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Rare Encounters: A Review of Wiltsche and Berghofer's *Phenomenological Approaches to Physics*

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Harald A. Wiltsche and Philipp Berghofer are not the first editors to assemble a volume on the relationship between modern science and phenomenological philosophy (see for example Ströker 1987; Hardy and Embree 1992), but the first who present their collection to scientists and phenomenologists alike. Already the conference, where several of the chapters originated, was attended by a number of physicists. This mutual engagement with the specifics of physics can only be welcome, just as many of the papers' contributions to connecting phenomenology and mainstream philosophy of science.

Engagement with the specifics of physics and comprehensiveness can be conflicting goals. The editors' fifty-page introduction is meant to ease the transition for physicists who have not yet encountered phenomenology. This bird's eye view covers so much ground in accessible terms that it might equally serve as a first reading in an overview course or as a background paper for a philosophy of technology class, even though the large range of topics and authors does not allow to introduce the specifics of existing debates and competing interpretations. Among the eleven papers that follow, the most focused contributions are on phenomenology and quantum mechanics as well as the origin of the gauge principle. The volume also contains chapters on the relationship between physics and mathematics, the scientific realism debate, and existentialism in the work of Hermann Weyl. To give a sense of the book as a whole, I begin with a brief summary, then return to the big picture sketched in the introduction, and finally identify some overarching questions.

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1 Contributed Papers

Robert Crease's opening paper "Explaining Phenomenology to Physicists" asks fittingly how practicing physicists could be convinced of the value of phenomenological reflection. His narrative is built around the metaphor of science as a workshop, in which natural phenomena can be "framed" by theory and revealed in experiment. Analytic philosophers stand side by side with the scientists, but investigate the logical properties of the frame, rather than the framed objects. Pragmatists step out of the workshop and recognize science as a cultural phenomenon, but only phenomenologists, according to Crease, can question the very practice of framing nature in a workshop. Here, phenomenology is understood as a form of *prima philosophia*, "another science of broader scope that is able to reflectively justify scientific activity" (58). As his opponents, Crease cites physicists who take philosophy to be a useless enterprise (most notoriously, Hawking and Mlodinow). Crease raises an important question, but his case for phenomenology could be more convincing if it addressed the concerns of his putative opponents in more detail. Unfortunately, Crease writes little about either Hawking and Mlodinow's pessimism about philosophy, nor non-phenomenological approaches to philosophy of science.

Mirja Hartimo's chapter "Husserl's Phenomenology of Scientific Practice" suggests that Husserl "is the first philosopher who took seriously the importance of concrete and diverse scientific practices" (64). But while this claim is singled out in the editors' summary (38), its defence does not appear to be the main ambition of the paper—otherwise one would expect to read about authors like Bridgman, whose operationalism dates back to 1927, or at least the pragmatist tradition. Instead, Hartimo traces the shift in Husserl's understanding of the relation between mathematics and mathematical physics from his middle period to the late *Formal and Transcendental Logic* and *Crisis*. While at the time of *Ideas I*, Husserl assumed, like his Göttingen colleagues Hilbert, Minkowski, and Klein, a kind of "pre-established harmony" between mathematics and physics (67), Hartimo identifies this assumption with the Galilean mathematization of nature, which Husserl rejects in his late work. In turn, mathematics and formal ontology become distinct projects, which gives physics more independence from mathematics (71). Mathematical investigations are independent of their applicability to the world, and where mathematics is applied successfully, there remains a distinction between the physical object and the mathematical model that fits in some respects but not in others. This shift is central for understanding Husserl's criticism of mathematization and should be given more attention, in particular for contributions that draw on multiple periods of Husserl's work. Metaphilosophically, Hartimo suggests that phenomenology should be understood as a metaphysically neutral set of methods, which is compatible with a minimal naturalist stance (75). Regardless of this compatibility, it seems to me that taking Husserl's later *rejection* of pre-established harmony at face value is to accept a metaphysical consequence of phenomenological philosophy, not just a methodological commitment.

