China (2022YFF0711500,2020SKA0120201), and in part by the Strategic Priority Research Program of the Chinese Academy of Science (XDB0550101).

References

(1) D. G. York *et al*., *AJ*, **120**, 1579, 2000.
(2) G. R. Ricker, in D. Apai & P. Gabor (eds.), *Search for Life Beyond the Solar System. Exoplanets, Biosignatures & Instruments* (https://astrobiology.nasa.gov/nai/seminars/featured-seminar-channels/conferences-and-workshops/2014/3/16/search-for-life-beyond-the-solar-system-conference/index.html), 2014.
(3) P. E. Dewdney *et al*., *Proceedings of the IEEE*, **97**, 1482, 2009.
(4) R. Nan *et al*., *Int. J. Mod. Phys. D*, **20**, 989, 2011.
(5) Ž. Ivezić *et al*., *ApJ*, **873**, 111, 2019.
(6) W. O'Mullane *et al*., *IEEE International Conference on Web Services (ICWS'05)*, **1**, 2005, p. 33.
(7) M. Wenger *et al*., *A&AS*, **143**, 9, 2000.
(8) F. Ochsenbein, P. Bauer & J. Marcout, J., *A&AS*, **143**, 23, 2000.
(9) M. Taghizadeh-Popp *et al*., *Astronomy and Computing*, **33**, 100412, 2020.
(10) C. Cui *et al*., in J. Wang *et al*.(eds.), *Proceedings of the 3rd International Conference on Wireless Communcation and Sensor Networks (WSCN 2016)* (Atlantis Press), **44**, 2017.
(11) V. Navarro, *ESA Data Exploitation Platforms: Accelerating Space and Navigation Science. SciOps 2022: Artificial Intelligence for Science and Operations in Astronomy (SCIOPS)* (Zenodo), 2022.
(12) M. Diaz *et al*., *Astronomical Data Analysis Software and Systems*, **XXVII**, 522 (Astronomical Society of the Pacific), 2020, p. 323.
(13) S. A. Russo *et al*., *Astronomy and Computing*, **41**, 100648, 2022.
(14) S. Stetzler *et al*., *AJ*, **164**, 68, 2022.
(15) M. Taghizadeh-Popp *et al*., *Astronomy and Computing*, **33**, 100412, 2020.
(16) R. Nikutta *et al*., *Astronomy and Computing*, **33**, 100411 2020.
(17) H. Yan *et al*., *The Innovation*, **3**, 100224, 2022.

REVIEWS

Conjuring the Void: The Art of Black Holes, by Lynn Gamwell (MIT Press), 2025. Pp. 208, 22·9 × 30·5 cm. Price $44·95 (about £33) (hardbound; ISBN 978 0 262 04996 2).

Gamwell is a non-fiction author and art curator, her books concentrating on the relationship between science, its history, and art. When encountering 'black holes' and 'art' in the same phrase, I usually think of Peter Galison (director of the Black Hole Initiative, philosopher, professor of the history of science and physics at Harvard, author, and film-maker), and indeed he is the first person thanked in the extensive acknowledgements. After a foreword by Neil deGrasse Tyson and an Introduction, there are three chapters of vastly different lengths: 'Black Hole Basics' (24 pages), 'Historical and Philosophical Background to Imaging Black Holes' (18), and 'Artistic and Scientific Images of Invisible Objects' (126), followed by a one-page 'Conclusion'. Each chapter has several sections (three, four, and ten, respectively) which more or less alternate between science and art (or, in either case, its history). Thus, we have the sequence (at the end of the third chapter) 'Supermassive Black Holes', 'Black Holes as a Metaphor for Nothing, Silence, and Blackness', 'Gravitational Waves Caused by Merging Black Holes', 'Immersive Art About Black Holes', and 'Direct Observation of Black Holes by the Event Horizon Telescope'.

