:—"[n]eedless to say, conversations cannot be reconstructed literally after several decades"—and that the book is not a proper memoir—"nor is the book intended as a collection of memories."[438] Rather, he claims, the book is an attempt to convey his experiences of modern physics: "[c]areful attention, however, has been paid to the precise and vivid description of the atmosphere in which the conversations took place."[439] Moreover, by centring the memoir around conversations, Heisenberg emphasises the claim that "science is created through dialogue" and gives it the form of informal exchange.

> Natural science is based on experiments; it arrives at its results through the conversations of those working in it, who discuss the interpretation of the experiments with each other. Such conversations form the main content of

[436] Much like the characters of the Socratic Dialogues: Debra Nails, *The People of Plato: A Prosopography of Plato and Other Socratics,* (Indianapolis: Hackett 2002).
[437] Thucydides after Heisenberg, 'Der Teil und das Ganze,' 9 translated Pomerans 1971.
[438] Heisenberg, 'Der Teil und das Ganze, 9.
[439] Ibid., 10.

> the book. They are intended to make it clear that science is created through dialogue [...] It goes without saying that after several decades, conversations can no longer be reproduced verbatim.[440]

The conversational style functions as a device to give the scientific practices of discussing results a structure.

Focused on experience rather than representation, the book uses stylistic devices to develop a vivid atmosphere. The use of the collegial form of the German "you [du]" and the use of first name are examples of such devices that gives the reader the impression of observing an informal and intimate conversation among colleagues and friends. While the reader might get the impression of being part of the conversation, the author suggests in the introduction that the informal tone used to develop the atmosphere is used to avoid the impression of historical accuracy.

> Many of the people involved are introduced in the text by their first name [...] partly because the author's relationship is better represented by using the first name. This also makes it easier to avoid the impression that it is a historically accurate reproduction in every detail.[441]

Departing from the observation that the memoir uses the form of conversations, I take a close look at a selection of the memoir's characters, namely Ferdinand von Lindemann, Arnold Sommerfeld, Niels Bohr, Wolfgang Pauli, Carl Friedrich von Weizsäcker, and Grete Hermann. Like the historical figures, these characters play important roles in the protagonist's professionalisation and his career as a theoretical physicist. Despite the resemblance to historical figures, the characters are created by the author and contribute to the construction of his persona as a model citizen and genius.[442] In addition to the historical actors featured in the memoir, I pay attention to the (lack of) presentation of figures who played an invaluable role in the development of modern physics—like Lise Meitner—or the author's/protagonist's career—like

[440] Heisenberg, 'Naturwissenschaftliche und Religiöse Wahrheit', 9.
[441] Heisenberg, 'Der Teil und das Ganze,' 10.
[442] Carson, *Heisenberg in the Atomic Age*, 152f..

mothers and wives. Together, the presentation of male and female characters contribute to the construction of theoretical physics as a male discipline, with distinct social structures and aesthetics amounting in the masculinity of the Romantic genius.

7.3.2.1 Ferdinand von Lindemann and Arnold Sommerfeld

In the memoir the literary influence of von Goethe is visible in the aesthetic repertoire and employed terms. For example, in the second chapter, the protagonist recounts two meetings with Professors at the Ludwig's Maximilian University of Munich which informed his decision to study physics rather than mathematics. The set of the first meeting with the mathematician Ferdinand von Lindemann draws on Faust's study from von Goethe's *Faust. A Tragedy from 1808*.

> I visited Lindeman [...] in a gloomy and strangely old-fashioned room style, on the first-floor, in which I felt an almost immediate sense of oppression. Before I could speak to the professor, who rose very slowly from his chair, I noticed a little dog with black fur, cowering on the desk, and was forcefully reminded of the poodle in Faust's study. The black four-legged creature [*der schwarze Vierbeiner*] looked at me with undisguised animosity; I was an unwelcome intruder about to disturb his master's peace of mind. I was so taken aback that I began to stammer, and as I spoke it dawned on me that my request was immodest. Lindemann, a tired-looking old gentleman with a white beard, felt obviously the same way about it, and his slight irritation may have been the reason why the small dog started to bark horribly. His master tried to calm him down, but the little animal only grew more hysterical, hindering the conversation.[443]

The encounter with the character, von Lindemann, draws explicit links to Faust's study. The office of Lindeman is dark, gloomy, old fashioned, situated on the first floor. With a small, dark-haired dog, cowering on the desk. The protagonist immediately associates the poodle with that of von Goethe's *Faust*. The poodle in von Goethe's *Faust* starts to bark, while Faust is working in his study, and turns out to be a manifestation of Mephistopheles, the devil. The protagonist recounts a sensory reaction to von Lindemann's office, a feeling of oppression, seeing himself as an

[443] Heisenberg, 'Der Teil und das Ganze, 30.

intruder, which leads to stammering and self-doubt. Heisenberg's stammering leads to the poodle barking.

In Faust, Mephistopheles presents himself upon his entrance as "the part of that power which still produces good, whilst ever scheming ill."[444] The chapter ends with the protagonist sitting in a lecture by Sommerfeld. Following the lecture, he reflects on his encounter with Lindeman, which he concludes by playing on Mephistopheles words,

> the little black dog in Lindemann's studies, appeared to me in my memory as 'part of that power which still produces good, whilst ever scheming ill produces good.'[445]

The good that Lindemann's poodle brought in this instance is Heisenberg's decision to study with Sommerfeld instead of Lindemann. The set of the second meeting with Professor Sommerfeld could not be more different to that in Lindemann's office. The physicist's office is described as "a bright room with a view over the university's courtyard where I could see students on benches beneath the large acacia."[446] The room is bright with a view that maintains a connection between the professor and the students. This indicated connection with the students is further present in the protagonist description of Sommerfeld.

> A small squat man with his martial dark moustache who left a rather austere impression me. But his very first sentences revealed his benevolence, his genuine concern for the young human, who sought his guidance and advice.[447]

The physical appearance of Sommerfeld is presented in opposition to his personality. While his appearance leaves an austere impression on the protagonist, he turns out to

[444] Von Goethe, *Faust.*
[445] Ibid., 44.
[446] Ibid., 31.
[447] Ibid..

be a caring person. He is a person concerned about students, who is willing and able to offer guidance.

The welcoming and helpful character of Sommerfeld has an antagonist in the memoir, Lindemann, who is modelled after Faust's study and his pact with the devil. Along with his antagonist, Sommerfeld has another counterpart, the character Niels Bohr who is also concerned with Heisenberg's professionalisation as a theoretical physicists. Although the statue of Sommerfeld and Bohr could not be more different, one small and the other tall, in the following Section 7.3.2.2 we see that the scene of the protagonists first encounter with Bohr resembles his meeting with Sommerfeld in his bright office.

7.3.2.2 Niels Bohr

Niels Bohr is first introduced in the second chapter as the author of a recent theory[448] while the character appears for the first time in the third chapter "The Concept of 'Understanding' in Modern Physics (1920–1922)." In the third chapter Heisenberg travels to Göttingen to attend a seminar held by Bohr and referred to as the "Gottingen Bohr Festival [*Göttinger Bohr Festspiele*]." During this visit, the protagonist encounters Bohr for the first time and gets in touch with his approach to modern physics.

> Gottingen Bohr Festival [...] The hall was filled to capacity. The great Danish physicist, whose very stature proclaimed him a Scandinavian, stood on the platform, his head slightly inclined, and a friendly but somewhat embarrassed smile on his lips. Summer light flooded through the wide-open windows. Bohr spoke fairly softly, with a slight Danish accent. When he explained the individual assumptions of his theory, he chose his words very carefully, much more carefully than Sommerfeld did. Each one of his carefully formulated sentences revealed a long chain of underlying thoughts, of philosophical reflections, which disappeared in the semi-darkness, never fully expressed. I

[448] Ibid., 39.

> found this approach highly exciting; what he said seemed both new and not quite new at the same time[449]

The description sets the scene, within which Bohr appears. It simultaneously introduces his character and his standing in the physics community. His physical stature as a tall man is elevated by him standing on a platform and emphasises his greatness when it comes to physics as he is able to fill a lecture hall. At the same time, he is made out to be friendly, with a smile on his lips, which is emphasised by the summer light and the open windows. The character "somewhat embarrassed smile" and his accent makes him relatable. Moreover, Bohr's character is related to his work which he approaches with care. Much like his smile, the philosophical foundation are not fully expressed and brought to the light of the room but rather veiled by the shadow. It is this semi-darkness, not the sunlight of Bohr's greatness that attracts the protagonist's excitement. These aesthetic qualities of semi-darkness and sunlight resemble the aesthetic repertoire of Heisenberg's religious experience (see Section 5.3) and the knowledge creation in Heisenberg's (see Section 7.2.3).

The protagonist recounts how he challenged Bohr's work in these bright room which lays the foundation to their long cooperation and friendship.

> the end of the third lecture I myself dared to make a critical remark. [...] Bohr must have gathered that my remarks sprang from profound interest in his atomic theory. He replied hesitantly, as though he were slightly worried by my objection, and at the end of the discussion he came over to me and asked me to join him on a walk over the Hain Mountain, that afternoon, to speak about the problems in more detail.[450]

The protagonist recounts his challenge as a dare to the voice of the great physicists, Bohr. This moment presents a turning point in Heisenberg's career as Bohr recognises his potential. It leads first to a walk during which Bohr inquiries about Heisenberg's interest in physics and later on research stays at Bohr's institute in Copenhagen.

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[449] Ibid., 58f.
[450] Ibid., 59.

Throughout the book, the character Bohr engages in conversations and appears as a key figure. Following his doctorate in 1922, Heisenberg goes on to work at Bohr's institute. In the memoir, Bohr's standing opens doors for Heisenberg beyond his arrival at the institute in Copenhagen .

> But when I explained that I wanted to work at the institute with Professor Niels Bohr, all doors were opened by this name and obstacles were overcome in an instant. From the very first minute, I felt safe under the protection of one of the strongest personalities in this small, friendly country.[451]

Once more, Bohr just like Sommerfeld is associated with friendliness as well as safety and protection.

The character, Bohr appears for the last time in the chapter "Scientific and Political Disputes [*Auseinadersetzungen in Politik und Wissenschaft*] (1956-1957)." After a time of exhaustion and sickness, the protagonist and his family spend some days in Denmark, in close proximity to Bohr. The protagonist recounts how the visit rekindled the past relationship, "mutual visits helped to cure my fatigue and gave me a chance to restore the links with our common past."[452] Once more, it is the epistemic aspect of the protagonist's research, this time on the *Weltformel*, that characterises the conversations with Bohr. He encourages again the protagonist in his endeavours, "he [Bohr] was in agreement with the general philosophical premises [...] and he encouraged me to proceed in the direction I had set out on."[453] Despite their differences, the protagonist and the character Bohr are presented throughout the memoir in agreement with Bohr as a believer in Heisenberg's and his work.

The references to Bohr are not limited to Heisenberg's memoir. In many of his popular texts, Heisenberg attributes knowledge, ideas, or examples to Bohr. For example, when he was writing the manuscript *Philosophy* in the early 1940s, he

[451] Ibid., 69.
[452] Ibid., 303.
[453] Ibid.

explains in a letter to Elisabeth that the aim of it is to captures Bohr's views and position on philosophical questions.[454] Similarly, in a speech from 1954, Heisenberg attributes an epistemological interpretation of quantum physics to Bohr.

> Natural science always presupposes the human being, and we must realise, as Bohr put it, that we are not just spectators but always also participants in the spectacle of life.[455]

Overall, Niels Bohr functions as a central figure in the memoir and Heisenberg's popular writings. In the memoir, Bohr's character is presented as a benevolent authority, a role model, a reference point, and an inspiration for Heisenberg's interest in the philosophical questions raised by modern physics.

7.3.2.3 Wolfgang Pauli

Another important character is Wolfgang Pauli who appears in the memoir for the first time at the end of the second chapter "The Decision to Study Physics (1920)." Unlike Sommerfeld or Bohr, Pauli is on the same level as the protagonist, a student of theoretical physics. Although Pauli and Heisenberg have quite different personalities, their careers are intertwined. Ahead of his first lecture in theoretical physics with Arnold Sommerfeld, the protagonist sits down next to Wolfgang Pauli.

