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Book Section:

Wilson, A. orcid.org/0000-0003-3027-5016 and Knox, E. (2021) Introduction. In: Knox, E. and Wilson, A., (eds.) *The Routledge Companion to Philosophy of Physics*. Routledge Philosophy Companions . Routledge , New York , pp. 1-3. ISBN 9781315623818

<https://doi.org/10.4324/9781315623818-1>

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Editors' Introduction

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What is philosophy of physics? We can give plausible-looking but uninformative answers of the form 'the intersection of physics and philosophy', but any serious investigation into the character of the field has to look at its historical context. Depending on what we identify as the same intellectual tradition, we obtain very different conceptions of philosophy of physics and of its beginnings. Attempts to understand the most general features of the physical world probably go back beyond recorded history, but by the first millennium BCE, the Babylonians and Greeks were engaged in systematic theorizing and hypothesis-testing about the natural world and in putting forward global metaphysical explanations for natural phenomena. Should we count the atomism of Democritus as a contribution to philosophy of physics, or to pure metaphysics? We leave that to the reader to decide.

Physics itself did not emerge as a recognizable discipline, distinct from the broader category of natural science, until after the Renaissance in Europe. Philosophical reflection accompanied the new discipline from the beginning. In the writings of Galileo, Newton and Leibniz we can recognize central questions that still animate contemporary philosophers of physics. Works like the Leibniz-Clarke correspondence (1717) and du Châtelet's commentary on her translation into French of Newton's *Principia* (1756) served as interpretive guides to the new physics and formed the core of a nascent foundational literature. Does this period mark the start of philosophy of physics proper? An interesting question no doubt, but not one we will address here: our focus is on contemporary philosophy of physics. We aim to take a pluralist approach to what counts as philosophy of physics, one which links the nature of the field to the varied institutions within which it is taught and researched.

By 1900, physics and philosophy had been institutionalized in Western universities as distinct disciplines within faculties of science and humanities respectively, but there were clear examples of cross-overs between these disciplines: Mach, Poincaré, Broad, Russell, Noether, and Eddington had very different academic careers but they worked on the same cluster of topics. For the first decades of the twentieth century, physics was respected within philosophy, and vice versa. That relationship has become strained at times in the post-war world; generations of physicists were raised with a distrust of philosophy under the enduring influence of logical positivist and logical empiricist traditions. In recent decades, though, philosophy of physics has found institutional security as a subfield in its own right. Today there are numerous undergraduate and postgraduate degree programmes which offer courses and qualifications in philosophy of physics, substantial research clusters at leading universities, well-established recurrent conferences, prizes, specialist journals, and the inevitable concomitant rankings. Our goal with the Companion has been to provide a representative cross-section of this wide-ranging research activity.

Limiting our focus to the contemporary practice of philosophy of physics does not of course guarantee a unified conception of what philosophy of physics is and how it should be pursued. Philosophers are fond of prescriptive definitions and divisions, and physicists are not much better. So it will hardly surprise the reader to hear that, even in a field as small as the philosophy of physics, methodological disagreements are rife. Given its essential engagement with as mathematical a field as physics, some gatekeeping is inevitable: without a solid understanding of the physics, things can go badly off the rails. But we are of the view that imposing divisions has largely hindered rather than helped the field: at times mathematical technical ability is mistaken for philosophical (or indeed physical) insight, while at others towering metaphysical structures are built on flimsy physical foundations. Likewise, philosophy of physics is at its most important and influential when it looks to the future, but work on contemporary theories suffers if the lessons of history are ignored. This volume is constructed with the assumption that good philosophy of physics can be done in physics departments, philosophy departments, HPS departments and independently. The very best work in contemporary philosophy of physics combines a deep understanding of the physics with philosophical, and sometimes historical, subtlety: we hope some of that work is showcased here.

