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Philosophical and scientific perspectives on cosmology

Khalil Chamcham, Joseph Silk, John D. Barrow, Simon Saunders (editors): *The Philosophy of Cosmology*. Cambridge: Cambridge University Press, 2017, 526pp, £49.99 HB

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The Philosophy of Cosmology, edited by Khalil Chamcham, Joseph Silk, John D. Barrow and Simon Saunders, gathers an impressive collection of articles in the form of independent chapters written by leading cosmologists and science philosophers. This book is the culmination of two programs of interactions between cosmologists and philosophers on both sides of the Atlantic and their coming together in a final joint conference on Tenerife.

Cosmology is unlike any other field in science as it describes a physical system in which observers are living. We have only one universe to study, namely the one in which we are living. This causes immediate difficulties as a basic tenant of scientific methodology is that experiments should be reproducible. Indeed, when unexpected physical phenomena are discovered, a typical historical example is that of the discovery of the violation of the CP symmetry in the weak interactions, experiments are repeated independently by other groups to verify the results of the first performed experiment. However, there is only one observable universe and obviously, we cannot repeat our universe in a lab. This changes the rules of the game and the scientific method needs to be adjusted. This leads to deep questions for physicists and for philosophers of science alike. Which scientific criteria, or rather maybe more precisely, scientific method, should be applied to cosmology? When can we have confidence that we understand a specific physical phenomenon in cosmology as we cannot do multiple observations of our universe to establish a confidence level for the phenomenon to be really taking place in a conventional sense using statistical methods? These are some of the main themes addressed in this book by leading cosmologists and philosophers of science.

The book is organized into five sections or parts. The first part deals with issues in the philosophy of cosmology. The second part covers structures in the Universe and the structure of modern cosmology. The third part of the book considers the foundations of cosmology: gravity and the quantum. The fourth part discusses quantum foundations and quantum gravity while the fifth part explores methodological and philosophical issues.

What is remarkable about this collection of chapters is that it offers a dialogue between two scientific communities (cosmologists/high energy physicists and philosophers of science) that unfortunately do not usually interact enough with each other. While some of the authors have definitely taken the risk of trying to address themes that are of common interest between the two communities and shown how this dialogue could lead to some progress in our understanding of our universe, others have offered more standard reviews of the state of the art in cosmology which might be found in the proceedings of any international conference in cosmology. Some of the chapters sometimes deal with very speculative fringe ideas that are neither relevant from a fundamental physics perspective nor from a philosophical one. On the other hand, the chapters attempting to make the link between philosophy of science and cosmology are rather fascinating. It is very refreshing to see that some cosmologists are thinking deeply about the possible limitations of their work and what we may ultimately hope to learn about our universe.

It is not possible to do justice to the number of interesting ideas and proposals presented in this very rich book in a short review. Among the most interesting contributions to this collection of chapters, from this reviewer's perspective, one should certainly mention the following. Ellis is making a very interesting job at defining the precisely the nature of what is under consideration in cosmology. He differentiates cosmologia from cosmology, the latter extends the study of the Universe to include the study of the origin of life and the nature of existence. He emphasizes that cosmologia is thus at the intersection of physics, philosophy and metaphysics potentially linking them to the meaning and purpose of our lives.

Cosmology forces us to think about the limits of science as nicely explained by Carr and there is thus some common ground with philosophy. He contrasts cosmography which deals with the structure of the universe on largest scales which can be explained by gravity from cosmogeny which concerns the origin of the universe and thus fundamental, very high energy physics, potentially even quantum gravity which we do not yet fully master. The latter part is still rather speculative from a scientific point of view and often guided by philosophical ideas rather than hard scientific facts. He explains that cosmology is so fascinating because it links very small scale physics (e.g. quantum gravity) to large scale physics, i.e. our universe. This is nicely illustrated by the cosmic uroboros picture.

Beispart deals with the boundaries between philosophy and cosmology. He emphasises that cosmology, being a science deals with empirical facts while philosophy deals with facts that are not yet supported by empirical facts. As science progresses the boundary between science and philosophy is shifting.

Tumulka attempts to answer a very deep question, namely why there exists something rather than nothing. He starts by stating that he has never seen anything intelligent written on this topic and unfortunately it is not obvious to this reviewer that his chapter is an exemption to that rule. Indeed, he bases his assumption on the fact that mathematical logic exists independently of anything and that a creator of the universe would be bound by mathematical logic in his act of creation. This appears to be reducing the notion of a creator to choosing the laws of nature that are compatible with a specific type of mathematical logic. This is not very convincing and the author of the chapter himself acknowledges that his explanation fails. Nevertheless, it takes a lot of courage to even attempt to find

something new to say about this longstanding problem that has been at the core of philosophy and theology for so many centuries. This chapter may be the best demonstration that physics or mathematics in this case is very far away from being able to answer this question, as it does not appear to be obviously within the realm of questions that can be answered with our usual scientific methods. This emphasizes the need for a dialogue between the different communities involved in this book.

Barrow's discussion of generalities in cosmology is quite fascinating. He explains that generality is a property of a universe that will occur near almost every initial data set. The question of initial conditions is a very important one in cosmology, as we do not have a theory of initial conditions, rather we think to know how to formulate partial differential equations that describe the evolution of a specific system once the initial data has been specified (that is when the system is not chaotic). The notion of generality is thus particularly important in cosmology as one would not want the evolution of the universe to depend very much of initial conditions which we cannot predict from first principle and which may be difficult to extract anyway from data. Historically speaking, this was one of the main motivations to consider inflationary models in cosmology. Barrow makes the link to when and how the standard scientific method can be applied in cosmology.

Among other things, Uzan discusses the mind-boggling possibility that the laws of nature and fundamental constants of nature, such as, for example, the strength of the interaction between electrons, may not be written in stone, but rather have a cosmological evolution.

The last part of this book on methodological and philosophical issues will be particularly interesting to readers caring about the foundations of cosmology and contains some of the most interesting chapters of this book. It should be a must read for cosmologists who are unfortunately too often not thinking about the foundations of their field. In particular, Rugh and Zinkernagel have a fascinating discussion on the limits of time in cosmology and especially the meaning of time in cosmology. Dorr and Arntzenius analyse self-locating priors and cosmological measures in their exciting chapter. Their discussion of Bayesian background is very well presented. The discussion of probability in cosmology by Sahlén is equally interesting.

In summary, this book presents a collection of chapters written by foremost experts in their respective fields. The most interesting of these chapters are those written by scientists who truly tried to build a bridge between philosophy of science and cosmology. Overall, this book is well worth reading as it contains many fascinating perspectives and ideas presented in a very accessible manner for the different communities involved in this project.