> when I walked into the lecture hall where Sommerfeld usually gave his lectures, I spotted a dark-haired student with a somewhat general and enigmatic [*hintergründigen*] face in the third row. Sommerfeld had introduced us during my first visit and had then told me that he considered this student to be one of his most talented pupils, one from whom I could learn a lot. His name was Wolfgang Pauli, and for the rest of his life, he played the part of a very severe critic and friend, both for myself and my scientific attempts. I sat down beside him and asked him to give me some advice about my studies, after the lecture.

Pauli is introduced as an exemplary student, well ahead of the protagonist in terms of his studies and able to share his insight. He is further presented as a lifelong friend

[454] Heisenberg to Elisabeth, 10.07.1941 In Hirsch-Heisenberg, *Dear Li!,* 153.
[455] Heisenberg, 'Das Naturbild der heutigen Physik', 406.

and critical colleague, who is nonetheless approachable. Following in Pauli's steps the protagonist goes on to work as an assistant of Max Born in Göttingen and later as an assistant of Niels Bohr in Copenhagen up until Pauli attains a full professorship at the university of Hamburg in 1923.[456] During the 1920s and in the late 1950s, the protagonist and Pauli worked closely together. On the influence of the historical actor Pauli on Heisenberg's writings see Sections 5.2, 5.3, and 6.2.1. Moreover, their close but complicated relationship in only partially represented in the memoir.[457] Rather, the character Pauli embodies alternatingly Heisenberg's detractor or friend.

The difference between the two physicists is indicated in the protagonist picture of the character Pauli as a person with a diametrically opposing character to his. Nevertheless, the Pauli is made out to be an outstanding physicist with an earnest character, serving as an academic role model from the start.

> At Sommerfeld's seminar, talks with Wolfgang Pauli constituted the most important part of my studies. But Wolfgang's way of life was almost diametrically opposed to mine. While I loved the daylight and spent as much of my free time hiking, swimming or cooking simple meals on the shore of one of the Bavarian lakes, Wolfgang was a typical night owl. He preferred the town and liked to spend his evenings in some old bar or cafe, and would then work on his physics through much of the night with great concentration and success.[458]

A night-owl, the character Pauli prefers the town, bars, and to work during the night, yet he successfully conducts his work with concentration. The protagonist, on the other hand has interests and character that is set in opposition to Pauli. Despite, Heisenberg's preference for nature and working at daylight, in the memoir, his breakthrough in quantum mechanics is set at night. While the protagonist, presents

[456] Pauli would leave his position in 1928 to take on a professorship at ETH (Federal Institute of Technology Zurich) in Zurich.
[457] Pauli's letter edited after his document their work relationship and Pauli's view on Heisenberg expressed in various letters to his colleagues, for Meyenn, *Wolfgang Pauli Wissenschaftlicher Briefwechsel mit Bohr, Einstein, Heisenberg, u.a. Volume II;* Meyenn, *Wolfgang Pauli Wissenschaftlicher Briefwechsel mit Bohr, Einstein, Heisenberg u.a. Volume IV.*
[458] Heisenberg, 'Der Teil und das Ganze', 66.

here concentration as the road to success in physics, it is rather experience of the new knowledge that characterises the protagonists breakthrough (see Section 7.4.3). Furthermore, as I had showed earlier (see Section 7.1), the ideals of the theoretician's work presented in Heisenberg's writings is often associated with intuition, instead of Pauli's great concentration.

Despite their oppositional characters, the conversations between the protagonist and Pauli are rather unanimous. Apart from their disagreement over the *Weltformel* (see Section 7.3.2), Pauli is largely in agreement with the protagonist. In the discussions on different positions about the relationship between science and religion for example , the Pauli confirms Heisenberg's suspicions and expands on his explanation, "Wolfgang agreed with my worry [about the compatibility position]"[459] (see Section 5.1).

The character, Pauli appears as a critical voice while offering the protagonist guidance and approval. Together with the character Bohr, Pauli is a reference point for philosophical positions and ultimately vouching for Heisenberg's positions. In terms of ideal of the physicists, Pauli's mathematical giftedness on which he relies on for his academic achievement presents an alternative to the Romantic genius of Heisenberg.

7.3.2.4 Carl Friedrich von Weizsäcker

Carl Friedrich von Weizsäcker might be the character with the least contrast to the protagonist, Heisenberg. He appears first in the chapter "Quantum Mechanics and Kantian Philosophy [*Quantenmechanik und Kantsche Philosophie*] (1930–1931)."

[459] Ibid., 117.

Still a student when he meets Heisenberg, von Weizsäcker joins the characters Bohr and Pauli as a third character who shapes and shares the protagonist's philosophical.

> Carl Friedrich von Weizsäcker joined this group at the age of only eighteen and introduced a philosophical note into our discussions; although he was a student of physics, he grew unusually animated whenever our talks impinged on philosophical or epistemological problems.[460]

This interest in philosophical problems tied to the protagonists research in physics is illustrated in the discussions on Kantian philosophy. Together, the two male characters, von Weizsäcker and Heisenberg defend their position on Kantian philosophy against one of the few female characters, Grete Hermann (see Section 7.3.5).

Throughout the memoir von Weizsäcker shares the protagonist's interest in philosophical questions. This shared interest is for example visible in the last appearance of the character in the memoir's final chapter on the connection of modern physics, i.e. Heisenberg's attempt on a unified field theory (*Weltformel*) and Platonism.

> Carl Friedrich was not at all satisfied: '[...] I am hopeful that the new approach will lead us to the real laws of nature. Your field equation, of which no one can say, for now, with certainty whether it represents nature correctly, looks as if it might have originated in this philosophy of alternatives. But surely we ought to be able to establish this fact with the necessary mathematical rigor.'[461]

Weizsäcker expresses his support for Heisenberg's *Weltformel*, despite raising the question of whether the *Weltformel* will hold up to mathematical scrutiny. Moreover, Weizsäcker eludes to the structural realism which we can find in Heisenberg's popular writings (see Chapter 6) when describing the *Weltformel* as an attempt to "led to the real laws of nature."

[460] Ibid., 163.
[461] Ibid., 331.

Beyond their shared interests in philosophical discussions on modern physics, von Weizsäcker and the protagonist share a mutual interest in mountaineering,[462] he accompanies, for example, the protagonist for the preparations of a skiing holiday.

> For the Easter vacation in 1933, I had invited Niels and his son Christian, Felix Bloch and Carl Friedrich for a skiing holiday on the Alm. [sic!] Niels, Christian and Felix wanted to come straight to Oberaudorf from Salzburg, where Niels had an engagement, and climb the rest of the way from there. Carl Friedrich and I had gone up two days earlier to make things homely and to lay in provisions.[463]

While many of the characters disappear with the chapters set during the war, von Weizsäcker is one of the few who continues to play a leading role until the end. Just like the protagonist, the character von Weizsäcker remained in Germany during the second World War and worked, with Heisenberg on the German project for an atomic bomb, the *Uranverein*.[464]

In the memoir, the protagonists draft for the *Uranverein* presents among others a bonding moment for the two men and an opportunity for Heisenberg to spend more time with von Weizsäcker.

> I received my conscription order. Quite unexpectedly I was ordered to report [...] to the Army Ordnance Department in Berlin. There I, like several of my colleagues, was told to work on the technical exploitation of atomic energy. Carl Friedrich had been given similar orders, which meant that we would have ample opportunity to meet in Berlin and to discuss and think about our situation.[465]

The project itself is described as a project for atomic energy rather than a nuclear weapons program. For their relationship, the work on the project brings the friends and

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[462] Beyond skiing and physics, the physicists Heisenberg and von Weizsäcker two shared many interests, such as music. Throughout their lives they maintained an incredibly close relationship which is not fully captured by the memoir. The memoir leaves also some of the more complicated aspects of their relationship out, such as a love-interest a then 32 year old Heisenberg had in von Weizsäcker's then 16-year-old sister, Adelheid, see Hirsch-Heisenberg, *Liebe Eltern!*, 206.
[463] Ibid., 175.
[464] While the historical project itself was not successful, much like the one in the memoir, the reasons for its failure inspired a variety of books and plays with more or less speculative claims, for example Robert Jungke, *Brighter Than A Thousand Suns: A Personal History of the Atomic Scientists* (San Diago: Harcourt 1986) or the theatre play by Michael Frayn *Copenhagen*, (New York: Random House 2000), premiered 1998.
[465] Heisenberg, 'Der Teil und das Ganze', 235.

colleagues even closer, now allies in the decision to remain in Germany with a shared fate to work on the *Uranverein.* The two discuss the ethical questions arising from their partaking in the research project in another chapter. As I have shown above (see Section 6.3), the protagonist suggests that individual research and actions, like Otto Hahn's (and Lise Meitner, see Section 7.3.2.6) or Heisenberg and von Weizsäcker ought not to be blamed for the atrocity of the Nuclear Bomb or in extend the Third Reich. Such projects are rather the results of the social context, in conclusion, neither the protagonist nor von Weizsäcker are responsible for their actions.[466]

In the chapters following the second World War, von Weizsäcker remains a prominent character as the driving force for Heisenberg's political engagement against the nuclear armament of West Germany and for the expansion of nuclear power. This is for example visible in the protagonists descriptions of the events leading to him signing the *Göttinger Manifest* in 1957 a memorandum against the nuclear armament.

> Working was out of the question, nor could I be present at the political discussions when Carl Friedrich and other friends hammered out our demands to the government. The day I got up–it was the end of November by then 'the 18 Göttingers [*Göttinger 18*],' as we were later called, met in my house and drafted a letter to the then Minister of Atomic Energy, Franz-Josef Strauss.[467]

While the protagonist is ill, unable to work or engage in political discussion, von Weizsäcker stands for Heisenberg's colleagues and the work that went into the objection of the West German plans for nuclear armament. In light of the protagonist's inability to leave the house, von Weizsäcker becomes an active character, continuing Heisenberg's work.

[466] This position has been, rightly so, contested during Student Protests in the later 1960s. Overall, much has been written on Heisenberg's role in the *Uranverein*.
[467] Heisenberg, 'Der Teil und das Ganze', 304.

In the memoir, von Weizsäcker is presented as a close friend and colleague with mutual interests serving as a resource and confirmation of the protagonist's philosophy and life choices.

7.3.2.5 Grete Hermann

The character, Grete Hermann makes her appearance in the same chapter as Weizsäcker, the chapter "Quantum Mechanics and Kantian Philosophy (1930–1931)." In this chapter that is dedicated solely to the interpretation of Kantian philosophy in light of quantum physicists, Grete Hermann is introduced as a young philosopher trained in Kantian philosophy in the tradition of the German philosophers Leonard Nelson and to an extent Jakob Friedrich Fries, a German post-Kantian philosopher.

> We were offered a special occasion for philosophical discussions one or two years later when a young philosopher [*eine junge Philosophin],* Grete Hermann, came to Leipzig to discuss the philosophical claims of the particle physicists –claims, of which she was initially [*zunächst*] convinced were wrong. Grete Hermann had studied and worked in the circle of the philosopher Nelson, there she came of age [*aufgewachsen*] in the tradition of Kantian philosophy [...] following this rigorous approach, Grete Hermann believed she could prove that the causal law –in the tradition of Kant– was unshakable. However, the new quantum mechanics seemed to be challenging these causal laws and the young philosopher [*die junge Philosophin*] was determined to fight this battle to the end.[468]

The repeated characterisation of Hermann as a young philosopher veils historical facts, while developing a hierarchy between Hermann's character and the particle physicists, represented by the protagonist and Weizsäcker. The historical person, Hermann is nine months Heisenberg's and even 12 years Weizsäcker's senior. However, the repeated description of her as a young philosopher, which is emphasised with the description of her philosophical work in Göttingen as a "coming of age [*aufwachsen*]" under the male philosopher Nelson, rather than as work or formation.

[468] Ibid., 164.

Moreover, the emphasis on her philosophical work renders the expertise in mathematics of the historical figure Herman invisible. Herman graduated in 1925 from her doctor in mathematics, which she had gained under the supervision of Emmy Noether, a German mathematician whose work in algebra was foundational to the mathematics of physics. Following her Hermann went on to work with Nelson in Göttingen until 1927 and her correspondence with theoretical physicists as well as the attendances of a seminar at Heisenberg's institute resulted in a series of publications. These publications offered a reconciliation of "a neo-Kantian conception of causality with the new quantum mechanics."[469] Beyond the absence of Hermann's academic credentials, the presentation of the character in Heisenberg's memoir does not reflect the success of her philosophical work.