Paolo Palmieri offers case studies of Galileo, Helmholtz, and Heisenberg, but in a rather idiosyncratic style. The title "Physics as a Form of Life" is not an allusion to Wittgenstein, but more literally the arc of the paper: the three case studies are

presented as exemplars for youth, old-age, and the posthumous maturity of *physics*. Palmieri formulates his guiding question as "why is it that the axioms of mathematical physics are not self-evident, despite the evidence and clarity that is gained through the deductive processes that flow from them?" (80). A similar question appears in §9 i) of the *Crisis*, where Husserl discusses Galileo's transformation of the concept of nature. It seems, however, that Husserl poses this question as *what a Galilean physicist would wonder*, when trying to axiomatize the mathematical manifold "physical nature." Since Husserl argues precisely that nature is *not* a mathematical manifold, this question does not appear to be Husserl's, but of course might be motivated independently. The case studies show what is first taken to be a naïve (Galilean) conception of nature as mathematical and then a more sophisticated conception that arises from Helmholtz's study of the psychophysiology of hearing, which motivated the introduction of complex ("imaginary") numbers. The posthumous phase of physics is ushered in by Heisenberg's search for a quantum theory that explains the spectral lines. Here Palmieri takes Sommerfeld's assertion that quantum mechanics is a "hidden organon" on which nature plays the "music of the spheres" and runs with it. The non-evidence of first principles of physics is finally explained by physics "concealing" its fundamental principles from the physicist who has the blasphemous intention to consider the universe as a whole. As he writes: "Physics must have recognized the morally evil character of her own existence. She invokes her own self-destruction" (104). Palmieri's chapter selects interesting examples but demands from its reader a rare combination of familiarity with higher mathematics and a tolerance for second order metaphor, while not always spelling out how the case studies contribute to the conclusion.

Norman Sieroka turns to some late "existentialist" moments in Hermann Weyl's philosophy of science, which is presented as a middle path between Heidegger's existentialism and Cassirer's scientism. The contrast to Cassirer is interesting—limiting the realm of symbolic forms to the natural sciences, rather than extending it to all of human culture—but developed in merely a page. The real subject of this chapter is how Weyl's "existentialism" offers a more nuanced picture of science than Heidegger's. The existential strand in Weyl stems from his recognition of a "double position of the ego" (112): when all rational questions have been answered, some existential questions remain open—it would still make sense to cry "but why did *I* have to be Judas?" The existential question of guilt is contingent on being this person rather than another, but no scientific theory can explain this contingency. What Weyl concludes from this is that the rationality of symbolic construction has to be balanced with existential reflection. But unlike for Heidegger, this existentialism does not lead to an "anti-scientific attitude" (111), because scientists also have a pre-theoretical relationship to the world. Sieroka argues that the "obvious" (115) analogy is that everyday tool use and scientific calculation are not that different after all. Programming an algorithm or preparing a cell culture can be as much a daily practice as ploughing an acre (116), so even the scientist need not have a formalizing, abstract relationship to the world. I would have found this argument more convincing if it also addressed the differences between implicit and explicit or propositional and practical knowledge. These seem more robust ways to distinguish hammering nails from (potentially familiar) programming, and one could wonder whether this

affects their mode of being. And even if the analogy can hold across the difference between propositional and practical knowledge, a priority of the quotidian would still need more justification. But independently of these questions about the practical and everyday side of scientific research, Weyl's "double position of the ego" deserves further exploration—a strikingly similar idea appears for example in Thomas Nagel's work on objectivity (1986, Chap. 4).

