

## BOOK REVIEWS

# Review of Konrad Kleinknecht's *Werner Heisenberg: Reality and Its Order*

Konrad Kleinknecht, ed., *Werner Heisenberg: Reality and Its Order*, with introduction by H. Rechenberg and commentary by E. P. Fischer, translated by M. B. Rumscheidt, N. Lukens, and I. Heisenberg. Cham, Switzerland: Springer (2019), 148 pp., \$129.99.

The philosophical manuscript Heisenberg began writing in the midst of World War II is, in a word, strange. But that doesn't mean there aren't still gems to be mined within. From this posthumously published essay, here translated into English for the first time, we stand to learn a great deal about Heisenberg's wartime worldview—a relatively unknown segment of his intellectual trajectory.

"Reality and Its Order" was likely written between mid-1941 and mid-1942, a time of unimaginable intensity for Heisenberg in his capacity as head of German nuclear weapons research. It is a detailed outline of his personal *Weltanschauung*—his understanding of how the natural world is ordered and unified. Although he did share the manuscript with some of his inner circle as it was being composed, he never completed or published it. It was transcribed and published for the first time in 1989 as "Ordnung der Wirklichkeit" in Heisenberg's *Gesammelte Werke* (Collected Works), with Helmut Rechenberg's introductory essay providing historical and philosophical context. The new English edition reviewed here was issued by the Heisenberg Society and includes a translation of both Rechenberg's introduction and Heisenberg's manuscript by Martin B. Rumscheidt, Nancy Lukens, and Irene Heisenberg. It also includes a commentary by Ernst Peter Fischer that, among other things, supplies the references Heisenberg never got around to adding. In what follows, I will not discuss the quality of the translation or Fischer's commentary but focus on Rechenberg's essay and, of course, "Reality and Its Order."

Rechenberg was perhaps the preeminent Heisenberg scholar at the time of his writing the introduction, but significant historical advances in the intervening 30-odd years importantly recolor his analyses. For instance, Rechenberg's extensive discussion of Heisenberg's philosophical influences wholly neglects one of the most important figures in this context: mathematician and neo-Kantian Grete Hermann. Echoes of Hermann's sophisticated philosophical stance reverberate throughout "Reality and Its Order." This is unsurprising; recent scholarship on Hermann (e.g., Crull and Bacciagaluppi 2017), in tandem with a newly published collection of her essays and scientific correspondence (Hermann 2019), not only demonstrates the depth and clarity of Hermann's thought but also reveals the extent to which

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Heisenberg was aware of, and explicitly influenced by, her writing. Several of the main theses in “Reality and Its Order” are taken nearly verbatim from Hermann’s 1935 essay on the philosophy of quantum mechanics (translated into English in Crull and Bacciagaluppi [2017]), published with Heisenberg’s benediction while she was briefly part of his *Leipzigkreis*. The same is true of her 1937 essay on the epistemology of modern science (reprinted in German in Hermann [2019]), which was submitted for—and won—the Avenarius Prize, with Heisenberg on the adjudication panel. The “Reality and Its Order” essay is worth studying on these grounds alone: to explore more fully the undeniable impact of Hermann on Heisenberg’s evolving views in these pivotal years, especially in connection with notions of language and objectivity; the quantum versus classical modes of description; the kindred concepts of chance, determinism, and causality; the idea that quantum mechanics involves holism (in the sense that there are no truly closed systems); and—in step with Bohr’s point of view also—the irrevocable dependence of quantum mechanical results on observational context.

Goethe is another important figure for Heisenberg; Rechenberg’s introduction and Fischer’s commentary do provide much-appreciated context here. As we learn from section 1 of “Reality and Its Order,” Heisenberg will adopt an approach in keeping with Goethe’s ordering of reality, moving from accidents (particular sensory perceptions) to scientific patterns, then beyond to ethics, religion, and imagination/ingenuity. Unsurprisingly, Heisenberg is most articulate regarding the ordering of scientific reality (this constitutes the heart of the essay, sec. 2–5), only afterward briefly describing the nonscientific orders: section 6 is titled “Symbol and Gestalt” and discusses language, art, science qua discipline, and community, whereas in the final section (sec. 7, “The Creative Forces”), he tackles religion, “illumination” (a better translation would be “transcendence”), and even politics. The nonscientific sections are where Heisenberg invokes the German idealists; it is also where his train of thought becomes somewhat obscure. Nevertheless, these sections of the essay will no doubt prove fascinating for those interested in examining Heisenberg’s wartime thoughts.

Returning to the richer scientific sections, Bohr’s name must again be mentioned here. Bohr’s twin principles of complementarity and correspondence serve as cornerstones in Heisenberg’s structure of reality, and the edifice built thereon introduces new fodder for two key debates: (i) In *this* time period, did Heisenberg consider quantum theory primarily a useful calculational tool or a description of fundamental reality? (ii) What did it mean for Heisenberg *in these years* to label a scientific theory “closed” or “complete”?