Rather, Hermann's philosophical ambitions are discredited by the protagonist's description from the start, by describing her hypotheses as "initially [*zunächst*]." By describing her ambitions as a determination "to fight this battle to the end" of rather than a civilised discussion, her character is presented as different from the true way of doing science, which is through conversations. The conversation unfolds in a way that that the protagonist and Weizsäcker gain control, with descriptions such as "But Carl Friedrich persisted [*nicht lockerlassen*]"[470] or the protagonist describing how he intervened after an argument by Hermann, "Here I tried to intervene [*einzugreifen*] again in the conversation."[471] The inadequacy of Hermann's position is emphasised.

> Grete Hermann was apparently very unhappy about this outcome of our conversation. She had hoped to use the tools [*Werzeug*] of Kant's philosophy to refute the claims of the atomic physicists in all rigour [*in aller Schärfe*] or,

[469] Guido Bacciagaluppi and Elise Crull, 'Heisenberg (and Schrödinger, and Pauli) on Hidden Variables', In *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics*, 40(4), (2009), 374–382, 378.
[470] Heisenberg, 'Der Teil und das Ganze', 168.
[471] Ibid., 170.

> conversely, to realise that Kant had made a crucial error in his thinking at some point.[472]

The protagonist describes the feeling of Hermann, and offers an interpretation, she is made unhappy. With her approach to the discussion presented as a hope rather than a theory, her engagement in the conversation is presented as motivated by personal emotions. This emotional driven approach allows only room for two outcomes. Without an interest in the process of learning, the options are presented as black and white, refute modern physics or disprove Kant's philosophy. Both outcomes would present a win over Heisenberg and Weizsäcker, which are an impossible outcome within the power dynamic set up in the chapter.[473]

The chapter ends with Heisenberg and Weizsäcker win over Hermann.

> We had the feeling that Grete Hermann was satisfied to some extent by this reply, which was partly on Bohr and that we understood the relationship between Kant's philosophy and modern science a bit better.[474]

The outcome of the conversation is an appeased Hermann, satisfied by the answer built on hearsay, given by a 18 year old von Weizsäcker at the beginning of his studies in physics. For the two physicists, the conversation is presented as an overall positive experience with both having learned something about Kantian philosophy.

The chapter develops a clear hierarchy between the character Hermann, on one side, and von Weizsäcker and the protagonist on the other side. One way this hierarchy is developed is the different ways the characters Hermann and von Weizsäcker are addressed. While von Weizsäcker is referred to with his first name Carl Friedrich suggesting an intimate relationship with the protagonist, referred to in a more formal

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[472] Ibid., 171f.

[473] Recent interest in Hermann's work showed that not only her philosophical work but also her scientific work fulfils the standards of the respective field, see Guido Bacciagaluppi and Ellis Crull, *Grete Hermann: Between Physics and Philosophy* (Dordrecht: Springer Verlag 2016) and Kay Hermann, *Grete Henry-Hermann: Philosophie – Mathematik – Quantenmechanik. Texte zur Naturphilosophie und Erkenntnistheorie, mathematisch-physikalische Beiträge sowie ausgewählte Korrespondenz aus den Jahren 1925 bis 1982*, (Wiesbaden: Springer VS 2019).

[474] Heisenberg, 'Der Teil und das Ganze', 173.

way with her full name, Grete Hermann. Furthermore, Hermann is not presented as an equal to the protagonist and von Weizsäcker, but rather is an idealist eager to prove or disprove a point, who relies on emotions rather than reason. It is the only occasion the character Hermann appears in the memoir and also the only occasion a female researcher engages in a conversations. The presentation of the character Grete Hermann reinforces theoretical physics as an all-male space and practice. Even though she engages in the conversation, her representation presents her as an outsider rather than as a respected interlocuter.

7.3.2.6 Lise Meitner

Another female scientists, whose (lack off) presentation in the memoir contributes to the reinforcement of theoretical physics as an all-male discipline is the physicist, Lise Meitner. While, there is no character named and modelled after Meitner in the memoir, her name is mentioned in relation to the characters Carl Friedrich von Weizsäcker and Otto Hahn.

Meitner is firstly mentioned in regard to her role as von Weizsäcker's supervisor.

> Carl Friedrich, who was then assistant to Lise Meitner in Otto Hahn's Institute in the Dahlem section of Berlin, would often attend our seminars in Leipzig [...].[475]

While the physicist Lise Meitner was heavily involved in the research on nuclear fission, her work was pivotal for the successful experiment. The presentation of the character eradicates not only the academic credentials of the historical Lisa Meitner but here pivotal role in modern physics as well. If she is mentioned in the memoir it is only in connection to other male scientists. The five times the research of Meitner and Hahn

[475] Ibid., 218.

on nuclear fission is mentioned in Heisenberg's memoir, it is only credited to Otto Hahn with a reference, "Otto Hahn's discovery of uranium fission would dramatically change the picture,"[476] "Otto Hahn's discovery of atomic fission may be used to produce a chain reaction,[477] "based on the method of uranium fission discovered by Otto Hahn,"[478] "Otto Hahn. Uranium fission, his most important scientific discovery."[479] This is an example where the existing work of a woman becomes invisible, and with it, the female scientist as well. But not so with Hahn, make the comparison clearer.

The absence of Meitner and her work is not only notable in the memoir but in Heisenberg's popular writings at large. By recognising Meitner only in relation to male characters or names without mentioning her credentials or scientific work, the memoir contributes to the erasure of one of the prominent and influential female scientists in the 20th century and in return manifests the physics as an (all) male discipline.

7.3.2.7 Mothers, Wives, and Girls

Apart from the characters and names of Grete Hermann and Lise Meitner no other female scientists appear in the memoir. The other female character's and figures appear in traditionally (*bildungsbürgerliche*) roles for women as wives, mothers, or girls. Apart from the authors and protagonists wife, Elisabeth all the other female character's remain nameless. By taking a closer look at their representation, I show the memoir reinforces not only the private role of women, attached to the household but also the all-male space for physics by eradicating the work, as carers and contributions, as interlocutors of women that makes research possible in first places.

[476] Ibid., 217.
[477] Ibid., 233.
[478] Ibid., 230.
[479] Ibid., 263.

Elisabeth, is the third character, next to Grete Hermann and Lise Meitner, who is referred to by name the memoir. Apart from the dedication, "Dedicated to my wife,"[480] the character Elisabeth appears for the first time when Heisenberg recounts meeting Elisabeth in the chapter "The Action of the Individual during the Political Catastrophe [*Das Handeln des Einzelnen in der politischen Katastrophe*] (1937-1941)." The protagonist recounts how he meets Elisabeth during an evening of Chamber music and marries her within a couple of months.[481] At large, Elisabeth is presented in the role of the caring wife, just like the wife of the character Niels Bohr, who is referred to as Mrs. Bohr (see Section 7.3). In the last chapter, the character Elisabeth engages in a conversation on the different approach of the younger generation to the philosophical questions of quantum mechanics.

> Do you really believe you can interest the young generation in such difficult problems, problems, moreover, that impinge on the wider context of science and life? From what you have occasionally said about physics in the great research centres here or in America, it looks very much as if the young generation is almost exclusively preoccupied with details, as if it had placed some sort of taboo on even speaking about a wider context.[482]

Elisabeth expresses a sentiment that becomes more prominent in his later texts. The sentiment that the younger generations no longer uphold crucial values for society and ideals of science. Here, the cultural critique is linked to the opposition between the two approaches to science, mechanical and organic, which stands at the centre of his writings from the start (see Section 5.1).

Any further female characters and figures remain nameless and appear largely in traditionally (*bildungsbürgerliche*) roles for women. In the second chapter, there is the mother of Heisenberg's friend Kurt, who engages in the conversation about the

[480] Ibid., 5.
[481] Ibid., 226f.
[482] Ibid., 332.

protagonist's decision to study physics rather than pursuing a musical career, "Walter's mother wondered why I had not decided to study music."[483]

The remaining female figures do not engage in the conversation and serve mainly as supernumerary. In the opening scene of the chapter "Lessons on Politics and History [*Belehrung über Politik und Geschichte*] (1922–1924)" the protagonist encounters a girl throwing a plum at him.[484] Upon his arrival on Helgoland, the protagonist encounters his landlady, who as recalled earlier offered to care for Heisenberg (see Section 7.2.4).[485] In the chapter "The Path to the New Beginning [*Der Weg zum neuen Anfang*] (1941–1945)" three female supernumerary appear in the description of an air ride on Berlin during the second World War. The first women is brought into a shelter, "Once, a groaning women was brought in."[486] The second women is the protagonists mother-in-law. Following the air-raid, the Heisenberg walks through the bombed city to his family-in-law. Once he reaches the house, the protagonist meets his mother-in-law "my wife's brave mother."[487] Leaving his mother-in-law to fight the flams of their burning house, Heisenberg encounters a third women. Following cries for help the protagonist meets a "young woman" and goes on to save her father from a burning house.[488] All three women remain nameless and are part of the scenery within which the actions of the protagonist or his colleagues take place. All these female figures with or without names are presented in roles, places, and agencies associated and occupied in a *bildungsbürgerliche* society by women. Against the background of the work in the household and the childrearing as well as the

[483] Ibid., 32.
[484] Ibid., 66.
[485] Ibid., 88
[486] Ibid., 250.
[487] Ibid., 256.
[488] Ibid., 257.

helpless nature, the protagonist becomes a live-saving hero and a physicists dedicated to advancement of knowledge.

The characters with whom the protagonist converses in earnest with portray physics as a largely male institution, just like the historical research places of physics remain up until today. However, as the examples of Hermann and Meitner show, the women who made it in the memoir and these spaces were not regarded as equals. Their academic accomplishments, such as holding a doctorate in mathematics (Hermann) or having the leading role in a crucial experiment (Meitner) are not recalled, their absence the result of cultural and professional bias I suggest. Apart from Hermann and Meitner, the roles of the female characters and figures are restricted to the household as mothers and supporting wives. The male characters, however, are presented in different roles as teachers, as friends, colleagues, role models, some in agreement and others in critic of the protagonist Heisenberg. Nevertheless, all the male characters are able to formulate critical thoughts about philosophical or scientific subjects. The disparity of presentation between the female and male character in the memoir draws on and reinforces the *bürgerliche* division between public and private, between the work of male characters and the work of female characters respectively. In consequence, the memoir conveys physics as an all-male space in the absence of female academics or equals at least. The reader observes the great physicist during his work, invited to see how he develops and defends a theory through discussion with his peers.

7.4 Conclusion

In this chapter, I showed how the aesthetic repertoire of Heisenberg's texts stands first, in the longue durée of the Romantics' and *Naturphilosophers'* studies of nature and second reinforces the idea of theoretical physics as an all-male discipline. Moreover, the distinct combination of the Romantic topos of experiencing nature and knowledge production in his writings constructs the scientific persona of Heisenberg as a Romantic genius. In connection to the sacralisation of nature by *Naturphilosophie* and knowing as encounters with nature, the experience of nature becomes the leading topos of knowledge production in Heisenberg's texts. This topos shapes the ideal of the academic practice of knowledge production as an experience of knowledge while simultaneously fashioning the ideal of the theoretical physicists as a Romantic genius.

The ideal of pursuing the creative forces of nature is visible in the discussion of theoretical physics and the practice of understanding in opposition to experimental physics and the practice of prediction. Through the combination of allegories and the somatic shifts, Heisenberg's texts develop a hierarchy between understanding and predicting, with the understanding of nature being presented as the supreme practice of knowledge production.

In the previous chapter (notably Section 6.1.3), I discussed how the ideals of nature (i.e., *natura naturans)* and of mathematical theories (i.e., a unifying formula) are associated with the practice of understanding. By contrast, in this chapter, I showed how the ideal of understanding is combined with the topoi of encountering nature. These topoi include the domination of nature (e.g., through mountaineering) as well as the immediate experience of nature. The topos of the experience of nature is prevalent in Heisenberg's memoir as he presents the formulation of matrix mechanics, which becomes an experience of nature through the combination of knowledge production

with the topos of the experience of nature and the ideal of the mathematical structure of nature. The aesthetic judgments of beautiful theories and the opening of the phenomenal 'veil' of the particle (much like the fog veiling a clear view of the landscape) amplify the novelty and singularity of the new matrix mechanics.