Matthias Egg presents Habermas' criticism of Husserl in the context of contemporary philosophy of science. First, Egg bridges ontic structural realism and Husserlian phenomenology: Ladyman and Ross might disagree with Husserl about *what* constitutes the furniture of the world, but they agree in their assumption that subjects can take up an entirely disinterested "theoretical attitude." Husserl at least seems to waver regarding this commitment: in §11 of *Ideas II*, the subject of the theoretical attitude is described as still having an interest in the production of theoretical knowledge.[1] On Egg's reading of Husserl, this is only a preliminary state. Scientific objectivism fails to achieve the truly disinterested theoretical attitude because of its unawareness of the lifeworld. Transcendental phenomenology, however, promises to finally realize the full theoretical attitude of a "nonparticipating spectator" (128, quoting the *Vienna Lecture*).

Habermas then argues that the "life-orienting role for science" cannot be recovered from the theoretical attitude without presupposing that theory mimics a cosmic order. Habermas is steadfast in the rejection of metaphysics, but Egg could also be taken to argue for the metaphysical non-neutrality of phenomenology (*pace* Hartimo). What he ultimately suggests is a parallel between Husserlian phenomenology and ontic structural realism (OSR). Proponents of OSR understand mathematical structures, rather than objects which instantiate these structures, to be the fundamental reality tracked by scientific theories. Especially Ladyman and Ross have been vocal in their criticism of armchair metaphysics (Ladyman & Ross, 2007, Chap. 1), which might make this comparison surprising. But Egg argues that both OSR and Husserlian phenomenology can be understood as the articulation of scientistic and phenomenological *stances* in van Fraassen's sense. Like for Ratcliffe (2008, Chap. 9), van Fraassen here might offer a way to talk about the metaphysical commitments of phenomenology without attempting metaphysical explanation or doctrine.

Lee Hardy, by contrast, tackles the question of scientific realism head-on and along the way presents a comprehensive interpretation of Husserl's philosophy. Against many interpreters, Hardy argues that Husserl's philosophy is indeed compatible with a form of scientific realism, and his criticism of mathematization only leads to an anti-realism about precise natural laws. Entities that are introduced on the basis of theories are non-instrumentally meaningful, even in the absence of possible perception of said entities. The chapter is not only written with great clarity but also has the virtue of discussing *why* other interpreters have come to a different reading of Husserl. Readers of *Nature's Suit* (Hardy, 2013) will be familiar with much of the argument, but the condensed presentation is useful and compelling. Hardy also adds new considerations about how motivation and sign-consciousness could help to account for the givenness of theoretical entities. Where I believe a scientific realist would still find

[1] I thank an anonymous reviewer for this reference.

Husserl's account to fall short is regarding Husserl's notion of truth. Hardy rejects the idealist interpretation, according to which *the givenness* of a proposition is what makes a proposition true (cf. my discussion of de la Tremblaye below). But even if what makes a proposition true is the state of affairs, not its givenness, the correlation between truth and a form of possible givenness entails knowability for every true proposition. Coinciding scopes of true and knowable propositions are often taken to be the hallmark of an anti-realist metaphysics (Dummett, 1978, 146; critically Künne 2003, Chap. 7; and Williamson 2000, Chap. 12). If truth is really independent of its recognition (rather than a shorthand for "belief at the end of inquiry"), it requires an explanation why the in principle knowable and the true should coincide. This casts some doubt on whether Husserl could firmly set foot in a realist camp, but Hardy here appears to be on a very fruitful avenue, especially for enabling engagement with debates beyond the phenomenological tradition. And like the ontic structural realists, this form of phenomenological scientific realism would come with its own criticism of how metaphysical realism is classically construed.

Arezoo Islami and Harald Wiltsche discuss *Wigner's puzzle*, according to which the appropriateness of mathematics for physics is a "wonderful gift which we neither understand nor deserve" (158). The authors do not dwell on terminology or exegesis, but rather present their own proposal from the ground up, illustrating technical notions with very simple but helpful examples. Genetically ("diachronically"), they argue that contemporary physics is not actually a study of phenomena like motion in the everyday world, but already begins with an idealization, like the mathematized notion of movement that is captured by the differential equations of Newton's theory. Because physical theories can no more be understood without reference to such idealizations, "objects in physics are constituted differently than the objects of everyday experience" (167).