Regarding (i): When Heisenberg applies complementarity and correspondence to his ordering of reality, he accomplishes a few novel things. Among these, he articulates an arguably quantum-fundamentalist view wherein higher-level laws like those of chemistry emerge in the limits circumscribed by the correspondence principle, and the meaningful application of certain concepts relevant to a given domain of inquiry is also restricted by those limits (recall, e.g., Heisenberg’s frequent published comments about the failure of classical concepts to apply strictly in quantum mechanics). But any parallel one might see between Heisenberg’s ordering of scientific disciplines and the old familiar intertheoretic reduction exercises stop

here: Heisenberg does not proceed from the quantum-grounded physical sciences to biology, psychology, and so on. Instead, he now “reboots” his framework, beginning anew with an ordering for the life sciences that is, in the full sense of the word, *complementary* to the ordering just established for the physical sciences. Thus Heisenberg’s order of reality cannot be interpreted as a hierarchy of fundamentality, complexity, generality, or the like, but instead, the fundamental theories on *both* sides (quantum mechanics for physical sciences and biology for life sciences) share important features that give their laws “superordinance” over the suite of laws contained within each as limiting cases. Just as “the laws of quantum theory are superordinate to those of classical physics, incorporating them as a restrict case” (59), so biological laws provide the grounds for different ways of understanding organic life, from embryology to Darwinian evolution to human consciousness and psychology.

The life sciences must stand in a complementary relation to the physical sciences and cannot be subsumed by or reduced to them because there is a notion of complementarity also at play *within* the first-order life science (biology) as well as the first-order physical science (quantum mechanics). The roles of complementarity in quantum theory are well known. The parallel Heisenberg sees with biology is also a continuation of Bohr’s thinking on the subject: the concepts of biology are all fundamentally “materialist” or “vitalist,” and these two concepts (as is evident, e.g., in Driesch’s work on entelechy) are in fact complementary in *multiple* senses. Here we again clearly see Hermann’s influence: in her 1935 essay, she provides a clear taxonomy of three different senses of Bohr’s complementarity within quantum mechanics, and Heisenberg uses precisely these three aspects to describe complementarity in biology. Here are two: First, materialism/vitalism modes of description are complementary, just like Hermann’s quantum/classical modes of description. Second, an organism’s state, on the one hand, presents a description that is objective (or approximately so) in space and time but, on the other hand, as the sum of possible outcomes. This shadows Hermann’s notion of complementarity of the quantum mechanical state, which within a single context evolves deterministically according to Schrödinger’s equation and so provides an objective space-time description of the system, but across more than one observational context, this state can only assign probabilities to possible final states.

Regarding (ii): I leave the exercise to posterity, but sprinkled throughout his description of the physical sciences and their complement in the life sciences are a number of fascinating statements about the closed-ness or completeness of a given theory, system, or concept. There is much to be investigated on this point, for although the notion of a closed/complete theory plays a dominant role in Heisenberg’s postwar philosophy of science, it is all but absent before that—the sole exception being a discussion of the “incomplete-ability” of quantum mechanics in an unpublished response he wrote to the Einstein, Podolsky, and Rosen (EPR) paper (Bacciagaluppi and Crull 2011; see also Bacciagaluppi and Crull 2023). “Reality and Its Order” introduces these notions in their near-nascent form; thus, the story of their coming to occupy a central role in his thought might now be better understood.

By focusing on the philosophy of science aspects in this wartime *Weltanschauung* of Heisenberg’s, I have left out a great deal that may be of potential interest; this

includes various topics like consciousness, music and art, creativity, and issues relevant to German idealism (e.g., the self as subject and how awareness of the self generates—and necessitates—the otherness of nature). Deeper dives into Heisenberg’s treatment of these topics alongside those concerning his philosophy of science likewise promise to be fruitful.

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## Review of Jeffrey McDonough’s *A Miracle Creed: The Principle of Optimality in Leibniz’s Physics and Philosophy*

Jeffrey McDonough, *A Miracle Creed: The Principle of Optimality in Leibniz’s Physics and Philosophy*. Oxford: Oxford University Press (2022), 234 pp. \$74.00 (hardcover).

It is well known that Leibniz is both a bold philosopher and a pioneering scientist, but it is unclear to what extent his philosophy hangs together with his scientific activities. The difficulty of this question arises partly because many of Leibniz’s scientific works are scattered in small pieces that tackle only specific technical problems, and it is hard to see how these fragments contribute to a systematic, philosophical understanding of the world like the one described in the *Monadology*. In *A Miracle Creed*, Jeffrey McDonough has successfully identified a leading thread that runs through some of Leibniz’s scattered scientific pieces: the principles of optimality. As the name suggests, the principles of optimality state that natural things and events exemplify the best (i.e., optimal) arrangement, and they are obviously rooted in Leibniz’s conviction that the actual world is the best of all possible worlds. McDonough’s main claim in this book is that the principles of optimality “gained specific content and structure . . . through Leibniz’s efforts to apply it to a series of particular problems in optics, mechanics, and statics between the years 1682 and 1697,” and through this more substantiated understanding of