Moreover, in describing awaiting the sunrise, knowledge production is linked to the experience of the infinite that stands at the core of Schleiermacher's concept of the religious experience. Here, the encounter of nature, similar to the mountaineer's laborious ascent, is tied to the ability to surpass bodily limits (e.g., working until morning, feeling dizzy, or climbing a rock). The ability to surpass psycho-somatic limits is central in the topos of exhaustion and endurance in the name of knowledge production. The physicist's endurance and success in overcoming bodily agony and obscurity to gain new knowledge draws on asceticism and contributes to the masculinity of scientists seeking the ideal of new knowledge.[489] Together, the topoi of the experience of knowledge and bodily exertion create and maintain the scientific masculinity of the Romantic genius, who is sensitive, able to communicate with nature, but also strong and willing to sacrifice himself in the name of a higher ideal: the formulation of new knowledge.

The masculinity of the physicist is further manifested in the histories of physics in Heisenberg's text. The historical narratives of physics are present in the genealogy of great men of science and their achievements. Continuous links between contemporary research and past work legitimise contemporary research, suggesting a sense of destiny, and present recent achievements as progress.[490] These genealogies are important devices in establishing and maintaining the ideal of physics as a discipline of great men. As for the more recent history of the 20th century, the

[489] Daston and Galison, 'The Image of Objectivity,' 121.
[490] On the device of the narrative strategy of history, see Kostas, 'Onwards facing backwards.'

conversational style in Heisenberg's memoir serves as a narrative strategy. These conversations establish Heisenberg's authority as a physicist by focusing on his active engagement in the production of the new knowledge of modern physics. With the analytical concept of scientific masculinity, the interesting aspect of such histories is how they develop and maintain physics as an all-male space that fosters distinct masculinities.

In both cases, physics is a homosocial sphere that upholds *bürgerliche* distinctions between the public sphere of work, associated with men, and the private sphere of the family, associated with women. By extension, the work of child rearing, cooking, cleaning, or networking becomes invisible in light of the outstanding achievements of male physicists. Even the research and the achievements of women, like Lise Meitner or Grete Hermann, become invisible or intrude on the aforementioned homosocial sphere. As such, these histories reinforce the scientific masculinity of the physicist as an outstanding human. The aesthetic analysis renders the role of the aesthetic regimes of Romanticism and *Naturphilosophie* visible in the presentation of somatic responses, sceneries, or aesthetic judgments involved in scientific practices.

Part III: Interference Patterns between Religion and Science

The third part of the thesis encompasses the analysis of the interference patterns between science and religion observed in the case of Heisenberg's popular science writings. Chapter 8 brings the findings of the second part in dialogue with the theoretical framework of Part I, in particular Chapter 2, to extend our understanding of the changing presence of religion in modern society.

Chapter 8 Popular Science Writings: A Mechanism of Meaning-Making in a Modern Society

The primary objective of this study has been the investigation of the role of religion in Heisenberg's popular writings. For that I have centered my attention on two aspects, Heisenberg's explicit reflection on religion and the mobilisation of religion. While the explicit religion includes discussion of the religious experience and "the relationship between science and religion," I showed that the mobilised religion includes , in particular the concomitant alternatives Neo-Platonism and Romantic religion. By activating these aspects of religion, Heisenberg's texts contribute to the communication system of religion and offers interpretations of personal experiences, social changes, and new knowledge. Over the last three chapters, I focused on three intertwined levels of religion in Heisenberg's texts: the explicit reflection on "religion," the activation of ideas and the concept of semantic apparatus of religion in the reflection on science, and the use of the aesthetic repertoire of religion for the narration of knowledge production.

I showed how religion plays a role first in Heisenberg's explicit reflection on religion, in particular the "religious experience" and the social relevance of religion and second in his reflection on the epistemological consequences of modern physics. We have seen that Heisenberg's texts invoke concomitant alternatives of Christian

monotheism when he, for example uses the idea of the *natura naturans* or Neo-platonic ideals in the aesthetic judgments of beautiful theories.

Despite the prominence of religion in Heisenberg's texts after the 1940s, I discovered an absence of any explicit mention or discussion of religion and concomitant alternatives in the letters available at the Archive of the Max Planck Institute and the Niels Bohr Archive. This absence extended also to Heisenberg's edited correspondences with his parents, wife, and colleague Wolfgang Pauli.[491] In the light of this void, a letter from 1937 to his friend, the Protestant theologian and priest, Wolfgang Rüdel stands out. Written ahead of his wedding with Elisabeth Schumacher in April, Heisenberg shares a reflection on his view of Christianity with his friend who would come and officiate at his wedding. In the letter, Heisenberg touches on many of the influences and concepts of religion that we have come across so far, like the Christian upbringing or the modern aesthetic religion of Romanticism. In the fashion of the Romantic religion, Heisenberg turns away from the institutional aspects of Christianity to favourably address the individual and immediate connection with sacralised nature.

> I would like to write you today at length about my position on Christianity [...] At the time when you and I got to know each other and I started to reflect on science, I initially detached myself completely from Christianity. Partly out of an unconscious rejection of the 'adult world and its doctrine' [...] partly because I had entered entirely in the sphere of reality of natural science, which nevertheless stands in a certain contrast to the spiritual reality of which Christianity speaks. I always retained my respect for the church and its teachings, but I couldn't access it inwardly [*innerlich keinen Zugang gefunden*]. My position about life formed mostly during my time at the boy scouts, back then I realised that the world only opens up to us when we are completely honest to ourselves - that is, it only opens up to those who are 'pure of heart'. And in the time that followed, a few hours were crucial, in which I felt the immediacy of being face to face with the essence [*das*

[491] While Heisenberg does reply to inquiries about his beliefs or views on religion after the Second World War, his answers are usually short and direct to the recipient of his published texts. When it comes to recounts of the experience of nature or the interpretations of quantum mechanics that incorporate the *natura naturans*, the letter rarely offers a more extensive discussion than the published texts.

> *Wesentliche*] itself. I don't know whether you would call these hours a religious experience.[492]

The main points Heisenberg describes are the Influences of his professionalisation as a scientist and the time spent in nature with the Boy Scouts, which he associates with two ways of approaching the world. While the professionalisation has led him to distance himself from institutional religion, it is the time spent in nature that has brough him closer to it. It is the immediate access to the creative forces of nature which constitutes the essence that shaped his position. Hence, the letter forestalls the four main influences on the role of religion in Heisenberg's texts: his work as a physicist, *bürgerliche* culture, *Naturphilosophie*, and Romanticism. Moreover, the letter bears witness to the change of Heisenberg's position about the relationship between science and religion. Unlike in the later texts, here, natural science and religion (with each representing a distinct reference point of reality) are interpreted as contrasting one another.

The aim of this chapter is it to bring the findings of the analysis of Chapters 5 through 7 on the different layers of religion in Heisenberg's texts together with the social perspective on the dynamics between science and religion in a differentiated society (see Section 2.1). Taken together, the current chapter discusses the interference patterns between science and religion observed in the previous chapters in the context of the shared history of religion and science in the 20th century. To do so I bring the different analytic threads and the theoretical frameworks together in order to work out additional insights in and through the case study of religion in Werner Heisenberg's popular writings about the role of religion in modern society.

[492] Heisenberg to Wolfgang Rüdel on 6.4.1937, in Becker, *Die Gruppe Heisenberg,* 449.

8.1 Religion as a Medium of Cultural Critique

Religion as a medium of cultural critique is the dominant interference pattern of the explicit reflection on religion. It is not any concept of religion but a distinct combination of two traditions that characterise the cultural critique in Heisenberg's texts. He combines the phenomenological concept of religion centred around "the religious experience" (see Section 5.1) with a functional concept of religion centred around ethics and Christian values.

With the focus on the religious experience, the texts activate and contribute to modern aesthetic religion. I showed how the religious experience discussed in Heisenberg's texts stands in the tradition of Romanticism and Romantic religion that emerged in Germany at the turn of the 18th century.[493] This aesthetic religion shapes not only the study of religion[494] but also the aesthetic repertoires used to make sense of knowledge. Despite its influence on the cultural *imaginaire* of knowledge production (e.g., the aesthetics of the hyper-individual experience of knowledge, see Section 8.3) only a few studies in the field of science-and-religion have recognised its relevance.[495] Beyond that, the Romantics universalised the individual, religious experience and presented it as an answer to the pluralism and differentiation of modern society.

This concept of religion shapes the discussion of "the relationship" that is closely entwined with a critique of the differentiation of society based on a distinction between the material and *geistige* world (see Sections 5.3 and 6.1.1). In these cases, Heisenberg draws on the idea of religion as a holistic approach to reality. Heisenberg draws on the order of reality sketched by von Goethe in the pursuit of an alternative to

[493] Hampton, *Romanticism and the Re-Invention of Modern Religion*.
[494] Marina, 'Friedrich Schleiermacher und Rudolf Otto.'
[495] Examples are Grieser, 'Imaginationen des Nichtwissens'; Grieser, 'Blue Brains'; Borrelli, 'Poetic Imagination in Scientific Practice'; Makrides, 'The Natural Sciences in the Framework of a European History of Religion.'

the materialist tradition of reality. Part of this critique is negotiated in and through the discussion of different positions on "the relationship." In the discussion of "the relationship" religion serves as a medium to critique the influence of scientific materialism on contemporary science and society.

In this context, my observations showed that Heisenberg's texts developed an additional interference pattern between the social systems of science and religion by transferring a concept from modern physics ('complementarity') into the discourse on science and religion.

The second concept of religion I found in Heisenberg's texts, is a social concept that sees religion as the value system for contemporary research and society. Here, Heisenberg presents religion as a solution for social challenges arising from the growing influence of science on modern life i.e., the atomic bomb and isolation. In both cases he uses a functional concept of religion as a framework of values and the integration of community. The discussion of religion plays a central role in Heisenberg's assessment of science in light of the successful and unsuccessful projects around the development of nuclear weapons along with the debates on nuclear armament. In these cases (see Section 5.2.3), Heisenberg invokes religion as the relevant ethical framework for scientific practices and pursuits. Here, the concept of religion draws on the Christian tradition of ethics that has been part of *bürgerliche* culture. He refers to religion as the system providing the values to assess the goals of research and maintain social coherency. This critique is further visible in his opposition to the "compatibility" or "exclusivity" positions of "the relationship between science and religion," which he associates with certain social challenges e.g., "the collapse of ethics."[496]

[496] Heisenberg, 'Der Teil und das Ganze', 118.

I further showed that Heisenberg observes and critiques the growing isolation of the individual in modern society in light of the advancement of modern science. He associates this isolation of the individual with the advancement of technology that is driven by scientific materialism at the core of modern science. To address the growing isolation, Heisenberg suggests a strengthening of religion, specifically Christian values, as a remedy for the individual isolation and lack of meaning in life, particularly among young people. This critique of modern society, because of a prevalent rationalisation and mechanisation of society, emerges and unfolds in the context of the student movements in West-Germany and the *Bildungsbürgerliche* critique of the culture.