The science sections are at the level of a *good* popular-science book, probably better than all summaries of similar length I've read; they are correct but understandable and concentrate on the important features. Good is that Wheeler is *not* credited with coining the term 'black hole' (though he did much to popularize it), and a case is made (probably correctly) that the term is due to Dicke. We get a good overview of the history of the black-hole idea and of the most important concepts. Many of the figures related to science are from technical papers, and there is a spectrum from those, through scientific 'artist impressions', through cartoons and sketches, through quasi-realistic art, to abstract art. While many readers are probably familiar with Jean-Pierre Luminet's classic black-hole image, we are shown other examples from around the same time. I was pleased to find out that Luminet is also an artist; one of his drawings is reminiscent of the work of M. C. Escher (and the front cover of the album 'Inside the Triangle' by 1970s band Thee Image — the back cover features a band photo which will probably be too much for those who didn't live through those times). Whether Luminet's image or those from (simulations of) the *Event Horizon Telescope*, we get not just the pretty pictures but also the explanation of how they were made and what they actually show.

I know more about science than about visual arts. As in the sections about the former, in those about the latter we get summary texts and illustrations, though understandably the image-to-text ratio is higher in the latter case. Most of the art is modern and most art I like is not modern, but all the same I found both the text and image portions of the art sections interesting. There are also tie-ins between the modern science of black holes and related ideas in other times and cultures, but fortunately what is emphasized are interesting parallels, not *Tao of Physics*[1]-style woo.

This is a beautiful book. The dust jacket contains a hole, revealing a circle of black velvet (or something similar) in the centre of the front cover. I refrained from my usual penciled-in notes in the margins, putting them on a blank page at the end instead. However, very few were necessary, as there are almost no typos nor other things I often complain about in reviews. Somewhat unusual are headers and page numbers at the bottom of the page (and only on pages which are not solely devoted to figures and captions — there are many pages which are). All of the images are in colour except the few which are originally black and white, and the large format and slick paper make for an enjoyable reading experience; considering the high production standard, the price is more than reasonable. Five pages of endnotes are mostly references, but one is a very long list of 30 popular-science books in English about black holes published since 2020. (I've reviewed four of those in these pages [2–9], and several others I've reviewed from the same time also touch on black holes; there is no shortage of literature.) The page of 'Photo and Diagram Credits' contains only those which are not in the corresponding captions; since there are illustrations on nearly every page and many pages devoted solely to illustrations and their captions, there are many of the latter. An index corresponding to a bit more than three full pages ends the book.

There is also no other book like it. Whether for the combination of science and art or for a good overview of either, this is a good introduction to black holes and their role in our thinking. — Phillip Helbig.

References

(1) F. Capra, *The Tao of Physics* (Shambhala Publications), 1975.
(2) L. Rezzolla, *The Irresistable Attraction of Gravity: A Journey to Discover Black Holes* (Cambridge University Press), 2023.
(3) P. Helbig, *The Observatory*, **143**, 229, 2023.
(4) B. Smethurst, *A Brief History of Black Holes: And Why Nearly Everything You Thought You Know About Them is Wrong* (Pan Books), 2023.
(5) P. Helbig, *The Observatory*, **145**, 125, 2025.
(6) B. Cox & J. Forshaw, *Black Holes: The Key to Understanding the Universe* (William Collins), 2023.
(7) P. Helbig, *The Observatory*, **145**, 129, 2025.

(8) M. Chown, *A Crack in Everything: How Black Holes Came in from the Cold and Took Cosmic Centre Stage* (Head of Zeus), 2024.
(9) P. Helbig, *The Observatory*, **145**, 216, 2025.

The Arrow of Time: From Local Systems to the Whole Universe, edited by Cristian López & Olimpia Lombardi (Cambridge University Press), 2025. Pp. 315, 17 × 26 cm. Price £130 (hardbound; ISBN 978 1 00958 157 8).

There are many arrows of time (as "time's arrow" a term coined by Eddington): cosmological, thermodynamic, electromagnetic, quantum-mechanical, causal, weak-interaction, *etc*. When I was a student at the Hamburg Observatory, in the excellent library I found and read a book on *The Nature of Time*[1], the proceedings of a meeting held at Cornell in 1963, convened by Hermann Bondi and Thomas Gold, which is particularly interesting as it includes extensive discussion as well as the papers presented. (One participant is identified only as 'Mr. X'; the consensus is that he was Feynman. The fact that even Feynman didn't want his name to be associated with such discussions perhaps reflects the fact that many perceive them to be fringe or at least only marginally related to 'real science'.) Much modern discussion parallels that in that book; on the other hand, there has been progress, at least with respect to defining terms and making various points of view more clear, though there is still much disagreement about the nature of time, particularly time's arrow. This book is also the proceedings of a workshop (which took place in 2023 in Buenos Aires). The 16 authors of the 13 chapters (three have two authors) are primarily philosophers of science (though some work in physics as well). Many of the usual suspects are here, either as authors or cited in the references. (In most books on the philosophy of physics I have read, I came across various subsets of about thirty names; it is a relatively small field in terms of people actively working in it, though not in terms of scope.) The older book contains many authors known for their work in cosmology, astrophysics, astronomy, or General Relativity (GR), reflecting the fact that there was less specialization back then (and, of course, much less to know). These days, there are several full-time philosophers of physics, though many have a background in physics and most are very knowledgeable about physics, not just the philosophy thereof.

