

books I've reviewed in these pages (though Kip Thorne is transformed into Kip Throne). There are just a handful of black-and-white figures; notes are footnotes and each chapter has its own reference list (as is often the case in the philosophical literature, titles of articles are included, which I find useful in general and prefer unless space is at a premium); a two-page small-print index ends the book. This is a good introduction to and overview of the topic, and the extensive references are a good starting point for those wanting to explore the philosophical literature not just on the arrow of time but on physics and cosmology in general. — PHILLIP HELBIG.

### References

- (1) T. Gold (ed.), *The Nature of Time* (Cornell University Press) 1967.
- (2) R. C. Tolman, *Relativity, Thermodynamics, and Cosmology* (Clarendon Press), 1934.
- (3) R. C. Tolman, *Phys. Rev.*, **35**, 904, 1930.
- (4) R. C. Tolman & P. Ehrenfest, *Phys. Rev.*, **36**, 1791, 1930.
- (5) R. Penrose, in E. J. Fenyves (ed.), *Fourteenth Texas Symposium on Relativistic Astrophysics*, vol. 571, 249–264 (New York Academy of Sciences), 1989.
- (6) D. Z. Albert, *Time and Chance* (Harvard University Press), 2000.

**The Universe: A Guide to Everything**, by Helge Kragh (Reaktion Books), 2026. Pp. 188, 22 × 15 cm. Price £17.95 (hardbound; ISBN 978 1 83639 179 1).

I've read most of Helge Kragh's books and reviewed<sup>1</sup> one<sup>2</sup> in these pages. Kragh is a well-known historian of science and has written many books on the history of cosmology. In the preface, he clearly lays out his plan for the book: "Rather than aiming to describe what the universe *is*, the focus is on how people have conceived the universe, from the ancient Greeks to the present. It is a partial and inevitably selective history of cosmology, the science of the cosmos. The modern universe is in many respects entirely different from that of the past, but it does have a connection to the thoughts about the universe that emerged more than two thousand years ago." [Emphasis and capitalization as in the original.] His book is a marvellous success, in terms of both content and presentation — the book is extremely well written, better than most of those by native speakers of English. Although of course it can't contain everything, Kragh's selection of topics, all of which are clearly explained\*, are all good choices, and despite the necessary brevity he manages to mention some aspects which aren't usually mentioned. He does, though, spend the short first chapter briefly describing what the Universe *is*. Subsequent chapters cover the time up to Newton, stars and galaxies, and the expanding Universe (which includes not only standard relativistic cosmology which led to the current standard model, but also various alternative models, whether or not based on General Relativity). So far, so standard, but very well done. There is a thirty-page chapter on the Steady State model (only one page less than the longest chapter, the previous one on the expanding Universe). It was of course scientifically a dead end, but very important in the history of cosmology. (In contrast, Kragh notes that much of the work which now comprises standard references in the field received very little attention at the time: (some of) the works of Friedmann; Lemaître; Zwicky; and Gamow, Alpher, and Herman.) The penultimate chapter, 'New Horizons', covers such current topics as dark energy, the Hubble tension, and the standard or concordance model of cosmology. It is certain that those topics will remain not only a part of the history of cosmology but of cosmology itself. The final chapter, 'Beyond the Standard Model', discusses some for which the former is trivially true but perhaps not the latter: pre-big-bang cosmology, the far future and fate of the Universe<sup>†</sup>.

\*Kragh avoids common misconceptions involving the Hubble(–Lemaître) law (Kragh also suggests "Lemaître–Hubble"), cosmological horizons, cosmological expansion, the date of publication of the first paper on relativistic cosmology<sup>3</sup>, the fact that Lemaître was *not* a Jesuit, etc.

<sup>†</sup>Although the laws of physics lend themselves just as easily to extrapolation to the future as to the past, the latter is much more popular than the former.

(citing a paper from this *Magazine*<sup>4</sup>), and the multiverse. The first and last of those topics are admittedly more speculative; my guess is that at least the last will become a standard part of cosmology and not just of its history. (For the long history of the multiverse idea, see an excellent book<sup>5</sup> reviewed<sup>6</sup> in these pages.)

So, is there nothing to complain about? I do have a few small quibbles. Some references (which refer to endnotes) are “quoted in Kragh. . .”. While ‘quoted in. . .’ is actually preferable to a direct citation if the information comes solely from the cited source rather than the original, that is obviously not the case if the cited source is one of Kragh’s own works. Although one can refer to the Hubble constant as the Hubble parameter, the fact that, in general, it is not constant in time is not a reason to do so. There are eight pages of colour plates at the centre of the book; some of the black-and-white figures scattered throughout the book could also benefit from colour reproduction. While the description of Olbers’s paradox is correct, it might not be clear to readers less familiar with it that most of the proposed solutions — in particular, two which are mentioned — don’t actually work. The de Sitter universe (empty of matter but with a cosmological constant; expanding exponentially) is described as static and spatially closed. That was indeed the way it was seen at the time, though the description is coordinate-dependent; today, it is usually described as spatially flat, of infinite extent, and of course expanding. That is difficult to make clear in such a book; for details see ref. 7.\*

Both the reference list and the 26 items in the ‘Select Bibliography’ (I’ve read exactly half and reviewed five in these pages) are excellent jumping-off points for those interested in more details — often entire books correspond to just a few paragraphs in this book. (Although I appreciate the full-information references, somewhat strangely all journal volumes are in roman numerals, although the journals themselves in most cases use arabic.) A five-page index ends the book.

Everyone with even a slight interest in the history of cosmology should read this book, and even those who have devoted their careers to the topic will benefit. — PHILLIP HELBIG.

### References

- (1) P. Helbig, *The Observatory*, **139**, 219, 2019.
- (2) H. Kragh & M. S. Longair (eds.), *The Oxford Handbook of the History of Modern Cosmology* (Oxford University Press), 2019.
- (3) A. Einstein, *Sitzungsb. Kön. Pr. Akad. Wiss.*, **VI**, 142, 1917.
- (4) M. J. Rees, *The Observatory*, **89**, 193, 1969.
- (5) T. Siegfried, *The Number of the Heavens: A History of the Multiverse and the Quest to Understand the Cosmos* (Harvard University Press), 2019.
- (6) J. Overduin, *The Observatory*, **140**, 107, 2020.
- (7) S. Röhle, ‘Mathematische Probleme in der Einstein – de Sitter Kontroverse’, <https://www.mpiwg-berlin.mpg.de/de/publikationen-ressourcen/publikationen/preprints-zum-download>, 2002, no. 210.
- (8) S. Röhle, *Willem de Sitter in Leiden – Ein Kapitel in der Rezeptionsgeschichte der Relativitätstheorien*, Ph.D. thesis, University of Mainz, 2007.

**Astronomical Hazards for Life on Earth**, edited by Gonzalo Tancredi (Cambridge University Press), 2025. Pp. 105, 25 × 18 cm. Price £98 (hardbound; ISBN 978 1 009 35308 3).

This slim volume, the proceedings of IAU Symposium No. 374, held in Busan (Republic of Korea) 2022 August 9–11, presents a partial summary of what was — or had the potential to be — a fascinating interdisciplinary symposium. According to the preface, the meeting included discussions of diverse astronomical risks and potential threats to life on Earth,

\*Readers of German might want to consult a doctoral thesis by the same author<sup>8</sup> for more background on that as well as de Sitter’s role in the early days of relativity and relativistic cosmology in general. The bulk of ref. 7 is also in German, but contains a foreword in English of more than 11 pages by David E. Rowe.