In all three cases, Heisenberg refers to religion as a solution to the challenges of modern society. Religion as a medium of critique is by no means a unique aspect of Heisenberg's texts. Rather, the texts stand in a wider tradition of the history of religion. The first historical moment I deem important to highlight is the development of the modern aesthetic religion by the Romantics. Many of the Romantics, including Schleiermacher, sought to redefine religion and demonstrate its relevance in light of the growing influence of rationalism, the Enlightenment, and anti-religious sentiments in the late 18th century.[497] As discussed in Section 5.1, a key characteristic of the Romantic movement was the interpretation of religion in terms of individual experiences rather than institutions and practices. The second moment involves the emergence and unfolding of a culture of critique that takes hold in West-Germany in the 1960s and which was part of a global movement at the time. When it comes to the link between religion as a means of critique and quantum mechanics, "the

[497] Hampton, *Romanticism and the Re-Invention of Modern Religion*.

counterculture"[498] on the West Coast of the USA has been particularly noteworthy.[499] In West-Germany, the cultural critique is not only directed at institutions with their unfinished denazification and the plans for nuclear armament but also favours the development of an ecological consciousness. Within this milieu the activation of past religious traditions often distinct from Christian institutions (e.g. paganism), was instrumental in the consolidation of religion as a medium of critique.[500]

The cultural critique is tied to three observations Heisenberg makes and problematises in his texts: first, the influence of scientific materialism leading to a decrease of religion; second, the growing influence of technology resulting from a focus on the application of scientific knowledge; and third, the isolation of the individual. All three critiques are set within an observed decline of religion and social differentiation. Hence, it is not surprising that Heisenberg defends religion as a remedy for these downsides of modern science and modern society. In Heisenberg's texts, the religion at the centre of the cultural critique combines past traditions, in particular *Naturphilosophie* and Romanticism with Christian ethics. By using religion as a medium of critique, Heisenberg bears witness to the changing role of religion in a differentiated society, occasionally going so far as to challenge the differentiation of modern society itself.

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[498] The term counterculture was coined by the historian Theodore Roszak, in his book *The Making of a Counter Culture. Reflections on the Technocratic Society and Its Youthful Opposition* (1969) about the cultural movements in the 1960s that spread across the Americas and Western Europe that protested against contemporary politics and social structures. In his guide to a socio-rhetorical interpretation of texts, Vernon characterises the counterculture by the rejection of the of the dominant culture or subcultures, *Exploring the Texture Texts,* 87.

[499] David Kaiser, *How the Hippies saved Quantum Physics. Science, Counterculture, and the Quantum Revival,* (New York: Norton 2012).

[500] von Schnurbein, *Religion als Kulturkritik: Neugermanisches Heidentum im 20. Jahrhundert*; Peters, *Esoterik als moderne Religionsform*.

8.2 Religion as a Source for Interpretations of New Knowledge

Looking at the use of religion in the explicit reflection on science in Heisenberg's texts through the model of interference, I suggest that religion serves as an interpretative system. These interpretations notably address the structural, epistemological, and ontological consequences of modern physics. It is surprising that Heisenberg, unlike many of the interpretations of quantum mechanics by third parties of the public, such as journalist or popular science communicators (on which I touch on in Section 8.4), does not develop a new theology on the basis of quantum mechanics. The epistemological novelty of quantum mechanics is rather a starting point to renegotiate some of the central premises of modern science and research. In these negotiations, I found that concomitant alternatives (e.g., Neo-Platonism, pantheism, or vitalism) are used to interpret the insights of modern physics about the limitations of "the mechanical objectivity."[501] In many cases, these alternatives find their way into Heisenberg's texts through the work of *Naturphilosophers*, most prominently von Goethe's.

In the analysis, I showed three main trends of how religion, in the guise of the aforementioned alternatives, serves as an interpretative repertoire of modern physics beyond science. These three interpretative patterns are: first, the "sacralisation of nature,"[502] second, the unification of science, and third, poetry as an immediate access to nature and knowledge.

The first trend – the sacralisation of nature – combines the use of the idea of the *natura naturans* and the monistic ideal of the One. I showed that the alternative of the idea of the *natura naturans* is focal in Heisenberg's texts (see Chapter 6 and

[501] Daston and Galison, *Objectity*. 115–190.
[502] Von Stuckrad, 'Naturwissenschaft und Religion.'

Section 7.1). In addition, especially in Heisenberg's later texts, the claim that the aim of science is the discovery and formulation of the core of reality, captured by one unifying formula activates the henological ideals. With this insight, I complement Blum's study on Heisenberg's research that marked the departure from empirical science with the 1950s on the *Weltformel*. Blum suggests that Heisenberg's research reflected monist ideals promoted in the early 20th century that I addressed in terms of the Neo-Platonic interpretations presented in Heisenberg's popular writings. Together the identification of nature in terms of a creative force and the pursuit of one unified formula contribute to the sacralisation of nature in the tradition of *Naturphilosophie*.

The second trend, the call for a unification of science in light of modern physics is entwined with the critique of the materialist science I discussed above. In the case of the structure of science, Heisenberg's structure explicitly draws on von Goethe's *Naturphilosophie* by suggesting a unification of the sciences in light of modern physics into one science.

The third trend is the activation of the *naturphilosophische* ideal of poetry as a means of immediate insight and, by extension, a way to understand nature. I showed that Heisenberg uses von Goethe's poetry along with his *Naturphilosophie* in his texts. In both cases, von Goethe's work serves as a focal point in Heisenberg's attempts to develop an alternative to a materialist science, inspired by the formulation of quantum mechanics. As I suggested above, materialist science is not only viewed critically with regard to its epistemic premises but also in terms of its social influences. With the call for a poetic language and the interpretation of central concepts of classical mechanics as poetry, Heisenberg's invokes the Romantics idea of poetry as a medium for immediate insight into nature. In addition, Heisenberg's interpretation of scientific concepts as evocative of poetry serves as a confirmation for the changed relationship between science and religion (see Section 5.3.3). With a slightly different focus, Borrelli

observed a similar use of non-propositional knowledge and argumentative structures in research articles in the fields of high energy physics, including Heisenberg's own work. In these cases, the physicists were shown to develop a style of argumentation that built on patterns of plausibility, and the combination of different elements (e.g., mathematical formulae and metaphors along with claims) to offer an intuitive as well as a cognitive understanding of the theories.[503] The shift from an explanation about experience as the central aspect of religion to a poetic account of such an experience became a central form of argumentation in the Romantic religion.

In sum, the analysis demonstrated how religion serves as an interpretative framework for the structural, epistemological, and ontological consequences of quantum mechanics. Moreover, I illustrated that religion and the concept of nature, activated in Heisenberg's texts, were notably shaped and perpetuated by the humanities.[504] With the analysis of religion in the explicit discussion of science and knowledge production, I showed how religion shapes the interpretation of new scientific knowledge and nature.

8.3 Religion as an Aesthetic Repertoire for Knowledge Production

Looking at the use of religion in the discussion of knowledge production in Heisenberg's texts through the model of interference, I suggest that religion serves as an interpretative system. Unlike in the previous chapter, religion serves here as an interpretative system of concepts (e.g., *natura naturans* or beauty), and aesthetic repertoires. In these discussions and presentations of knowledge production I found two ways in which ideals of the concomitant alternatives of *Naturphilosophie* and

[503] Borrelli, 'Die Genese des Gottesteilchens.'
[504] Gladigow, 'Pantheismus und Naturmystik,' 119.

Romanticism shape the interpretation of knowledge production: first, the reflection on understanding as the immediate and full grasp of nature and second, the narration of knowledge production as experiences of knowledge.

The first way can be observed in discussions where understanding emerges as the central practice of knowledge production (see Section 7.1). This ideal of research as understanding nature is paired with the use of aesthetic judgments (e.g., beauty or harmony) as epistemic values. Borrelli showed in his study on high energy physics (which is linked to Heisenberg's own work) that the aesthetic judgments of beauty and symmetry as well as narratives became an integral part of theoretical physics in the second half of the 20th century.

The second way is the link between moments of knowledge production and the topoi of encounters of nature. These topoi (e.g., mountaineering or experience of nature) incorporate the re-definition of religion as way of sensing and feeling, a concept associated with Schleiermacher. The connection between the aesthetic repertoire of the experience of nature and moments of knowledge production leads to the topos of the experience of nature. In this context, knowledge production is no longer a cognitive accomplishment but an experience, inscribable in the tradition of the influential modern aesthetic religion.

Tied to the description of knowledge production, the aesthetic repertoire of the modern aesthetic religion gives shape to the ideal of the physicist as a man with a sensibility towards nature who stands in opposition to the "rationalist scientist" or "the man of science." Carson suggests that Heisenberg's popular writings and persona are concerned with "the sensibilities of the individual", which can be seen through the attempts in his writings to overcome the fragmentation of modern society.[505] Golinski

[505] Carson, *Heisenberg in the Atomic Age*, 261.

has highlighted the friction that arose with the emergence of a masculinity built on the sensitivity to nature as an alternative to the hyper-cognitive rational men of science, for example in the case of Davy. Sensitivity and a focus on the body draw on codes which are associated with female attributes. The scientific persona of Werner Heisenberg stands in the *longue durée* of what is referred to as Romantic genius. Taken together my analysis of religion and the aesthetic repertoire showed that religion serves as an interpretative framework to conceptualise and narrate knowledge production. Moreover, it contributes to the *imaginaire* of the physicist as a Romantic genius, whose sensitivity towards nature trumps the everyday practices of research e.g., problem solving or writing letters and papers. By rendering the practical aspect of research invisible,[506] the Romantic genius further reinforces the link between physics androcentrism.

8.4 Popular Science Writing as a Medium of Transport for Religion

A prominent interference pattern of Heisenberg's texts is the transport of religion in the medium of popular (science) writings. The reflection on the concept of religion and the use of religion (e.g., concepts or aesthetic repertoires) in Heisenberg's texts contribute to the ongoing communication maintaining the social system of religion. I showed that Heisenberg's popular writings transport religion in two ways: first, as a distinct concept of religion (see Section 8.1) and second, the offers of orientation and an aesthetic repertoire linked to the new knowledge of modern physics (see the previous Sections 8.2 and 8.3).

[506] See Sarah-Jane Leslie, et al., "Expectations of Brilliance underlie Gender distributions across Academic Disciplines," In *Science,* 6219(347), 262–265.

The concept of religion transported by Heisenberg's popular writings is a combination of different concepts of religion (e.g., social, psychological, or phenomenological) that, when taken together, present a rather generic idea of religion. This generic idea of religion is one of the reasons for the wide reception of Heisenberg's texts. In the tradition of the Romantics, Heisenberg universalises Christian concepts (e.g., "All religion" or the inclusion of non-European traditions, see Sections 5.1 and 5.2) and thus conceals their situatedness.

Central for Heisenberg's texts as a transport medium for religion is the handling of and contribution to the debate on the concept of 'religion.' The concept and view of religion change over the years. By recognising the historicity of the texts, in particular, the impact of the Second World War and the bombings of Hiroshima and Nagasaki we can see how those events affected the perception of modern physics and the role of ethics in modern society. Heisenberg uses history to dismantle the idea of an inherent conflict between science and religion is central to his claims of religion as a valuable resource for modern science and society. Along with the historical examples Heisenberg presents the development of quantum mechanics which plays a central role in reassessing the idea that such a conflict between science and religion truly exists (see Section 5.3).

The second way religion is transported by Heisenberg's writings is through the use of ideas and aesthetics that stand in the tradition of the concomitant alternatives such as Neo-Platonism, vitalism, or Romanticism (see Chapters 6 and 7). Together, they invoke a sacralised nature in the tradition of *Naturphilosophie.* He presents the idea of a living nature that is shaped and maintained by a creative force in opposition to the scientific materialists' understanding of nature.

The effectiveness of both aspects of the religion transported by Heisenberg's work results from the resonance with the shared cultural context of the

bildungsbürgerliche public and the counterculture. Consequently, this study shows how popularising texts may transport religion beyond cosmological questions and claims.[507] In these cases, offers of orientation appear separately from scientific knowledge.[508] By analytically engaging with the different layers of religion in Heisenberg's texts, I showed how religion essentially shaped the presentation of scientific knowledge along with the view of society. Consequently, the texts demonstrate the influence of religion on the discussion of modern science and society in the 20th century.

8.5 Popular Science Writings and Meaning-Making in the Public Eye

Gladigow described two ways science popularisation may be coupled to meaning-making. This thesis is dedicated to the first way, by engaging in the process of popularising science, scientists use and contribute to the communication system of religion in and through their interpretations of science. Because of this distinct focus, the second way, the production of meaning on the basis of scientific knowledge by third parties, remained in the background. However, as Gladigow notes it is an important part of the meaning-making in modern society which often not in control of the scientists involved in the knowledge production.[509] As a result this section goes beyond Heisenberg's texts to take a look at the reception of Heisenberg's popularisation of science in different media. In doing so, I show that the act of public outreach along with

[507] Ansgar Jödicke discusses this in a study of popular writings across three hundredt years of meaning-making or rather the production of orientation tied to cosmologies, 'Schöpfung und Kosmologie in der popularisierenden naturwissenschaftlichen Literature', In *Religion im Wandel der Kosmologie* edited by Dieter Zeller, (Frankfurt/Main: P. Lang 1990), 105–119.
[508] See Ibid., 111, on the distinction between popularising books that focus on scientific knowledge and discuss religion independently from the knowledge and the books that discuss the scientific knowledge and religion together.
[509] See Section 2.2 and Gladigow, "Europäische Religionsgeschichte," 296.

the texts forged the public interpretation of modern physics as well as Heisenberg's perception of himself as a scientist, modern priest, model citizen, and/or a Romantic genius.

