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MULTIVERSE THEORIES

If the laws of nature are fine-tuned for life, can we infer other universes with different laws? How could we even test such a theory without empirical access to those distant places? Can we believe in the multiverse of the Everett interpretation of quantum theory or in the reality of other possible worlds as advocated by philosopher David Lewis? At the intersection of physics and philosophy of science, this book outlines the philosophical challenge to theoretical physics in a measured, well-grounded manner. The origin of multiverse theories is explored within the context of the fine-tuning problem, and a systematic comparison between the various different multiverse models is included. Cosmologists, high-energy physicists, and philosophers including graduate students and researchers will find a systematic exploration of such questions in this important book.

SIMON FRIEDERICH is Associate Professor of Philosophy of Science at the University of Groningen and holds PhDs in both physics and philosophy. His work on multiverse theories was supported by a Veni grant from the Netherlands Organization for Scientific Research.

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A Philosophical Perspective

SIMON FRIEDERICH
University of Groningen

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To my children, who have entered my life since I have been working on this book

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Preface

The history of this book starts in 2008, with a visit that my wife (then girlfriend) and I, at that time living in Heidelberg, received from our friend Marlene Weiß, former string theorist, recently turned journalist. Marlene told us about a radio feature she was making on a topic at the intersection of physics and philosophy of science: the "multiverse." Despite being an aspiring philosopher of physics, I had never heard of this "philosophical challenge to theoretical physics," as Marlene's radio feature puts it. She was in the process of interviewing numerous expert physicists and philosophers for it – among them my PhD supervisor in physics, Christof Wetterich, and my (nowadays) colleague Richard Dawid, string theorist turned philosopher of science.[1]

I found what Marlene told us about the multiverse debate very interesting, and I felt a bit ashamed for not yet being familiar with it. I also made a mental note to read and think more about it when I got a chance. A few months later – after Marlene had already abandoned the topic – I took the time to do so and started reading about the multiverse debate. In doing so, I began to understand what the anthropic principles are about, and I also began to think that the intriguing puzzles of self-locating belief, which seemed, in some not quite clear way, connected to the anthropic principles.

Later, during the two years in which I worked at the University of Göttingen (2012–2014), I had the opportunity to teach several courses on these topics, among them colloquia for more advanced students, in which I could fruitfully discuss many of the issues treated here and develop my thoughts on them. In 2016, now working at the University of Groningen in the Netherlands, I was lucky to obtain a Veni grant (NWO project number 275-20-065) from the Netherlands Organization

[1] A transcript of Marlene's highly recommendable feature (in German) is online and can be found at www.deutschlandfunkkultur.de/manuskript-die-beste-aller-moglichen-welten-pdf.media.d3645e999b4cac85489d482043313616.pdf.

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for Scientific Research (NWO) for a project on the "Epistemology of the Multiverse," which gave me time and greatly facilitated my work on this book. Another facilitating factor has been my contact with the Munich Center for Mathematical Philosophy, notably the group of Stephan Hartmann. He was also my mentor in a habilitation process that resulted in an earlier version of this book.

Academics often have strong feelings about the views that they defend or criticize. This has its advantages and disadvantages. An advantage is that academics are often motivated by the passion they feel about their topics of interest to engage in great efforts in order to provide argumentative or empirical support for their conjectures and favorite hypotheses. Another advantage is that it makes them inventive in devising intelligent criticisms of hypotheses that they do not like. A disadvantage is that their passion tends to make their judgment biased, especially when it comes to assessing views to which they have already committed themselves publicly.

The considerations on multiverse theories in this book are somewhat unusual in this respect, for they have been developed and compiled by someone who has never had any strong feelings about their central topic; the question of whether there are other universes where physical parameters differ from those in our own leaves me rather cold, and so does the question of whether physical theories that entail the existence of other universes are empirically testable or not.