There is little actual astronomy in the book, even in the last, fourth part 'The Whole Universe'. On the other hand, most or all of the arrows of time are relevant for astrophysics, and the contributions provide a good overview of current thinking on the various arrows of time and the relationships among them. I was pleased to see two old papers (co-)authored by Tolman cited — not one of his many papers on entropy in cosmology (though his book on that topic[2] is) — but rather on thermal equilibrium in General Relativity[3,4]. I found useful the discussions on the distinction between time-reversal invariance, reversibility, and the arrow of time (Chapter 11) and on various ideas on how an arrow of time can arise even if the underlying physical laws are time-reversal invariant. An important role is played by the 'past hypothesis', a term coined by David Albert referring to the assumption that the Universe started in a low-entropy state[*] (and as such is a boundary condition rather than a law of Nature); most of the chapters cite his influential book on the topic[6]. There are, however, other ideas concerning the origin of various arrows of time, some of which I find intriguing and some of which seem to me to be rather desperate. Some of the contributions discuss the concept of free will and its relation to the arrows of time; there is certainly no consensus regarding free will[†], though I hope that most readers agree with me that the idea of free will being able to change the *past* as well as the future is going too far.

The writing and editing are good, especially considering that the editors and many of the authors are not native speakers of English, and there are fewer typos and so on than in most

*Penrose[5] discussed the idea of a 'special' state of the beginning of the Universe in a somewhat different context.

[†]I don't think that I could believe in it even if I wanted to.

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[1] one[2] 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†

*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[3], the fact that Lemaître was *not* a Jesuit, *etc*.

†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*[4]), 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[5] reviewed[6] 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[8] 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.

including those associated with solar variability and its long-term evolution, the effects of a supernova or gamma-ray burst close to the Solar System, a rare stellar passage through the Oort cloud, and even the ultimate fate of the Universe. Life's end poses questions as deep as those of its origin, and it would have been interesting to have seen a summary of key points arising from the contributions missing from these proceedings and the round-table discussions.

The book, conceived before the COVID health emergency but occurring (perhaps ironically) during health restrictions associated with the pandemic, unfortunately does not achieve its promise. Instead, most sections focus on different aspects of the near-Earth asteroid (NEA) impact hazard. While that might be a significant long-term threat to life on Earth (the threat to humanity is much greater), it is only one of many possible astronomical influences facing the evolution of life, whether on Earth or elsewhere.

Still, there are interesting papers. The editor's introduction gives a useful summary of various astronomical hazards that might occasionally affect life on Earth; several contributions show how different aspects of the impact hazard are now part of the corpus of 'normal' astronomical research, demonstrating how far the modern subject has advanced from its origin forty years ago in the weeds of the 'giggle' factor. There is a nice discussion of lunar impact events, and of possible fireballs that might be linked to the *c.* 370-m-diameter Apophis, which will pass within an astronomical whisker of Earth on 2029 April 13. Other papers discuss the relatively short (several Myr) time-scale for overturn of the observed NEA population, and how all-sky observational surveys will soon revolutionize our knowledge especially of small members of the population, presumably fragments of larger bodies.

In summary, this book will appeal to NEA specialists but probably not to the wider community of researchers suggested by its broad title. The cost, at nearly a pound a page, is disappointing. — Mark E. Bailey.

Astronomy and Satellite Constellations: Pathways Forward (IAUS 385), edited by Peter Grimley, John Barentine, David Galadi-Enriquez & Constance Walker (Cambridge University Press), 2026. Pp. 264, 25 × 18 cm. Price £98 (hardbound; ISBN 978 1 009 39922 7).

This is a review of the printed proceedings of IAU Symposium 385 (IAUS 385) held on 2023 October 2 in La Palma, Canary Islands, Spain.

