

Multiverse Theories: A Philosophical Perspective, by Simon Friederich (Cambridge University Press), 2021. Pp. 214, 25 × 17.5 cm. Price £49.99/\$64.99 (hardbound; ISBN 978 1 108 48712 2).

Few topics in cosmology are as hotly debated as the Multiverse: for some it is untestable and hence unscientific; for others it is unavoidable and a natural extension of previous science. There are well-known and respected cosmologists on both sides of the debate. There is no shortage of literature on the Multiverse: the volume edited by Carr¹ demonstrates the extent to which the Multiverse has become mainstream; Tegmark has written an influential popular account² (reviewed³ in these pages). So can this book by philosopher of science Simon Friederich (a busy young man, not yet 40, with doctorates in both physics and philosophy — from Heidelberg and Bonn, respectively — as well as a *Habilitation* in philosophy from Munich, and with five daughters, a tenured position in Groningen, and even his own interpretation of quantum mechanics⁴) offer anything new? Yes. At the beginning of the last chapter, he states explicitly what the reader who has come that far will have noticed: “Throughout the discussion of multiverse theories in this book, I have set aside the most heated discussions about the multiverse and ignored the most scathing criticism of such theories” Also interesting is the fact that “[t]he considerations on multiverse theories in this book are somewhat unusual ... for they have been developed and compiled by someone who has never had any strong feelings about their central topic” The result is an interesting book which is not only about the Multiverse but also about the epistemology of the Multiverse.

Tegmark² had defined four ‘levels’ of Multiverses: the Level I Multiverse is what many call the Universe (his Universe being what many call the observable universe).^{*} The Level II Multiverse consists of other universes (or Tegmark’s Level I multiverses), perhaps with different values of the constants of nature, different laws of physics, or different initial conditions. The Level III Multiverses are the many worlds in Everett’s interpretation of quantum mechanics; the Level IV Multiverse is Tegmark’s own Multiverse of mathematical structures. Level I is accepted by essentially everyone, Levels II and III[†] by many, while Level IV is speculative. The bulk of the book is concerned with the Level II Multiverse (which is usually meant if it is not specified in detail), though the penultimate chapter discusses, and rejects as incoherent, Levels III and IV and also David Lewis’s ‘Multiverse’ of modal realism⁵.

The three chapters in Part I set the stage and discuss in general terms fine-tuning for life, which, along with the Anthropic Principle, is entwined with some of the ideas of the Multiverse. Three more chapters in Part II continue the discussion of fine-tuning in the Multiverse, including a new argument by Friederich which avoids the inverse gambler’s fallacy, a common charge against multiverse arguments. Those chapters have some overlap with, but are more technical than, the discussion in the book by Lewis & Barnes⁶ (also reviewed here⁷).

^{*}Most people wouldn’t think of the stuff outside of our horizon as being in another universe or as being part of the Multiverse, but at least Tegmark is consistent in his terminology. Also, there are some similarities: by definition we cannot observe things outside the observable Universe, but nevertheless no serious scientist doubts that such things exist.

[†]There is some evidence that Everett’s many-worlds interpretation has become more popular in the last few decades. However, quantifying that is rather difficult. As Penrose quipped, “There are probably more different attitudes to quantum mechanics than there are quantum physicists. This is not inconsistent because certain quantum physicists hold different views at the same time.”

Three chapters in Part III discuss the idea of testing multiverse theories, making extensive use of Bayesian reasoning (already introduced in the third chapter). An interesting related topic, puzzles of self-locating belief, is discussed in Chapter 9, where we meet Sleeping Beauty, Lazy Adam, the Pretentious Philosopher, and the Principal Principle. The first chapter in Part IV rejects, as mentioned above, some multiverse theories, while the final chapter is a dispassionate discussion on whether the Multiverse is a scientific idea (either a hypothesis or a consequence of other theories). Friederich takes the possibility seriously that we might actually live in a Level II Multiverse, but also points out the difficulties, both technical and sociological ('researcher degrees of freedom') in actually being able to obtain compelling evidence one way or the other. As long as the Multiverse is not ruled out, some parameters in physical theories might be 'environmental' rather than fundamental and thus inexplicable *via* conventional progress in theoretical physics. Friederich sees the question of understanding the value of the cosmological constant as an example of such a parameter; it might never be understood within the context of a conventional physical theory. On the other hand, the questions of the identity of dark matter and whether some sort of modified gravity might also be an explanation for some phenomena for which dark matter is invoked are largely independent of the question whether we live in a Multiverse.

There are no figures, and a few footnotes. Almost all equations concern probabilities. As almost always, I would have phrased some things differently with respect to style, but there are few actual typos and I noticed no factual mistakes. The book is well written despite (as far as I know) Friederich not being a native speaker of English. In the last several years I have thought much about many of the topics covered by the book. Much of the corresponding discussion is in the philosophy rather than the physics literature and thus might present something of a barrier to physicists interested in the epistemology of the Multiverse. Friederich's book is a good bridge across that gap and otherwise a good introduction to the topic, with many citations in the text and a corresponding 12-page list of references in small print which point the reader to more detailed discussion of various topics (thankfully including titles of articles); the book ends with a two-page index in even smaller print. I recommend it highly. — PHILLIP HELBIG.

References

- (1) B. J. Carr ed., *Universe or Multiverse?* (Cambridge University Press), 2007.
- (2) M. Tegmark, *Our Mathematical Universe* (Allen Lane), 2014.
- (3) P. Helbig, *The Observatory*, **134**, 150, 2014.
- (4) S. Friederich, *Interpreting Quantum Theory: A Therapeutic Approach* (Palgrave Macmillan), 2014.
- (5) D. Lewis, *On the Plurality of Worlds* (Blackwell), 1986.
- (6) G. F. Lewis & L. A. Barnes, *A Fortunate Universe: Life in a Finely Tuned Cosmos* (Cambridge University Press), 2017.
- (7) P. Helbig, *The Observatory*, **137**, 243, 2017.