In 1966, Werner Heisenberg gave an interview, titled "Harmony of Matter," which was published in a magazine of the Catholic Focolare movement called *Neue Stadt* [New City]. The introduction announces the interview, conducted by an employee of the magazine, T. Marzano, as way to foster to relationships with the modern world, a recommendation of the Second Vatican Council (1962–65). By situating the interview in the context of intra-Catholic politics, the introduction establishes contemporary physics as a part of the modern world, with Heisenberg as a suitable interlocuter.

> In the spirit of the Council, we visited the well-known physicists, Professor Werner Heisenberg. Werner Heisenberg –born December 5th 1901, in Würzburg, Director of the Max Planck Institute of Physics and Astrophysics in Munich– is one of the fathers of particle physics.[510]

Heisenberg's authority as a theoretical physicist is here grounded in his position as a director of a prestigious research institute. His reputation as an outstanding physicist is developed through the reference to his academic work which contributed to the procreation of physics with the presentation of Heisenberg as the father of a new tradition in physics. The introduction offers a reasoning for why Heisenberg is the right person for a conversation between a Catholic magazine (and its readership) and the modern world.

> Professor Heisenberg is a person, who thinks ahead, who sees behind all the precise experimental and theoretical physics also 'the metaphysics', i.e. the reality that stands behind the phenomenal world.[511]

[510] Heisenberg and Terzano, 'Harmony of Matter,' 388.
[511] Heisenberg and Terzano, 'Harmony of Matter,' 388.

Heisenberg is not only an authority on physics, he is also a person who cultivates connections for meaning-making on the basis of his physics research and interpretation of reality.

The persona of Heisenberg developed in the introduction of the interview places him in the position of the scientist as a priest. In contrast to this diagnosis that scientists are the new priests,[512] Heisenberg repeatedly rejects the role, and also any implication that he might be a prophet. Asked in the interview about his stance on a religious view towards the world, Heisenberg omits his position as a scientist in a rhetorical question, "if I may speak from the standpoint of a philosophy-minded person."[513] By introducing himself as a philosophy-minded person, Heisenberg distances himself from a distinct affiliation with religion, in particular Christianity and indicates his own s limited expertise in the relevant matters. Moreover, he rejects the idea that ethical claims can be deduced from the philosophical insights of quantum physics, "I do not think that there any conclusions of this kind."[514] Similarly, epistolary inquiries are answered by Heisenberg with the remark that his position is laid out in his writings and that he does not see himself in a position to go beyond what has been written. Furthermore, the analysis of Chapter 5 and 6 showed that Heisenberg's texts did not include theological conclusions on the basis of quantum physics. Consequently, the interpretation of Heisenberg as a priest of the modern world, as the introduction of the interview makes him out to be, does not stand up in light of the texts.

My analysis of Heisenberg's writings (see Chapters 5 through 7) opposes Terzano's conclusions that Heisenberg's work and writings confirm any personal belief in a creator, God.

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[512] Weber, 'Wissenschaft als Beruf: 1917/1919,'; see, Spengler, *Der Untergang des Abendlandes* for a stronger cultural critique of the growing influence of scientists.
[513] Heisenberg and Terzano, 'Harmony of Matter', 393.
[514] Ibid., 391.

> He formulated the famous uncertainty principle and, more recently, a fundamental equation of matter, also known as the *Weltformel*. It expresses, in a surprising way, a unity and harmony of nature that points a thoughtful person to the Creator.[515]

Terzano suggests that the *Weltformel* presented by Heisenberg in 1958 and developed in collaboration with Wolfgang Pauli, seems to or directly confirms theological claims. Again, Heisenberg's answer does not support the claim that the *Weltformel* allows one to draw conclusions about the Creator, but instead, his answer includes references to Plato and Platonic ideas. Heisenberg argues, for example, that his recent work confirms Platonic ideas, "[…] today we can simply say that experience has decided for Plato."[516] By linking quantum mechanics to Platonism, Heisenberg's popular writings develops new interpretation patterns.[517] The novelty of these patterns is the result of an attempt to make sense of modern physics within a wider framework that consists of the combination of known traditions, in particular neo-humanism, Neo-Platonism, *Naturphilosophie*, and Christian terminology.

Following the analysis of Heisenberg's popular communication, it becomes clear that the interpretations, put forward by the interviewer M. Terzano, as exemplified above go beyond the claims and explanations Heisenberg makes in his writings. Nevertheless, I hope I succeeded in showing that Heisenberg's texts do not so much develop new ideas but rather invoke concepts and traditions e.g., religious experience or Neo-Platonism, that have been shaping the intellectual history of Europe for some time. The novelty of Heisenberg's arguments and interpretations stems from their combinations with the epistemological questions posed by modern physics.

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[515] Ibid., 388.
[516] Ibid., 390.
[517] Raimundo Fernandez Moujan, 'Greek Philosophy for Quantum Physics: The Return to the Greeks in the Works of Heisenberg, Pauli and Schrödinger,' In *Probing the Meaning of Quantum Mechanics: Probability, Metaphysics, Explanation and Measurement*, edited by Diederik Aerts et all, (Shanghai: World Scientific 2023), 101–137.

Moreover, although Heisenberg distanced himself from taking an explicit stance on Christianity in contrast to Max Planck, or from assuming the role of a modern priest, he nonetheless occupied an important place in the cultural *imaginaire* of the West-German public. Carson claims that this comes down to the resonance of his texts and practices with the *Bildungsbürgerliche* culture. In particular, the interest in the early 19th century ideal of "the critical scientist" in post-war Germany paved the way for wider recognition of Heisenberg's persona. The recognition of a broader class of "reformist critiques" was essential for the effectiveness of his persona. The critical scientist paired the "literary intellectual" with the "liberal *bildungsbürgerliche* practitioner," now ascribed to Heisenberg's persona.[518] The persona of the *Wissenschaftler* stood in the tradition of the *Naturphilosopher*, a man who gained knowledge about the world through immediate access to nature and his ability to connect with "other realms of his experience."[519] The other realms of experience, such as politics and religion, were shaped by the shared ideals and culture of a *bürgerliche* society. Committed to the role of a coherent individual, Heisenberg was inclined "to put science and context back together."[520] The reflection on religion and the incorporation of ideals of *Naturphilosophie* is a particular aspect of this ambition and, consequently, of his scientific persona. Heisenberg embodied the scientific persona of a coherent man, speaking on behalf of scientists and intellectuals who both recognised his role and shared his values.[521] As such, Heisenberg's texts activated and successfully linked to the *bildungsbürgerliche* culture of West-Germany.

Around the same time on the West Coast of the USA, quantum physics gained in popularity within research and beyond through the combination of quantum

[518] Carson, 'Objectivity and the Scientist', 256.
[519] Ibid., 244.
[520] Ibid., 26.
[521] Ibid., 261.

mechanics with esotericism and the New Age movement. David Kaiser presented a compelling narrative of how the use of alternative traditions of doing science and relating to the world shaped the imagination of physics after the Second World War and in particular the atomic bombing of Hiroshima and Nagasaki. The neo-humanistic approach to physics by physicists, including Heisenberg, and the cultural imports of Vedantic thought were deployed in building an alternative to the physics of the war, which centred on calculations and practical applications.[522] An important factor for this movement was the foundation of the Fundamental Fysiks Group in 1975 by two physics graduates of the University of California, Berkeley. A member of the group was Fritjof Capra, a trained physicist from Austria who made a name for himself beyond the field of physics with a number of popular science books, such as the *Tao of Physics* or *An Exploration of the Parallels Between Modern Physics and Eastern Mysticism*, the latter of which being the most successful. Capra names Heisenberg as one of the people the book is dedicated to and with whom he was in contact around 1970. The preface of the *Tao of Physics* opens with a quote attributed to Heisenberg, which is only the first in a long series of references to him.[523] Additionally, the *Tao of Physics* is a seminal book of what the scholar Wouter Haanegraf described as "*New Age* science."[524] Capra builds on the premise that quantum physics offers scientific confirmations of the ideas of Buddhist teaching.

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[522] Kaiser, *How the Hippies saved Quantum Physics*.
[523] Capras dedication reads as follows "I dedicate this book to Ali Akbar Khan, Carlos Castaneda, Geoffrey Chew, John Coltrane, Werner Heisenberg, Krishnamurti, Liu Hsiu Ch'i, Phiroz Mehta, Jerry Shesko, Bobby Smith, Maria Teuffenbach, Alan Watts, for helping me to find my path and to Jacqueline who has travelled with me on this path most of the time" and the opening quotation from Heisenberg reads without a reference: "It is probably true quite generally that in the history of human thinking the most fruitful developments frequently take place at those points where two different lines of thought meet. These lines may have their roots in quite different parts of human culture, in different times or different cultural environments or different religious traditions: hence if they actually meet, that is, if they are at least so much related to each other that a real interaction can take place, then one may hope that new and interesting developments may follow," page 10.
[524] Wouter Haanegraf, *New Age Religion and Western Culture: Esotericism in the Mirror of Secular Thought*, (Leiden: E.L. Brill 1996), 62.

Kaiser suggests that the physicist's interest in Eastern thought and engagement in the counterculture was essential for the revival and the popularisation of quantum mechanics in the US. Similarly, Carson suggests that the popularity of Heisenberg's memoir in West Germany was due to its success both amongst the *bildungsbürgerliche* public and the readers of the counterculture. The counterculture in West Germany incorporated Heisenberg's non-partisan scientific commentaries into their "spirituality" and research-informed worldviews,[525] while the combination of *Naturphilosophie*, Romanticism, and Neo-Platonism resonated with the *bürgerliche* audience.

In addition, the topos of the experience of knowledge stands at the centre of the popular science book *Helgoland* from 2021 by the theoretical physicists, Carlo Rovelli.[526] Already, the title announces the central topos of Heisenberg's experience of the matrix mechanics in *Helgoland* as the central moment of knowledge production in his memoir (see Section 7.2). The first chapter of Rovelli's book opens with an adapted quotation[527] of this moment of knowledge production in Heisenberg's memoir. By embedding the topos of experiencing knowledge in the context of Heisenberg's academic achievements, Rovelli idealises Heisenberg as a genius and vanguard of humanity, with Heisenberg described as "having been the first to glimpse one of the most vertiginous of Nature's secrets ever looked upon by humankind"[528] Consequently, knowledge production is presented as a result of intuition and not only as the product of diligent work and in-depth training in physics. *Helgoland* is Rovelli's

[525] Carson, *Heisenberg in the Atomic Age*, 56.
[526] Carlo Rovelli, *Helgoland*, translated by Erica Segre and Simon Carnell, (London: Penguin Books 2021).
[527] "It was around three o'clock in the morning when the final results of my calculations were before me. I felt profoundly shaken. I was so agitated that I could not sleep. I left the house and began walking slowly in the dark. I climbed on a rock overlooking the sea at the tip of the island, and waited for the sun to come up." The quotation is not verbatim which Rovelli acknowledges in the footnote, by stating that the quotes are taken "with minimal adaptation," Rovelli, *Helgoland*, 7.
[528] Ibid., 9.

most recent popular science book on physics. Much like *Helgoland* Rovelli's book from 2017, *Reality is not what it Seems: The Journey to Quantum Gravity,* presents contemporary concepts and problems of theoretical physics as the result of a long history of insight by outstanding men, like Heisenberg. Similar to the genealogies of modern physics presented in Heisenberg's texts, Rovelli's history of physics draws links between the work of philosophers from antiquity and recent research in quantum mechanics and related fields. Consequently, Rovelli sustains and amplifies the *imaginaire* of the physicists as a Romantic genius.