This is only the second IAU symposium I've attended in-person; the first was IAUS 90[1*]. Curiously, CUP's on-line portal, Cambridge **Core**, has an information panel showing a date of 2024 December but published on 2026 January 19.

Given the rapidly moving subject of satellite launches and megaconstellations, the publication delay relegates the excellent papers published here to being an historical collection rather than a timely, useful work feeding promptly back into the community[†] — a point equally bemoaned by Helbig in his review[2] of the proceedings of IAUS 368.

The symposium was organized by the IAU Centre for the Protection of the Dark and Quiet Sky (IAU CPS) and partitioned according to the four 'hubs' within CPS: Community Engagement Hub, SatHub, Policy Hub, and Industry & Technology Hub. The total of forty-five papers in these proceedings are organized mostly in the order of the presentations in the programme, with about ten of those being separately contributed and poster-related papers following the others.

*For context, there was no 'on-line version' in 1979 as the internet really didn't take off until about four years later and the world wide web came about six years after that!

†The rapid growth of satellite megaconstellations is an *existential* problem for terrestrial astronomical observations and a growing challenge for orbiting observatories; astronomical research is under threat from fast-moving, politically unconstrained commercial interests and academic publication timescales are too slow!

Unfortunately there are about 35 presentations not present in the proceedings and no detailed report on the public session with UN Delegates & Observers held on the last day. Also, unlike the IAUS 90 proceedings, there is no inclusion of any Q&A discussion following each presentation though I certainly recall many such discussions. As such, these proceedings are not a complete representation of the symposium; perhaps there should have been more incentive for symposium contributors to submit papers for publication in the proceedings?

I agree with Helbig [2]: I find the paper used to be too thin with some text and dark/shaded diagrams showing through the paper.

There is a list of symposium participants but it doesn't distinguish between those who attended in-person and those who were on-line. Perhaps either an additional column for that list denoting in-person/on-line attendance or simply italicizing the names of those who were on-line would have made it clear. Also, it would have been a useful courtesy to include a key to the faces shown in the group photographs as was done for IAUS 90 [1].

There is no use of colour in the book at all, maintaining a grey-scale for all of the figures. However, the on-line version uses colour for all submitted papers that included colour (including the symposium group photographs). Both Helbig [2] and Phillipps [3] mentioned the lack of colour in their respective reviews of IAU symposium proceedings (both published by CUP) with Helbig commenting that the printed version is more likely to be purchased by libraries and Phillipps suggesting that the lack of colour may be unimportant since the on-line version is likely to be more accessible to researchers (depending on the type of access).

That may also be true for other submitted papers but, comparing the source material of my own submission to these proceedings (p. 113) with what has been published, I noticed that the pie-chart figures have been significantly re-organized to optimize the use of space. Unfortunately, the associated pie-chart legends, kept with the relevant text, often became overly separated from their pie charts, necessitating a lot of page-flipping to match the legends to the pie slices.

In summary: for the price I would have expected a more complete record of the symposium, better-quality paper, and more use of colour. This is, however, a fair collection of papers covering a reasonably wide range of topics but, sadly, with about half of the presentations not appearing as papers and no post-presentation Q&A discussions included. For a topic of such importance to astronomy and its practitioners, the delay between the symposium and the publication is unhelpful. — Paul A. Daniels.

References

(1) I. Halliday & B. A. McIntosh (eds.), *Solid Particles in the Solar System (IAUS 90)* (D. Riedel Publishing Company), 1980.
(2) P. Helbig, *The Observatory*, **146**, 96, 2026.
(3) S. Phillipps, *The Observatory*, **146**, 97, 2026.

Grubb Dublin and Grubb Parsons, by Ian S. Glass (Centre for Astronomical Heritage), 2026. Pp. 340, 29·7 × 21 cm. Price £0 (open acess) (on-line PDF file; ISBN 0 7503 0454 5 (previous edition)).

[This book is an expanded and updated edition of *Victorian Telescope Makers: The Lives and Letters of Thomas and Howard Grubb* (Institute of Physics Publishing Ltd), 1997, original ISBN 0 7503 0454 5. The copyright was ceded to the author in 2008. With many photos, traditional paper publication would be prohibitively expensive. It is freely available as a PDF file (formatted like a traditional book, and with both a fancy on-screen-reading interface and a link to the plain PDF file) at https://cfah.org.za/resources/grubb-glass and, with the permission of the author and in the interest of long-term

availability, also at https://www.obsmag.org/issues/published/2026/08/grubb_dublin_and_grubb_parsons.pdf (plain PDF file) — Ed.]