The authors then continue with a static ("synchronic") analysis of an act of mathematization. The key step is that mathematics can be applied in experiments by determining the horizon of a perceived object. That scientific theories affect the horizons of perceived objects seems accurate, but to talk of perceiving a physical thing "through" a mathematical noema is a bit puzzling. Several technical concepts from phenomenology work together when the authors write that the "shift of attitude is the result of intending the probe through a very specific noema, namely through the ideal mathematical content '$\mathrm{F}(P)=e \cdot \mathrm{E}(P)$'" (171). This noema is supposed to function "like a filter, screening off all sensible properties" (172). It is understandable that the authors are not interested in rehearsing debates about the noema, but to then use the concept without explicit comment on its interpretation opens much room for misunderstanding. And finally, the chosen example appears to skip a number of steps. The noema that serves as a filter is an identity statement, and this ideal mathematical content plays a particular role in representing a concrete particular. Other acts switch between ideal and straightforwardly perceptible contents, but they retain a structural similarity. In the case of seeing a round shape and intending a mathematical circle, we are moving from a one-rayed act directed at a concrete object to a one-rayed act directed at an ideal object. The authors' example moves from a proposition that asserts an identity—the matter of a categorial, multi-rayed act—to a concrete perceptual object, which should be the object of a one-rayed act.

A different interpretation of mathematization is suggestive and seems to inform the editors' introduction (23). What happens when we intend a mathematically ideal circle on the basis of an imperfect drawing is that a second act is "founded" upon a perceptual act. But this founded act is directed at the determinate, idealized circle, rather than offering another way to relate to an indeterminate, perceivable object. The objectivist then takes perceptual objects to be mere "signs" that stand for the determinate natural world of scientific theory. But it is already the founding, perceptual act, which is directed at reality, not its scientific apprehension.

Ultimately, this can be understood as depending on how morphological and exact essences are related (Husserl, 1982, 166 f.). When perceptible objects instantiate shape-like properties, are these exact properties? Or are exact properties idealizations? Wiltsche's and Islami's account, I take it, requires that perceptual objects have some exact properties, and we can be directed at them *through* some of these exact properties. This would work if there is a pre-established harmony between physics and mathematics, but not if there is a categorial difference between inexact (perceivable) and ideal essences (see Hardy, 149, maybe Hartimo, 70, and Drummond 1984, 790). How could, on the latter account, an inexact perceptible object be intended through a mathematical noema? These questions turn on the interpretation of Husserl's noema, which the paper does not purport to offer. But without an explicit interpretation, the technical vocabulary soon becomes ambiguous.

Thomas Ryckman spells out the phenomenological motivation for Hermann Weyl's gauge principle. This principle of theoretical physics is remarkable for its origin in the context of general relativity but finding its later application in quantum electrodynamics and to this day, the Standard Model. This chapter might paradigmatically show that phenomenology already *had* a significant influence on theoretical physics. The chapter is lucidly written but goes through quite advanced terrain which presupposes some familiarity with tensor calculus notation. It will be mostly accessible to physicists who want to learn about the philosophical background and theoretical motivation of the gauge principle.

But even without an interest in the mathematical side of science, phenomenologists should look into Weyl's and Ryckman's work. Husserl's correlationism is often taken to require that any state of affairs which is postulated through physical theory has a corresponding (ideal) possibility of givenness (Wiltsche, 2012, 2017). Weyl's understanding of scientific theory as a "symbolic construction" of the world presents a more holistic understanding of the content of theories (187), which does not require a possibility of direct givenness for every postulated state of affairs. It is therefore attractive for phenomenological philosophers of science with realist inclinations.

The final three essays discuss quantum mechanics, beginning with an arresting contribution by Steven French. In its historical ambition, the paper traces how London and Bauer's 1938/39 interpretation of quantum mechanics is based on phenomenological philosophy but entered mainstream discussion only through Wigner. The philosophical head in that collaboration is London, who, before his career as a physicist, had written a philosophy thesis supervised by Pfänder and published in the 1923 *Jahrbuch* (Gavroglu, 1995, 15).