The resonance of the topoi and narratives in Heisenberg's writings that contribute to the masculinity of the Romantic genius (see Chapter 7) can be observed in the titles of news articles in West Germany, for example "Intuition overcame Classical Physics [*Intuition überwand klassische Physik*]."[529] The second example is the topos of danger and the *terra incognita* (see Section 7.2) with the reference to limits and boarders "At the Limit of the Exact Knowledge of Nature [*An der Grenze der exakten Nautrerkenntnis*]"[530] and "Advance to the Limits of Thought [*Vorstoss bis and die Grenzen des Denkens*]."[531] The last example is the topos of dawn and the term of the Weltbild, "The Dawn of a New *Weltbild."*[532] In most of these cases, new articles not only adopt a phrase or idea from popular writings as their titles but also thoroughly explore these matters within the articles themselves.

The titles of the news articles illustrate further how the aesthetic repertoire of the encounters of nature shaped the reporting on Heisenberg. Moreover, once we take

[529] Gernod Eder, 'Intuition überwand klassische Physik' published in the Austrian daily, *Die Presse* in 1976 for Heisenberg's death.
[530] Alfred Püllmann, 'An der Grenze der exakten Nautrerkenntnis' published in Frankfurter Neue Presse and Weser-Kurier for Heisenberg's 50th birthday in 1951.
[531] Heinrich Pfeiffer, 'Vorstoss bis and die Grenzen des Denkens' published in the newspaper *Vorwärts* of the Socialist Party of West Germany (SPD) in 1976.
[532] K.E., 'Die Morgenröte eines neuen Weltbildes,' published in 1951 In *Badische neuste Nachrichten*, Issue (08/12/1951) 288, Badische Landesbibliothek Karlsruhe.

a look at the biographies on Heisenberg, we can observe how the topoi of encounters of nature shape the presentation of his persona as an outstanding physicist, a Romantic genius. In these cases, the aesthetic repertoire of Heisenberg's texts, in particular the experience of knowledge or mountaineering, influenced the way biographers presented Heisenberg's life or how publicists report about the development of modern physics. To illustrate the integration of these topoi and narratives into the presentation of Heisenberg's persona, I discuss three biographies on Heisenberg.

The first biography that covers Heisenberg's whole life was written by the German historian-of-science-turned-science-communicator, Ernst Peter Fischer. Fischer aims to revitalise Heisenberg as a great scientist in this biography, called *Werner Heisenberg:* A Wanderer between two Worlds *[Ein Wanderer zwischen zwei Welten].*[533] Fischer uses a language rich in metaphors to present Heisenberg as an "enlightened mind and romantic human [...] who was able to create new worlds."[534] Fischer models his biography around the topoi of mountaineering and the experience of knowledge. These topoi appear already in the title, *Wanderer between two Worlds* [535]*,* and shapes the first chapter, "Insight. The Wanderer *[Einblick: der Wanderer]*." In this chapter and throughout the book, Fischer characterises Heisenberg as a person who had the ability to *wandern* [wander or hike], from hiking in the mountains to 'wandering' in physics, while connecting these worlds by wandering between them.[536] Fischer associates this ability to wander between different social systems with

[533] Ernst Peter Fischer, *Werner Heisenberg: Ein Wanderer zwischen zwei Welten,* (Heidelberg: Springer Spektrum 2015).
[534] Fischer, *Werner Heisenberg*, 1
[535] The title of Fischers's biography shows a great resemblace to the autobiographical work by Walter Flex '*Der Wanderer zwischen beiden Welten: Ein Kriegserlebnis'* from 1916. From the letters to his parents, we can deduce that Heisenberg knew of the book and most likely read it, as he asks his parents in a letter from November 19th, 1924, to gift him the book for his 24th Birthday, with the note, "I need some 'immature idealism'" in Hirsch-Heisenberg, *Liebe Eltern!,* 82.
[536] Fischer, *Werner Heisenberg*, 2.

Heisenberg's public engagement, in which he "described atoms and quantum leaps in a plain language."[537] Together with the experience of knowledge, the topos of wandering foreshadows the imaginative genius within Heisenberg: "One night, his whirling thoughts bring him very close to the atoms and their secret, suddenly a new dimension of the world of numbers opens up inside him."[538] While the experience of knowledge in Heisenberg's memoir is located outside of him, Fischer heightens the individuality of this experience, and with it Heisenberg's imaginative genius, by locating the secrets inside of him. The experience of knowledge takes centre stage in Fischer's book with the onset of the second chapter, "One Night in Helgoland [*Eine Nacht auf Helgoland*]." The night in Helgoland is presented as a turning point for Heisenberg: "he lived no longer as a sad guest [*trüber Gast*] on the dark earth [...] Heisenberg had become the companion [*Wegbegleiter*] of a new view of reality."[539] While in Heisenberg's memoir the experience of knowledge is tied to modern physics, in Fischer's biography, it becomes a turning point in Heisenberg's life, similar to an epiphany. In this biography, the topos is a central piece of the "forgotten genius,"[540] and Heisenberg is made out to be "one of the most important thinkers of the 20th century."[541]

The second biography I address was published in 1976, on the year that Werner Heisenberg passed away. Written by Armin Hermann, the short biography is titled: *Werner Heisenberg in Testimonies and Pictures* [*Selbstzeugnissen und Bilddokumenten*].[542] A former doctoral student of Heisenberg's, Hermann had submitted a draft of the biography to Heisenberg to get his feedback. In the epilogue,

[537] Ibid., 1.
[538] Ibid., 3.
[539] Ibid., 14–15.
[540] Ibid., vf.
[541] Ibid.,, back cover.
[542] Hermann, *Werner Heisenberg in Selbstzeugnissen und Bilddokumenten*, (1976).

Hermann cites Heisenberg approval of the biography: "he wrote me, how he 'read many paragraphs with pleasure.'"[543] Hermann tells a story of an ambitious man who sought to gain a deeper understanding of nature by focusing on unity. Along with the insights offered into Heisenberg's research career, Hermann presents Heisenberg as a physicist who left a mark not only on the scientific community, but also on the political landscape of Germany.

In Hermann's biography, the topos of experience of knowledge is combined with the metaphors of the *terra incognita* and the building of bridges: "Heisenberg built a bridge and stepped on the new land." Hermann further draws on the metaphor of piety by setting the breakthrough in a "seclusion" that allowed Heisenberg to focus on "the essence" of the mathematical problem. Rather than referring to Heisenberg's memoir, Hermann interprets the breakthrough by citing from a letter Heisenberg had written in which he describes the experience as an epiphany: "There was a moment in Helgoland, in which it came to me like an epiphany."[544] While Fischer uses the narrative of an epiphany as a turning point, Hermann embeds the epiphany in the wider context of contemporary research in physics. The research that brought forth the seminal papers on matrix mechanics is characterised as "the genius' obsession with its object."[545] Unlike Fischer, Hermann emphasises Heisenberg's "nice and humble" character with a continuously balanced "sense of facts and intuition."[546] As a result, the scientific persona of Heisenberg is one of a public speaker with the ability to capture his audience's attention with "unusual intellectual clarity" and "serenity."[547] Hermann's

[543] Ibid., 148.
[544] Ibid., 31.
[545] Ibid., 32.
[546] Ibid., 115.
[547] Ibid., 109–110.

biography draws attention to the public efficacy of Heisenberg's persona and builds on the communal and political aspects of his life.

The last selected biography was written by another of his postgraduate research students, Helmut Rechenberg. After his graduation, Rechenberg turned to the history of physics to write, among other things, a scientific biography titled *Werner Heisenberg: The Language of Atoms, Life and Work: A scientific biography, and The "Joyful Science" (Youth until Nobel Prize)* [*Die Sprache der Atome: Leben und Wirken: Eine wissenschaftliche Biografie: Die "Fröhliche Wissenschaft" (Jugend bis Nobelpreis*)].[548] Rechenberg concentrates on Heisenberg's professionalisation and his research up until 1933, the year Heisenberg was awarded the 1932 Nobel Prize in Physics for "the formulation of quantum mechanics."[549]

Rechenberg's biography, by contrast to Fischer's, focuses on Heisenberg's academic work. Concentrating on the discussion of the esoteric knowledge Heisenberg worked on in 1925, Rechenberg cites the experience of quantum mechanics (see Section 7.2.3) from Heisenberg's memoir as evidence for the "dramatic events" brought by his stay in Helgoland.[550] Furthermore, the focal chapter is titled "The Breakthrough to Quantum Mechanics on Helgoland *[Der Durchbruch zur Quantenmechanik in Helgoland]*" and includes a formulation that resembles a passage from Heisenberg's memoir: for example, the swiftness of progress, "in the pollen-free air of Helgoland, he immediately recognised how he had to use Sommerfeld's integral,"[551] or "naturally this uncertainty [*Unbestimmtheit*] annoyed

[548] Helmut Rechenberg, *Werner Heisenberg: Die Sprache der Atome: Leben und Wirken: Eine wissenschaftliche Biografie: Die „Fröhliche Wissenschaft" (Jugend bis Nobelpreis*), (London: Springer 2010).
[549] The Nobel Prize in Physics 1932.
[550] Rechenberg, *Werner Heisenberg: Die Sprache der Atom*, 333.
[551] Ibid., 325

Heisenberg in June 1925, but in Helgoland he easily found the answer."[552] The experience of knowledge is present in Rechenberg's biography, although it is less prominent than in Fischer's biography and even more embedded in the discussion of Heisenberg's research than in Hermann's book. Together they contribute to the scientific persona, which Rechenberg presents as "a juvenile genius"[553], who "finalised quantum theory" during the "the golden age" of physics.[554] The three biographies use the topoi of mountaineering and the experience of knowledge to tell their stories of Heisenberg's life and his achievement, ultimately contributing to shape his scientific persona as a Romantic genius.

The positive reception of Heisenberg's popular writings lies in the efficacy of his writings. This effectiveness can be observed in different settings and takes various forms. The interview with the Catholic magazine exemplifies how Heisenberg's writings, the arguments, the ideas, the language, or the topoi are interpreted and used in other contexts, which might have gone beyond most of Heisenberg's claims and intentions. The reception of Heisenberg's texts in the counterculture shows how his ideas can be connected to various interpretative systems. Along with the counterculture, Rovelli's book stands exemplarily for contemporary physicists who draw on the scientific masculinity of the Romantic genius for which the aesthetic repertoire of Heisenberg's texts are central. Lastly, the biographies show how different topoi of encountering nature, such as the experience of knowledge, are pivotal in the narration of Heisenberg's life and the creation of his scientific persona as a *Bildungsbürger*. In addition, these topoi can also be mobilised to reinforce the scientific masculinity of the Romantic genius. Ultimately, Heisenberg's arguments and the aesthetic repertoire of

[552] Ibid., 327.
[553] Ibid., 950.
[554] Ibid., vi.

the texts shape the *imaginaire* of the theoretical physicists as well as the practices of knowledge production.

8.6 Conclusion

This chapter discussed the different interference patterns between science and religion on the basis of Heisenberg's popular writings. I showed how the discussion of religion along with the activation of concomitant alternatives, in particular Romanticism and *Naturphilosophie*, functions as facilitator for the interference between science and religion, which, in turn, confirms von Stuckrad's suggestion.[555] Furthermore, the analysis expands and confirms Gladigow's claims that science popularisation, including the popular writings of physicists, are a central mechanism of meaning-making in the 20th century. As such, scientists, like Heisenberg contribute to the communication system of religion in a functionally differentiated society.

At large, the individual interference pattern developed by Heisenberg's writings remain similar across the decades. While we can distinguish different phases in regard to some subjects and language, recurring patterns of phrases, structures, and arguments are clearly present over time. In some incidences they are almost identical, which indicates that Heisenberg might have consulted his earlier work while writing his latest texts. Nevertheless, there are significant shifts in his claims about the social role of religion and the ethics of science. I showed how the role of religion as a medium of cultural critique and a compensation of science becomes more prevalent after the Second World War.

[555] Von Stuckrad, 'Naturwissenschaft und Religion.'

