groundwater that is locked in the lithosphere. For river-running enthusiasts, a chapter deals with the hydrotectonics of Grand Canyon groundwater, which presents a rare chance to monitor vertical water movement without the use of boreholes. Check out the book and find out what the Indonesian Gateway is! The volume finishes with an unusual chapter on the relationship between grain size and landscape. So if you feel like a bit of a change, then start reading the book from the back. — Gillian R. Foulger.

The Cosmic Microwave Background: Historical and Philosophical Lessons, by Slobodan Perović & Milan M. Ćirković (Cambridge University Press), 2024. Pp. 215, 25 × 17·5 cm. Price £39·99/$49·99 (hardbound; ISBN 978 1 108 84460 4).

As the subtitle states, this is a book on the history and philosophy of the CMB. However, it does not stray far from actual physics, and points are made with the help of concrete examples. The second author is someone I've often encountered in the history-and-or-philosophy-of-science literature, and the authors have a good grasp both of that and of astrophysics. The conventional narrative is that the CMB suddenly proved that the Steady State cosmological model was inviable. While the CMB is expected in the Big Bang scenario, it is not impossible in the Steady State theory, which is based on the idea that on a large-enough scale, the Universe looks the same at all places and at all times. Nevertheless, one would still like to have an astrophysical explanation for the CMB within the Steady State theory. For Fred Hoyle, one of the main motivations for the Steady State cosmology was that it in principle made all processes accessible to scientific inquiry, which might not be true of the Big Bang itself. However, counts of radio sources ruled out the Steady State model. Both supporters of the Steady State model and those of Big Bang cosmology investigated alternative explanations for the CMB, and it was not until features in the power spectrum were discovered about 25 years ago that the scales were finally definitively tipped in favour of a Big Bang origin for the CMB. That is not only an interesting story in itself, but also such dead ends are important because they illustrate how the scientific process actually works.

The thirty-one chapters are clearly structured into seven parts covering the basics of cosmology, the Big Bang, and ΛCDM (referred to, unusually, as λCDM); discovery of the CMB and the current standard model, but including a discussion of shortcomings in usual potted histories; the nature of (un)orthodoxy in cosmology; moderate unorthodoxies (CMB with Big Bang); radical unorthodoxies (CMB without Big Bang); the history of how the current orthodoxy came to be; anomalies in the CMB and wider issues such as the Anthropic Principle, boundary conditions in cosmology, and the Multiverse, using the CMB as a jumping-off point. Too long to quote here, the end of Chapter 9 ('Was the CMB a smoking gun?') is a good summary of the strategy of the book: a balance between questioning a too-streamlined view of history without questioning the state at which that history has (probably correctly) arrived; learning from blind alleys and misconceptions, some of which later proved useful in other contexts; and a good balance between astrophysics and philosophy by authors knowledgeable about both topics. To some extent, this book reminded me of a similar book with much broader scope[1] reviewed in these pages[2], though I found that the latter was sometimes a bit too broad and too forgiving. (At the same time, that book is conspicuous by its absence in the otherwise thorough sixteen-page reference list in somewhat smaller print, though two of his articles, one on essentially the same topic as his book, are

cited.) An interesting idea is adapting the idea of biological exaptation to cosmology: features originally developed for one purpose are later put to another use (*e.g.*, feathers for heat regulation being used as components of wings for flying); similarly, ideas which were mistaken at the time might later prove useful in other contexts. The authors also use the history of CMB research to point out the "abject failure of simplistic social-constructivist notions about the sociocultural determination of the *content* of scientific theories" and the more 'mature' culture of debate compared to some previous controversies, avoiding "juicy tabloid details like the personal relationship of actors such as Hoyle and Ryle".

At best confusing is the two-page Chapter 28 which briefly sketches ideas about two (initially) puzzling phenomena: 'fingers of God' in the distribution of galaxies and the 'axis of evil' regarding the alignment of CMB multipoles. While the summaries are fine, the authors don't point out that the former is now understood (peculiar velocities of galaxies introduce redshift-space distortions so that the true shapes appear distorted when plotted in redshift space as opposed to distance), while the latter — on which the jury is still out but might be something genuinely interesting — is toned down by (correctly) suggesting some possible banal explanations. Otherwise, my only real complaint is that some citations in the text are not in the reference list; in some cases there are obvious mistakes (the year is off by one, for example), but in others (one of which is cited often) they appear genuinely to be missing. (I always wonder why authors do not use BibTeX or some other scheme to automate references, at least when not writing a book review for *The Observatory*.)

There are a few black-and-white figures scattered throughout the text. Eight pages of small-print endnotes follow the main text (which includes two appendices on relativistic cosmological models and dipole anisotropy). A four-page small-print index follows the reference list. Despite neither author being a native speaker of English (as far as I know), the language is good and both typos and questionable choices of style are few. The emphasis is on what the CMB can tell us about how science is (and has been) done rather than on the physics of the CMB itself, a basic knowledge of which is assumed. It is thus a good book for those with such knowledge who want to learn more about the history and philosophy of the field in the context of a concrete example. I've recently attended several conferences on the history and philosophy of science★ and am often surprised about how well the participants are familiar with scientific details (though it is true that many were trained as scientists then switched to history and/or philosophy). Despite Feynman's claim that the philosophy of physics is as useless to physicists as ornithology is to birds, I think that it would be good if more working physicists were familiar with the history and philosophy of their field, both for its own sake and for the benefit it can bring to actual science; this book is a good starting point. — Phillip Helbig.

References

(1) M. López-Corredoira, *Fundamental Ideas in Cosmology: Scientific, philosophical and sociological critical perspectives* (IoP Publishing), 2022.
(2) P. Helbig, *The Observatory*, **143**, 214, 2023.

★I'm writing this in 2025 January, a few days before a workshop on the philosophy of dark energy. Of nine conferences I attended last year, seven were on the history and/or philosophy of science (usually physics, here usually astrophysics, and there usually cosmology); among others were workshops on the philosophy of inflation and the philosophy of black holes. As a joke I asked a fellow participant when we could expect one on the philosophy of radio interferometry, but interestingly he didn't take it as a joke at all. (Interestingly, several of those conferences were co-organized by one of the two back-cover-blurb writers.)