This account by Dr. Glass of the successful evolution of the telescopes that formed and defined astronomy's own capabilities illustrates how parallel developments in industry, matched with home-made inventions and refinements, enabled the construction of large machinery that could be harnessed to achieve pointings on the sky of delicate precision and images of sub-arcsecond purity. To be sure, timing was everything; the founder (Thomas Grubb) was an exceptionally skilled engineer in many of the facets which telescope making required, and sufficiently supplied with the tools, facilities, money, and time that he could devote as long as it took to test, refine, and perfect instruments that all worked to spec. Glass has presented us with a masterful account of the achievements of this adventurous, industrious, and successful team, introducing numerous correspondence with like-minded astronomers and technicians in Europe and beyond, and sprinkling it with touches of family life and enough humour to render the book eminently readable from beginning to end. The result is a product of commendable scholarship, and deserves a place in every library that caters to general science, engineering, and the history of science, as well as astronomy.

The successes which the Grubb team could chalk up seemed to be due to the ability to stay ahead of the game. All the various stages of building, whether in driving heavy machinery yet maintaining delicate positional accuracy, annealing glass blanks to form acceptable bases for large mirrors, fabricating achromatic lenses, or grinding and (particularly) figuring and polishing the mirrors themselves, their techniques and materials could benefit from the abundant R&D which their processes engaged. As Glass relates, their heyday was the mid-to-late Victorian decades, and if their later merging with the (also Irish) Parsons Company could be regarded as an inevitable product of the rigours of two world wars, a number of the Grubb or Grubb–Parsons instruments are still in active service today. This book is well illustrated by images of both people and equipment, and concludes with lists of products from the original Dublin and the later Newcastle (UK) companies, furnishing a fine sense of the substantial and significant output which owes its roots to the foresight and persistence of Thomas Grubb's efforts on his first creations.

Scotland (through James Watt) gave us the steam engine, Wales (in the person of Philip Vaughan) the ball bearing, England (by one John Harrison) the chronometer, and Ireland (through the Grubbb family) the telescope. As Glass shows, it wasn't a question of being academic, but of knowing one's materials, the best tools to work on them, and (also) of achieving therewith a near monopoly for several decades in this specific field of observational astronomy. — Elizabeth Griffin.

The Impossible Man: Roger Penrose and the Cost of Genius, by Patchen Barss (Atlantic Books), 2024. Pp. 247, 24 × 16 cm. Price £33·35 (hardbound; ISBN 978 1 83895 932 6).

Roger Penrose needs no introduction. Patchen Barss does, at least to me. He is a Toronto-based science journalist with the usual credentials but also author of *The Erotic Engine: How Pornography Has Powered Mass Communication, from Gutenberg to Google*. At first glance, that might seem rather removed from Penrose, but a (to me) surprisingly large part of the book being reviewed is concerned with Penrose's (real and hoped-for) sex lives. As the author notes, Penrose cooperated intensively and extensively with the author, but the book is not an authorized biography in that Penrose didn't approve (or reject) any of the contents.

The prologue introduces us to the current Penrose, before a capsule history of the Universe brings us up to his birth and a very brief description of his life. The next few chapters are what one might expect: parents, siblings, childhood, undergraduate studies, his interest in Dutch artist M. C. Escher, doctorate, marriage. Those chapters give an idea of some of the influences which shaped Penrose, but to me they don't seem as special as the author makes them out to be. We then follow Penrose (on a NATO fellowship) to the United States (where

he worked at Princeton, Syracuse, and Cornell), learn about his stillborn daughter, and meet some of his friends and colleagues, such as Wolfgang Rindler, Ted Newman, John Wheeler, Ivor Robinson, Andrzej Trautmann, and Engelbert Schücking, but I would have liked to learn more about them. Penrose's first wife Joan was from Detroit, and his father offered the newlyweds a cottage he owned across the border in Canada, Blink Bonnie, which became something of a North American base for Penrose. The conference in Jablonna (Poland) was one of the legendary conferences on General Relativity, and we are reminded about how much more adventurous travel was in those days.