Along with the political context that can be observed in and through the lecture of Heisenberg's texts, I showed how his research, in particular on the *Weltformel,* finds its way into the arguments about the aesthetic values and one fundamental unity, such as the creative force of the *natura naturans*. In the early 1940s, the prevailing interference patterns emerge from the interplay of fundamental concepts in *Naturphilosophie* with insights gained from quantum physics regarding the nature of reality. Along with *Naturphilosophie*, religion is discussed in terms of meaning-making and based on an individual's experience and belief. A decade later, in the late 1950s, the interference pattern is mainly a result of the combination of monistic Neo-Platonism with research in high-energy physics, present in the discussion of the *Weltformel*. The texts from the late 1960s refer to religion in multiple ways, as an epistemological framework to interpret the latest insights of modern physics, such as the role of the observer for knowledge production as well as a conservative stance on the importance of religion to the functioning of modern society. Nevertheless, quantum mechanics remains an important reference point in Heisenberg's writings.

Beyond the immediate influence of Heisenberg's research and political work, I demonstrated how the *bildungsbürgerliche* culture along with the traditions of Romanticism and *Naturphilosophie* shaped Heisenberg's texts. Romanticism, *Naturphilosophie*, and the classics were and continued to be transported through the *bildungsbürgerliche* culture that emerged in the German-speaking world of 19th century. In addition, the Boy Scout movement became a significant cultural force and social phenomena around 1900 – challenging *bürgerliche* ideals, notably by referencing Romantic principles paired with patriotic and anti-modernist sentiments. Part of the wider *Lebensreform* movement, the Boy Scouts movement sought out nature, experiencing nature and using it as a space to imagine social alternatives. The two cultural influences of *Bildungsbürgertum* and Boy Scouts were central for the

creation of Heisenberg's scientific persona as an outstanding physicist, a public intellectual, and a model citizen. With the focus on religion, I showed that the Romantic genius is the central scientific masculinity that informed Heisenberg's public persona. I demonstrated in this chapter that religion plays a significant part in shaping the interpretations of both modern society and modern physics within Heisenberg's popular writings.

Chapter 9 Conclusion: Religion as a Medium of Cultural Critique and a Framework for Interpretation?

In honour of Werner Heisenberg's 50th birthday, in 1951 the newspaper *Badische neuste Nachrichten* published an article titled "The Dawn of a New Weltbild [*Die Morgenröte eines neuen Weltbildes*]." Like many of the newspaper articles published in West Germany on the occasion of Heisenberg's birthday, this article recounts Heisenberg's academic achievements and situates them in the development of modern physics in the early 20th century (i.e., with respect to Einstein's theory of special relativity and the advent of quantum mechanics). Going one step further, however, the author with the initials, K.E., praises Heisenberg's research more specifically on matrix mechanics and the uncertainty principle and his demonstration of "the absurdity of a purely rational and materialist understanding of the world."[556] Together, the title and the article exemplify how elements of Heisenberg's popular writings and his authority as a physicist are coupled with claims of a new understanding of the world, a new *Weltbild*. The article recombines several of the aesthetic forms that Heisenberg used in his text, for example, the breaking of dawn, from the topos of the experience of knowledge (see Section 7.2.3). We also observe how the article uses the idea of a holistic, harmonious *Weltbild* and a critique of the materialist science of the 19th century developed in Heisenberg's writings (see Section 6.1). Not only the variety of aesthetic forms but also the use of religion found its way into the media (see Section 8.4 and 8.5). Thereby Heisenberg's texts and their reception contributed to the meaning-making in modern society through the mechanism of science popularisation.

This thesis opened with an example of Heisenberg's critique of the separation between a material and a *geistige* realm of the world which he associates with the

[556] K.E. 'Die Morgenröte eines neuen Weltbildes. Zum 50 Geburtstag des Nobelpreisträgers Prof. Werner Heisenberg.'

investigation of nature by modern science. In the ensuing investigation—which comprised a distinct focus on the role of religion in Heisenberg's writings and in extend the interplay between religion and science—I showed that the critique of a positivist science founded on classical mechanics is, indeed, a prominent subject of Heisenberg's popular writings. However, as my analysis of the texts established, this critique does not necessarily endorse the speculative corollaries of quantum mechanics that corroborate religion. Heisenberg explicitly rejects a similar interpretation of modern physics in an interview with the Catholic magazine *Die neue Stadt* and continued to uphold distinct ideas about religion and science as different spheres of modern societies. And yet people pursue "quantum theology"[557] or press on with non-technical interpretations, as demonstrated by author of the aforementioned newspaper article, K.E.,: "The faith has been overwhelmingly vindicated by knowledge. This, however, documents the intellectual achievement of the technical age par excellence."[558]

These cases illustrate how galvanising the public and in particular the media found Heisenberg's writings and his scientific persona. In shedding light on the role religion plays in Heisenberg's popular writings, the current work also extended the understanding of the dynamics between religion and science in the 20th century. Within the framework provided by the European History of Religion, I showed how Heisenberg's popular writings contributed to meaning-making through the interpretation of nature. Heisenberg's texts offer a direction to re-think and re-define modern science by incorporating the concept *of natura naturans* and further pantheistic concepts of nature or aesthetic repertoire of Romanticism in the

[557] Wilson C.K. Poon and Tom C.B McLeish 'Is there a Distinctive Quantum Theology?,' In *Zygon,* 58(1), (2023), 265-284.
[558] The original: "Der Glaube hat durch das Wissen eine überwältigende Rechtfertigung erfahren. Darin aber dokumentiert sich die geistigen Leistung des technischen Zeitalters schlechthin," K.E. 'Die Morgenröte eines neuen Weltbildes.'

interpretation of modern physics. The activation of religion (i.e., concomitant alternatives of a Christian monotheism) serve as a framework for the interpretation of the epistemological and ontological questions posed by modern physics, culminating at time in a sacralisation of nature. As a repository to make sense of new knowledge, religion persists despite or rather because of the prominence of scientific explanation in modern society. Moreover, Heisenberg uses religion as a medium to critique contemporary science and society. In consequence my study confirms Gladigow's claim that the popularisation of science is one way through which meaning is produced in a society where interpretation and orientation are largely derived from the 'immanent,' the 'world.'[559]

I chose the cultural and historical frameworks to focus on the interdependence of Heisenberg's reflection on religion (e.g., the critique of modern society) and the use of religion (e.g., the wider interpretation of modern physics). To that end, I concentrate my analysis on three layers of the texts through which I analysed the interference patterns between science and religion developed by Heisenberg's writings, in particular the contribution to meaning-making by the popularisation of science. The analysis of the first layer showed that the explicit discussion of religion is informed by often Christian concepts of religion, in particular the religious experience or religion as the foundation of ethics. The main insight gained by the study of the second layer was that Heisenberg's texts activate concepts that stand in the tradition of concomitant alternatives, such as Neo-Platonism or pantheism, which have been transported by *Naturphilosophie* or Romanticism. These interpretation patterns promote a new form of dealing with religion once science becomes a system that shapes not only the knowledge available in a society but also the politics. Thirdly I showed that the

[559] Hampton, *Romanticism and the Re-Invention of Modern Religion*, 1; Gladigow, 'Europäische Religionsgeschichte,' 296.

aesthetic repertoire of Romantic religion is linked to the narratives of knowledge production. These narratives are central in shaping the cultural *imaginaire* of the physicist as a Romantic genius.

My analysis on three levels of Heisenberg's popular writings showed that religion plays multiple roles in his texts. As a result we were able to observe different interference patterns between science and religion, including: popular science writing as a transport medium for religion; the transfer of a concept from physics (complementarity) into the discourse on the relationship between science and religion; religion as a medium of cultural critique; religion as a framework of interpretation for newly produced knowledge and the processes of knowledge production. Most notably these interference patterns are coupled with two patterns of interpretation of the new knowledge (in the form of a sacralisation of nature) and social changes (in the form of a cultural critique). Taken together these three entangled layers of religion also offered insight into the role of religion in modern society and in particular the dynamics between science and religion in the 20th century. The first pattern—concerning religion as a medium of cultural critique—is linked to discussions revolving around the term religion and a Christian concept of ethics. The second pattern is the use of concepts and aesthetic repertoires of Christianised pantheism or Neo-Platonism for the interpretation of modern physics leading to a sacralisation of nature. In Chapter 6, we saw how these two patterns are focal aspects of the *bildungsbürgerliche* culture and the Romantic answer to modernity in which science becomes a dominate paradigm of interpreting nature and society. As such this analysis contributes to our understanding of how religion remains relevant under the functional differentiation of modern society.

Moreover, I extended the model of interference introduced by Gladigow for the study of the dynamics between science and religion. As seen above, the model and the concept of interference can help to distinguish different levels of the interaction

between science and religion. The three levels on which I investigate interference pattern, are: the semantic apparatus of the explicit reflection on religion, the discourses on nature and the structure of reality, and the aesthetic repertoires of Heisenberg's popular writings. As a result, my analysis highlighted the diversity of possible interference patterns along with the varieties of historical religions and concomitant alternatives involved in these patterns. I established that Christian ethics were invoked in Heisenberg's cultural critique of modern society and, more specifically, modern science. Furthermore, I showed that the modern aesthetic religion coined by Schleiermacher plays an equally important role in the interpretation of experiences and new knowledge in Heisenberg's texts. As such, the model and concept of interference goes beyond intellectual debates on "science," "religion", and their relationship by opening up the field of science-and-religion to the dynamics between the social systems of science and religion.

In addition, the analysis of Heisenberg's popular writings gave insight into the construction of his scientific persona. By combining the role of the public intellectual with the scientific masculinity of the genius for which the aesthetic repertoire of the experience of nature proved to be an important factor, Heisenberg integrated his academic work as a physicists and the meaning-making through the popularisation of science. For his persona, religion plays a double role: first, his reflection on religion contributed to his role as a public intellectual and second, the topos of the experience of knowledge is focal for his masculinity as a genius. I expanded on Carson's interpretation of Heisenberg's scientific persona, by showing that the activation of Romanticism and *Naturphilosophie* in his writing resonated with the *Bildungsbürgerliche* culture of West-Germany and beyond. In addition, Heisenberg's scientific persona became a signpost for the scientific authority in the public eye and a model for German citizenship. Here, the intersection of the history of religion, the

history of science, and the history of the nation-state becomes acutely visible. Consequently, scientists like Heisenberg play a pivotal role in the self-fashioning of science as an indispensable part of modernity, and particularly the identification of modern nations. The scientific masculinity of the genius continues, even today, to shape the cultural *imaginaire* of theoretical physicists within and beyond academic institutions.

Beyond the interference patterns visible in Heisenberg's writings, this study brings together the historical case studies of Heisenberg's texts and the social dynamics between science and religion, which jointly highlight the changing role of religion in modern society, confirming that the popularisation of science is a central aspect of the shared history of science and of religion. As the current work showed, popular writings do not only transport religion and contribute to the meaning-making in modern society, but they further shape the social roles of religion and science as systems that allow individuals to make sense of the world. The aesthetic religion of Romanticism plays a crucial role in imagining and presenting scientific knowledge beyond the presentation of knowledge production in Heisenberg's texts. The topos of knowledge production as an overwhelming experience has further found its way into the self-fashioning of physics (e.g., Rovelli's *Helgoland*) as well as its presentation in other media, such as film (e.g., "The Theory of Everything" based on the life of Stephen Hawking). Furthermore, this popularisation shaped the landscape of religion, contributing to the pluralism of systems of meaning and, in particular, because it remodels alternatives to institutional religions.

By developing interference patterns through these references to religion, Heisenberg's writings paved the way for meaning-making that goes far beyond his texts and intentions, as evidenced by the article heralding this Conclusion. Contemporary discourses on quantum physics that exceed the arguments in Heisenberg's texts

include those of researcher programs (e.g., new materialism) and the public (e.g., practices of quantum healing or manifestation) alike. In both cases, the authority of the physicist and the theories of quantum physics are used to develop alternatives to a pure scientific materialism.

The thesis' distinct focus on religion in Heisenberg's popular writings gave further insight into the social role of science and of religion in modernity. In modern society, physics as part of science becomes an important part of self-fashioning of modernity, and meaning-making in modernity. With the challenges of modern society becoming more and more prominent, considering the growing political polarisation, the rapid expansion of technology, and a changing climate, the public faith in and resonance with scientific authorities has never been more important but also contested. What this study ultimately suggests, then, is that religion as a medium of cultural critique and a framework for the interpretation of (new) knowledge remains a prominent response to changes in modernity.

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