BOOK REVIEWS

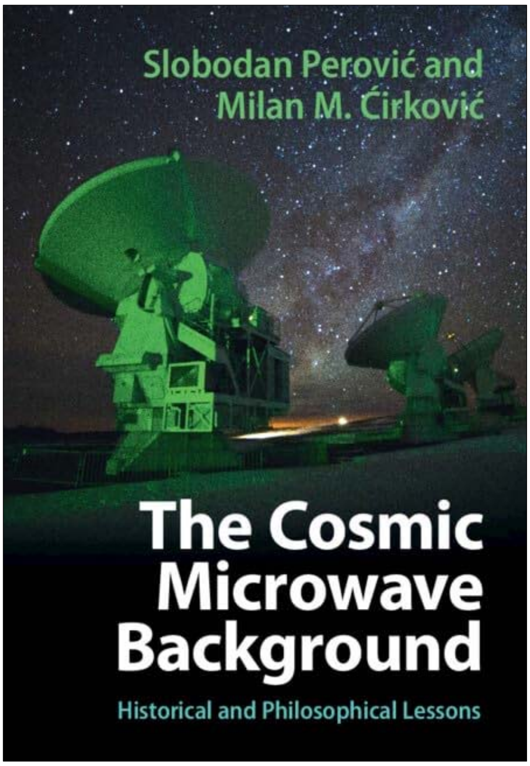
***The Cosmic Microwave Background: Historical and Philosophical Lessons*, by Slobodan Perović and Milan M. Ćirković. (Cambridge, Cambridge University Press, 2024). Pp. x + 205. ISBN 978-1108844604 (hardback). 170 × 244 mm. US$50.97.**

With this volume we are treated to yet another entry in the growing field of the philosophy of astronomy, drawing heavily on history (see my review of *The Philosophy of Astrophysics* by Boyd et al. in the June, 2024 issue of this journal). Slobodan Perović is a Professor of Philosophy and History of Science at the University of Belgrade, and Milan Ćirković a well-known astronomer with broad interests, working at the Astronomical Observatory of Belgrade. In this volume they undertake a … "philosophically motivated historical analysis …" of the discovery of the cosmic microwave background (CMB) and its aftermath (page 1). In particular, they are interested in alternative explanatory hypotheses of the CMB before the hot Big Bang model was eventually accepted as the best explanation for the origin of the Universe. As they write

> Our central goal is to understand the emergence of the consensus, the exact role alternatives and their failures played in its formation, and the epistemological attitudes that drove all this. (page 31),

all in the service of broad philosophical questions. They succeed in showing that there were many alternative interpretations of the CMB, and that (contrary to popular and even scientific opinion these days), it was not immediately and universally accepted as the remnant radiation of the Big Bang, the 'explosion' postulated in 1931 by Georges Lemaître and definitively detected in 1965. In the process they demonstrate Helge Kragh's thesis that many false trails and blind alleys are followed before consensus is reached on the best theories—here as elsewhere in cosmology and in the history of science in general (Kragh, 1997).

By way of introduction the authors delineate four eras in physical cosmology up to 1965: (1) antiquity to 1917, a pre-history of cosmology that includes Olbers' dark sky paradox and Newton's 'gravitational paradox' where the Universe should collapse under the force of gravity but doesn't, both indicating a finite Universe; (2) 1917 to 1929 beginning with Einstein's first static cosmological model based on General Relativity and the further pursuit of a static universe based on mathematics rather than empirical knowledge; (3) 1929 to 1948, featuring the expanding Universe and the work of Lemaître and George Gamow and 1948 to 1965 dominated by the great controversy between the Big Bang cosmology and the Steady-State theory of Fred Hoyle and others. They do not delineate eras since this date, though one can reasonably infer from their analysis that the COBE (Cosmic Background Explorer), WMAP (Wilkinson Microwave Anisotropy Probe), and Planck spacecraft delineate a new era of precise observation of the CMB extending from the early 1990s to 2013 when



the last of them (Planck) ceased to operate. These spacecraft observationally demonstrated the perfect blackbody curve of the radiation required by the Big Bang theory, as well as the anisotropies in the 2.73 degree Kelvin radiation, measured by COBE to one part per 100,000 and by WMAP to one part per million—the primordial seeds of modern-day structures such as galaxies. During this era the acceptance of the CMB as the remnant radiation of the Big Bang was finally widely accepted, though even now other possibilities are discussed.

The story of the serendipitous detection of the CMB in 1965 by Arno Penzias and Robert Wilson, one of the greatest discoveries in the history of cosmology along with the expanding and accelerating Universe, is well known. The authors briefly review this history from the prediction of remnant radiation in the famous paper by Ralph Alpher, Hans Bethe, and Gamow in 1948, to Penzias and Wilson's investigation of 'noise' in their Holmdel, N.J. antenna (recently saved from destruction), interpreted by Robert H. Dicke and colleagues as remnant radiation of the Big Bang already shortly after the discovery of the CMB. However, as is often forgotten, the Steady State theory of Bondi, Gold, and Hoyle was still very much alive in 1965. This story of the discovery of the CMB, described in more detail in other books by both historians and cosmologists (e.g. Kragh, 1996; Peebles, 1993), comports well with the idea of extended discovery in science. In other words, contrary to popular opinion, discoveries are never a Eureka moment (Caneva, 2005; Kuhn, 1962), but rather consist (in my analysis, at least) of three phases: detection, interpretation and understanding (Dick, 2015), often with one or more 'pre-discoveries', in this case by Andrew McKellar in 1941 in connection with the energization of the interstellar cyanogen molecule by a thermal background of about 2.3 degrees Kelvin. Such a scenario gives force to the idea of 'collective discovery', with all kinds of social implications, including awarding Nobel Prizes.