Wigner cites Bauer and London when developing a thought experiment that extends Schrödinger's cat and is now known as "Wigner's friend." Wigner concludes

that quantum mechanics gives conscious observers a different role than inanimate measurement devices. This interpretation was fiercely rejected for requiring a dualistic interpretation of mind and body, with no plausible account of their causal interaction. But this is precisely where the phenomenological origin of the view matters. The collapse of the wave function is not the result of a *causal* interaction between experimenter and apparatus, but the result of a reflective separation between observed and observer. On this basis, French suggests that the phenomenological origin of London and Bauer's proposal is not merely a historical oversight but a live option. French sketches the route to defending it systematically by combining aspects of different standard interpretations of quantum mechanics, especially relational QM and the many minds interpretation, and anticipates objections and responses. French's paper is an absolute highlight in this volume—not only for what it achieves, but also for the bridges to further research that it opens.

Michel Bitbol's contribution focuses on the Quantum Bayesian (henceforth 'QBist') interpretation of quantum mechanics, which he discusses in relation to Merleau-Ponty's reflections on encountering the flesh of the world. The introduction of Bitbol's paper shows that this is taken in a more strongly antirealist spirit than the previous contribution by French. On Bitbol's account, the lesson from quantum mechanics is not that the world has a relational structure, but that we should give up the pre-critical "dream of reason" to find a representation of "things as they are" (229). Quantum theory can "not even offer a hint" in this regard (230). The phenomenological epoché suspends the assumption that successful theory represents the world. Bitbol argues that exactly the same happens in QBism: rather than understanding the state-vectors as properties of physical systems, they describe the rational bets about experimental outcomes. The consequence of the non-representational nature of quantum mechanics is that QM can only teach negative lessons about the structure of the world: it can only show which metaphysical picture fails, without providing a new picture to replace it (238, 240).

However, the lessons that Bitbol draws from the QBist interpretation are not entirely quietist, despite appearances to the contrary (237). Bitbol turns to Merleau-Ponty and Michel Henry and their theory of cognition as embedded and embodied, culminating in the claim that "since the flesh is the whole world, any division between the constituter of objectivity and the constituted object is meaningless" (236). QM, on Bitbol's account, teaches the same lesson: the probabilities of QM are neither epistemic, nor objective propensities, nor indicating metaphysical indeterminacy, but "express the indivisibility between the act of knowing and what is to be known" (240). Why this indivisibility has to be expressed in precisely these probabilities, however, remains without discussion. It would also have been interesting to read more to dissolve the apparent tension between understanding quantum states as mere norms for betting behaviour and QM teaching a fundamental lesson about the place of the mind in the world.

Laura de la Tremblaye's narrower focus gives her paper a clear agenda: to show that the QBist interpretation of measurement can be understood in terms of Husserl's account of perception. More precisely: "the state vector is the analogue of the *internal horizon* of an object […], the anticipated possible profiles correspond to the eigenstates that compose [the] quantum state before the measurement" (254). This

proposal is only the more significant since QBists have looked to William James' pragmatism, rather than to the phenomenological tradition.[2] The proposal is very clearly presented, with the examples of measuring a particle's spin state and observing a cup fall to the ground. Upon measurement, the physicist updates her information to optimize subsequent bets. Seeing the cup shatter on the ground likewise updates its internal horizon, because it is no longer expected to survive the fall (255).