While a form of pluralism is at the heart of this volume, some carving up of the field is inevitable. Our chosen primary division, between ‘Theories’ and ‘Themes’, aims to divide without excluding, and thereby to capture important work even where it falls at the edges of philosophy of physics. Many, but not all, philosophers of physics consider themselves ‘philosophers of X’, where X is a theory or family of theories: quantum mechanics, general relativity, or the like. The first half of this volume aims to capture a range of this kind of theory-focused work with respect to the main theories that form the core of modern physics: specifically, classical mechanics, relativistic mechanics, quantum theories in their various forms, statistical mechanics and thermodynamics. But this focus on particular theories can obscure the wider philosophical questions that arise from physics; much exciting work, particularly in recent years, lies at the boundary between philosophy of physics and other areas of philosophy. The second half of the volume encompasses this kind of thematic work: philosophy that reflects on the discoveries and the practice of physics to reach conclusions about topics of wider philosophical interest such as explanation, causation or reduction.

We hope that this two-fold structure helps to make the book suitable for a wide audience: for the physicist interested in the foundations of their field, for the philosophy of physics graduate student looking for a thesis topic, but also for the philosopher seeking to understand how physics bears on their areas of interest. We’ve aimed for a range of levels of accessibility within the sections, and at least some chapters in each section should be readable by an advanced philosophy undergraduate without physics training. That said, in areas such as quantum field theory, authors inevitably presuppose more specific knowledge of physics. In others, like spacetime physics, important results cannot be expressed without a certain level of technical sophistication. Typically, chapters increase in degree of technicality through sections, especially in the ‘Theories’ part. But generally, we have not tried to impose

too much uniformity on the style or structure of the chapters; part of the strength of philosophy of physics, as we have tried to highlight, is diversity of individual approach amongst its practitioners. We hope that this shows through in the varied character of the contributions.

It is traditional in an introduction like this to opine on the future of the field. Such crystal-ball gazing has its drawbacks: 20 years ago, for example, one might not have pegged the study of Newtonian spacetime for a comeback. Nonetheless, recent years have seen substantial developments in our understanding of various Newtonian spacetime structures and the relations between them. But some trends in the discipline are easier to spot. Several spring from the renewed relationship between physicists and philosophers mentioned above: as physics pushes new boundaries, new philosophical problems come to light, and old ones spring back up from the dusty corners to which physics tried to relegate them. A host of new physics research programmes, and the grants that accompany them, involve physicists asking for active input from philosophers. Some of these new research programmes are featured in this volume. Developments in quantum gravity, or perhaps the lack of them, raise questions about progress in science, as well as revealing fault lines along old philosophical lines (it is hard to do quantum gravity without implicitly taking a stand on the measurement problem, for example; in cosmology, no external observer is available to collapse the wavefunction). But quantum gravity also reveals exciting new philosophical questions, for example: what might it mean for the spacetime of our experience not to be fundamental? How should we think about the ‘dualities’ posited by string theory? In a theory without a primitive notion of time, do we need a primitive notion of causality to replace it? The philosophy of cosmology is likewise a relatively young field, and one that looks set to grow in the coming years. Here the pressing questions are often obviously connected to more general philosophical issues: how do we deal with ‘one-shot’ theories for which experimentation is impossible? What role might anthropic reasoning play in such a theory? Can non-empirical values play a role in theory choice here that they might not play elsewhere?

It will not escape the reader’s attention that many of the questions addressed in this Companion seem to sit in general philosophy of science and or in metaphysics rather than in the philosophy of physics, narrowly conceived. That is certainly true, although it’s also true that dealing adequately with these problems in the context above requires a good understanding of both physics and philosophy of physics. But the expertise that physicists sometimes lack and seek elsewhere is often distinctively philosophical. So here, perhaps, is the moral for a graduate student in search of a topic: philosophers of physics can sometimes underestimate the importance of their general philosophical training, but is it also the unique skill they bring to the table. Work at the outwards facing edges of philosophy of physics is as difficult and significant as technical and theory-centered work.

Inevitably in a project of this scale, we have not managed to achieve as uniform a coverage as we would have liked. In particular, we regret the lack of chapters on quantum information theory and black holes. We hope to fill some of these gaps in future editions, as well as keeping the treatment of cutting-edge topics up to date. We’ve aimed to take a snapshot of

the philosophy of physics community which is reasonably diverse with respect to geography, disciplinary affiliation, gender, and other social variables; however, there is no getting away from the fact that philosophy of physics as it is currently practiced is lacking in demographic diversity. We hope and expect that this situation will improve in the coming years. Philosophy of physics, overall, is in as good a shape as it has ever been, and we hope that this Companion will provide a useful resource for existing practitioners and for newcomers alike.