Following their brief history of the Penzias–Wilson discovery the authors then demonstrate how the standard textbook accounts after the detection of the CMB have many shortcomings. Specifically, they find only a 'moderate convergence' of opinion on the interpretation of the Penzias and Wilson discovery as related to the Big Bang, until the COBE spacecraft observations in the 1990s resulted in a 'wide convergence' of acceptance that the CMB was indeed the remnant radiation of that primordial event (page 32). They show how the 25 years between 1965 and the results from COBE … "left a sizeable domain for the development of various alternative explanations." (page 32). The alternatives, which the authors categorize as moderate and radical unorthodoxies, are detailed in 13 of the 31 chapters. In the former they include various versions of the Cold or Tepid Big Bang, as opposed to Gamow's Hot Big Bang in which there must be a dense hot phase at the beginning. These include the idea that the remnant radiation was produced from numerous but as yet undetected discrete sources such as primordial Population III objects. The radical unorthodoxies include Hannes Alfven's plasma cosmologies, the time reversal hypothesis of P. C. W. Davies, and various versions of the steady state theory itself. The originality of this book is to analyze these alternative theories, how they were supported and eventually rejected, and the kinds of arguments cosmologists used in their arguments. The authors emphasize that these non-standard hypotheses were often proposed by authoritative scientists, such as Paul Dirac, Sir Martin Rees, Geoffrey Burbidge, Jeremy Ostriker, and Sir Fred Hoyle. These names and others such as Halton Arp and Thomas van Flandern (the latter my colleague at the U.S. Naval Observatory for many years), are known for their out-of-the-box ideas, which sometimes turn out to be true.

What, then, are the lessons learned as promised in the subtitle? The authors nowhere delineate them in a single list (which might have been useful), but the takeaways scattered throughout the book include their conclusion that the emergence of orthodoxy came only after substantial and careful theoretical consideration of the options, which, although too technical to be treated in the media, were nonetheless important; that the theorizing about alternative models played an important subsequent role in subsequent ideas about inflation, dark energy, and the new standard cosmology known as Lambda Cold Dark Matter, and other areas; that scientists should therefore be encouraged to develop alternative, bold, and even fringe models; and that in the end it was observations that clinched the case, at least for now. The book also examines methodological issues, such as the relation between analogy, simulation, theory, and observation, with history-based caveats such as the selection effects of large-scale numerical simulations, and epistemological issues such as the 'underdetermination' of theories, in other words how evidence sometimes does not unequivocally decide between different theories, as often happens in cosmology. In these terms, the early acceptance by some of the CMB as proof of the Big Bang is a case of underdetermination, and is a good case study of this phenomenon for philosophy of science in general (Stanford, 2023).

In the broadest sense this volume amply demonstrates the essential symbiotic relationship between history of science, philosophy of science, and science itself. To those who ask of what use are history and philosophy of science, I answer not only for the increase and diffusion of knowledge and the pleasure of research and writing (and dare I say asymptotically approaching 'truth'?), but also for their usefulness to science. Big Science projects have realized this utility for some time, and backed it up with funding. Robert Smith's work on Hubble Space Telescope history immediately comes to mind (Smith, 1989), as does the history of high energy physics (e.g. Hoddeson et al., 2008). My own work on SETI history, astrobiology, and the history of the U.S. Naval Observatory also falls in this category, providing context and lessons for the management and practice of science (Dick 1993; 2003; Dick and Strick, 2004). Such utility extends to the history of technology as well. During my time as NASA Chief Historian, the Columbia Accident Investigation Board devoted an entire chapter to history in its official report on the Columbia Space Shuttle accident, and concluded that "… history is not just a backdrop or a scene-setter, history is cause." (Columbia Accident Investigation Board, 2003). Today historians and philosophers are increasingly intimately involved in ongoing astronomy projects, most recently in the Black Hole Initiative (Galison, 2023) and the Rubin Observatory's Legacy Survey of Space and Time Discovery Alliance (Nichols, 2024). And volumes such as the one under review contain much that astronomers would find useful.

The philosopher Norwood Russell Hanson's suggested long ago that history of science without philosophy is blind, while the philosophy of science without history is empty. I would add that both history and philosophy of contemporary science without input from scientists runs the risk of being divorced from reality. This book is neither blind nor empty, nor divorced from reality. Rather, it is a nuanced and substantial contribution to both the history and philosophy of astronomy.

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***Almagestum Novum: History of Astronomy*, by Giovanni Battista Riccioli (Michal J.A. Paszkiewicz, tr.). (London, Cricetus Cricetus Ltd., 2023). Pp. vii + 284. ISBN 978-1-7393145-6-9 (hardback), 157 × 235 mm, UK pounds 19.99.**

Giovanni Battista Riccioli (1598–1671) published his 2-volume *Almagestum Novum* (*History of Astronomy*) in 1651. This title is the first in a series of books (likely more than 20) that software developer Michal Paszkiewicz plans to publish, as a complete translation of that text, which can rightly be regarded as one of the most important books ever published in our field of study. Only