The analogy is very suggestive, but it seems to require a fully idealist reading of Husserl, in which also everyday objects depend on our perceptions of them. For the QBist Fuchs, quantum states are states of knowledge, rather than representations. De la Tremblaye argues that such states of knowledge correspond to the perceptual horizons. As an account of perception, this seems to emphasize the noetic, subject-side of the intentional relation. On this noetic reading of the horizon, the belief in the colour of a perceptually given surface refers to further beliefs about the colour of its adjacent surfaces. But one could also take the coloured surface itself to point toward a continuation of the same colour in its vicinity. The difference becomes important when we consider the cup before looking. Not knowing whether the cup has shattered or not can affect the noetic horizon. But would I not approach this situation in the knowledge that the ambiguity between a shattered and non-shattered cup is a contribution from my own ignorance—and that the actual cup has either shattered or not, even before I look (cf. empty and determinately prefigured horizons in Husserl 2001, § 2/p. 46)? Unfortunately, de la Tremblaye does not write about how to think about the unobserved cup. It seems that, if the analogy with QBism is taken seriously, the state of the cup could only be understood in terms of the noetic horizon: it is indeterminate, as long as there is no observation. Hence, the analogy to QBism seems to require an idealist reading of Husserl (pace Hardy). But to explain what it means that the cup is neither broken nor unbroken before I look seems only gradually different from the counter-intuitiveness of Schrödinger's cat, a discussion of which would have been a helpful addition to this paper.

These 11 chapters have been split into three parts. While part III has a clear focus on quantum mechanics, the unity in parts I and II is harder to make out. The partition also separates chapters that would have been good candidates for appearing together, such as Sieroka's and Ryckman's papers on Weyl, or Hartimo's and Islami and Wiltsche's papers on the relationship between physics and mathematics.

2 Commentary

With a brief summary of the individual chapters in place, I can return to the editors' opening chapter, which carries the subtitle "Mapping the Field" (1). They begin with a rejection of the continental-analytic division and promise that "phenomenological reflections […] provide rich resources for addressing many of the most pressing

[2] The exchange between phenomenological philosophers of science and physicists working on the QBist interpretation of quantum mechanics is ongoing. The editors of the reviewed volume have organized a conference "QBism and Phenomenology" at Linköping University in Sweden; due to the pandemic, this meeting has been postponed to June 2022.

issues in (philosophy of) physics" (3). The characterization of phenomenology that follows is that of an a priori, foundationalist first philosophy which investigates the necessary structures of first-personal experience. Unlike the third-personal natural sciences, which systematize collected data, phenomenology "is concerned with how we look at the world" (9). These points suggest more sympathy for the Fregean interpretation of the noema and seems in contrast with an understanding of phenomenology as a world-involving inquiry (presented for example in Zahavi 2017, Chap. 4), but this is not discussed explicitly. The editors also add a brief discussion of Heidegger, hermeneutic philosophy of science, and Merleau-Ponty. This large arc is spanned with remarkable clarity, which recommends the chapter as a background reading for introductory courses. And the 119 book and article references alone are a valuable resource for anyone surveying the literature on phenomenology and natural science.

That the introduction aims for "mapping" a field, however, might suggest a bit too much unity about what a phenomenological approach to physics amounts to. The price for the condensed presentation of phenomenology is of course that dissenting readings are not spelled out, which furthers the same impression. The most obvious room for such disagreement concerns the relationship and commitment to metaphysical claims, which remains in suspense. Symptomatically, the crucial concept of "constitution" is used, but not further clarified, which may be a stumbling block for the initiated and uninitiated alike. I end by spelling out disagreements between the contributions and further questions that would be worthy of discussion in their own right.

Questions about realism and anti-realism are the most obvious recurring topics. One contribution engages with the topic directly (Hardy), but more common are statements to the effect that the question of realism is hard to spell out for phenomenology (Wiltsche and Berghofer, French), has been transcended (Bitbol, de la Tremblaye), or that phenomenology is metaphysically neutral or orthogonal to metaphysics (Hartimo, arguably Islami and Wiltsche). Hartimo's paper, however, defends the idea that there is *no* pre-established harmony between mathematics and physics. If phenomenology can sustain such a claim, this might be taken as a metaphysical implication after all. Egg argues that there remain metaphysical assumptions in phenomenology, but that this could result in a problem. Whichever take one prefers, these proposals seem substantially different.