In analogy to the advantages and disadvantages of passion in academia just mentioned, my indifference about the truth and testability of multiverse theories has its corresponding disadvantages and advantages. A disadvantage has been that I have sometimes not been as motivated as I would have liked to have been to work on the topics treated in this book and sometimes pursued that work mostly for the sake of the intrinsically rewarding intellectual exercise. But a complementary advantage might be that the considerations presented in this book are developed from the relatively disinterested perspective of someone without any "skin in the game." My hope is that this will have allowed the present book to steer clear both of uncritical enthusiasm about multiverse ideology and of unconstructive bashing as unscientific of any serious mention of the possibility that there might be other universes.

Some of the thoughts and passages that appear in this book have appeared, sometimes in different or more preliminary form, in other publications by me. Those are the following:

- S. Friederich, 2018, Fine-tuning, *Stanford Encyclopedia of Philosophy*, ed. by E. N. Zalta, Fall 2018 edition.
- S. Friederich, 2017, Choosing beauty, *Logique et Analyse*, 60:449–463.
- S. Friederich, 2017, Resolving the observer reference class problem in cosmology, *Physical Review D*, 95:123520.

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- S. Friederich, 2017, Fine-tuning as old evidence, double-counting, and the multiverse, *International Studies in the Philosophy of Science*, 31:363–377.
- S. Friederich, 2019, Reconsidering the inverse gambler's fallacy charge against the fine-tuning argument for the multiverse, *Journal for General Philosophy of Science*, 50:29-41.
- S. Friederich, 2019, A new fine-tuning argument for the multiverse, *Foundations of Physics*, 49:1011–1021.

Section 10.1.3, about the Sebens/Carroll approach to the probability problem of the Everett interpetation, has partly been shaped by discussions with Richard Dawid. Complementary to the considerations developed in that section, we provide further criticisms of the Sebens/Carroll approach in a forthcoming paper "Epistemic separability and Everettian branches – a critique of Sebens and Carroll," which is currently under review with a journal.

Among those who helped this book come to fruition, I would like to thank first of all Stephan Hartmann for hospitality in Munich and many lively discussions there. Thankfully, I received a plethora of stimulating comments and criticisms on an earlier incarnation of this book, which was accepted as a habilitation thesis at the University of Munich, by George Ellis, Dieter Lüst, John Norton, and Chris Smeenk. I would also like to thank Chris for inviting me to be a visiting scholar at the Rotman Institute of Philosophy at the University of Western Ontario in June 2019 and the members of the Rotman Institute for their amazing hospitality and a stimulating experience.

I am also grateful for useful comments on drafts of papers that morphed into parts of this book as well as for other rewarding exchanges with Guus Avis, Luke Barnes, Christoph Behrens, Jeremy Butterfield, Eric Curiel, Richard Dawid, Sean Gryb, Robert Harlander Richard Healey, Leah Henderson, Mike Hicks, Klaas Landsman, Casey McCoy, Felix Mühlhölzer, Jan-Willem Romeijn, Karim Thébault, Sylvia Wenmackers, and Claire Zukowski. I am also grateful to the anonymous referees who reviewed my papers for various journals and to the anonymous referees who were consulted by Cambridge University Press.

Moreover, I would like to thank members of the audience at seminars, conferences, and workshops in Brisbane, Bristol, Crete, Düsseldorf, Göttingen, Groningen, Hamburg, Munich, Sydney, Turku, Utrecht, and Wuppertal. Among the audience members whose questions I found particularly stimulating were David Albert, Harvey Brown, Pete Evans, Martin Gustafsson, Joel Katzav, James Ladyman, Marco Livio, Tim Maudlin, Dean Rickles, Simon Saunders, and David Wallace. For fantastic support in designing my grant application to the NWO, I am grateful to Jeanne Peijnenburg and David Atkinson.

Most of all, I would like to thank my wife Andrea and our five daughters for making my life as happy and rewarding as it thankfully is.

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