Another recurring question on which the contributors implicitly disagree is whether phenomenology amounts to a *prima philosophia*: is phenomenology before all scientific knowledge, or are there cases where phenomenology defers to scientific results? That phenomenology should be understood as *prima philosophia* is quite apparent in Crease's and Bitbol's chapters, whereas Hartimo most clearly disagrees, taking phenomenology as a set of methods for studying the history of science. The introduction is also written in the spirit of classical phenomenology as the founding science of all sciences. But when the editors turn to Merleau-Ponty, they suggest that developments in the sciences themselves can undermine the natural attitude. QM makes limits of third-personal description apparent and necessitates a relational understanding the natural world. On this account, the metaphysical insight grows out of empirical research, not an independent a priori reflection.

More specific questions arise for interpretation of scientific idealization and the relationship between mathematical and physical essences. Hartimo spells out in detail how Husserl's view developed from *Ideas I* to *Formal and Transcendental Logic* and the *Crisis*, and this distinction is also central for Hardy's criticism of realism about laws. Physical things instantiate shape properties, but the morphological essence of these shapes are not identical with the formal essences studied by geometry. This distinction between the empirical essences of real physical things and the ideal essences studied in formal sciences is central for Husserl's late account of the "substruction" of a mathematical manifold for empirical reality. But it is not a distinction that can be found in Islami and Wiltsche's paper, which fits better with the pre-established harmony of the *Ideas I* (see also the Introduction, p.19).

For those who approach the volume with a background in general philosophy of science, a notably absent topic is inference to the best explanation. The introduction presents phenomenology as justifying its claims only by intuition, not by logical (or abductive) inference (10), but what this entails for the scientific use of such inferences remains open. There are hints that there might be substantial disagreements: Ryckman's paper mentions that Weyl's account of symbolic construction allows for a holist form of theory confirmation. This could be understood as a break with the stricter version of Husserl's epistemology that demands an intuitive basis for any meaningful posit (see the Principle of all Principles, Husserl 1982, §24). As an anonymous reviewer has pointed out, Berghofer also attributes Husserl a more permissive understanding of justification, that allows for justification by "mediate inference" (Berghofer 2018, 14). However, this is not what distinguishes inference to the best explanation from deductive and inductive inference. And if phenomenological semantics or an independent principle or correlation requires that all true propositions could be given intuitively, this limits the scope of candidate explanations in any case, even if they can be justified through mediate inference. In the light of these open questions, a phenomenological discussion of inference to the best explanation and its relation to apperception would be most welcome (Vallor, 2009 discusses related issues with respect to Merleau-Ponty).

It would be impossible for a single volume to address all questions that could be raised about phenomenological approaches to physics and the sciences more generally. The huge topics of embodiment and non-propositional representations in scientific practice, for example, are only broached in Bitbol's paper, and could have been pursued in Sieroka's. Hartimo defends Husserl as a practice-first philosopher of science but does not discuss non-representational knowledge.

In the light of these different grand schemes of things, it might be too soon to consider the present volume as presenting a clearly outlined "field." But the ways towards such a field are much more clearly in view. *Phenomenological Approaches to Physics* is to be commended for its relative accessibility to non-phenomenologists, the sophistication with which it engages with physics, and for constantly having contemporary debates in view. Most of the best papers also do not lament the marginal role of phenomenology within the philosophy of science, or expand programmatic promises, but pick a question and just get on with it. Hermeneutically oriented phenomenologists will make good use of the collected papers as well, in particular Egg's discussion of the theoretical attitude and Sieroka's discussion of Weyl. Readers

whose theoretical reference points are Kant, Hume, or the Ancient Greeks, however, might be better served with a different book (e.g., Harvey 1989).

The audience for the present volume is specific: systematically oriented phenomenologists who are not afraid to dive into the physics or physicists who are not scared of philosophical concepts that might resist explicit definition. And even within this specific group, most readers will want to focus on a number of chapters only—but once this book has found its audience, it makes for an exciting read, because there is very little like it.

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