Oil money attracted many relativists to Texas in the 1960s, including Penrose, who, however, quickly became disenchanted with Austin and the States in general (around the time of and partly because of the Kennedy assassination). Before setting off for Texas, they had visited Escher in the Netherlands, accepting a print as a gift, and son Christopher was born. In Austin, Penrose was in the company of of Schücking, Roy Kerr, and Ray Sachs, and just a few hours away in Dallas were Rindler, Robinson, Alfred Schild, and Istvan Ozsváth. Scientifically, he was the right person in the right place at the right time, but of course Texas is very different from the northeastern United States, and the Kennedy assassination was a real shock. He was killed while many of Penrose's colleagues in Dallas were waiting for him to arrive and address them.

Back in England in 1964, Penrose became a reader at Birkbeck College, and 22 months after Christopher, son Toby was born. At that point, the book shifts the emphasis somewhat from travel to Penrose's work, and we learn about Penrose diagrams, the singularity theorems (Penrose quoted as believing that Hawking got too much credit for their joint work), and his work on spinors. Around 1970, domestic life had become predictable, but Penrose was convinced that his most important work lay in the future, and he began to advertise himself *via* popular-science articles and so on. His sister Shirley mentioned that her childhood friend Judith Daniels was now studying maths. Penrose fell in love with Daniels, and the book quotes extensively from their correspondence; the letters had been made available to the author by Penrose. She comes across as something like Einstein's first wife, with whom he discussed his early work, but with time Daniels could no longer follow Penrose's increasingly complex forays into twistor theory. Penrose saw her as a muse, but also wanted more, which she made clear would not happen, at a meeting in Trieste. Despite the lack of a sexual relationship, their 'affair' ultimately led to the end of his marriage to Joan, and a professorship at Oxford was a welcome opportunity to leave the family (now including third son Eric) behind in London. (Before the Rouse Ball Professorship at Oxford became available, Penrose had considered applying for the Plumian Professorship at Cambridge, as Fred Hoyle had resigned — in part because he knew that Joan didn't like Cambridge and hoped that that might facilitate a break-up without him having to take the initiative. The Plumian Chair went to Martin Rees.)

That was the time of Penrose's work on aperiodic tiling. In general, things were looking up: a prestigious position at Oxford, his widowed mother happily remarried, separated from Joan, and still in contact with Judith. In the 1970s and 1980s, while still based in Oxford, Penrose was a frequent visitor to Dallas, Austin, and Houston. Here he met Salley Vickers, who had followed her husband (a former student of Dennis Sciama) to Austin. After a failed marriage with children, she and Penrose found common ground, eventually living together in California after Penrose had accepted a sort of adjunct associate professorship at Berkeley. Though she knew less about maths and physics than Judith, Penrose saw her in a similar role. However, in this case, Penrose realized that it wouldn't work out, and ended the relationship (which is also what Vickers wanted) after returning to England.

In 1987, another student of the ubiquitous Dennis Sciama, David Deutsch, became a postdoc with Penrose (who had helped him publish a paper on quantum computing a couple of years before). Although Deutsch had only one meeting with Penrose's relativity group, they often discussed quantum computing, consciousness, and so on. We learn about Penrose's

disagreeement with Hawking regarding the black-hole information paradox, and the — at best — mixed reception to his books expounding his ideas on consciousness[1,2]. Around the same time, Penrose married his doctoral student Vanessa Thomas, who is 34 years younger. Although an obvious conflict of interest might have been avoided by switching to some other supervisor, it would be interesting to know why "she had no choice but to leave her DPhil unfinished when they married". They had a son, Max, in 2000, and remained together for another twenty years or so. The prologue introduces Penrose shortly after their separation, living alone, brewing coffee every Friday, and microwaving cups of it as needed throughout the week. During the corona pandemic, he made his own muesli every two weeks, and used one of two baths for banana storage, keeping them under water *via* a glass plaque he had received in return for delivering a talk in Texas.

While controversial, Penrose's later books* had become successful, and he described his work in physics in a massive tome[5] (the first edition of which probably contains more typos than any other book I have read). Later books presented his unorthodox views on cosmology[6] and his general disenchantment with current trends in physics[7]. The last proper chapter ends on a sad note, with an abortive attempt to set up a Penrose Institute and Penrose once again seeing a woman as his muse who didn't want to be seen as such, this time Ivette Fuentes(-Schuller), now a professor of quantum physics at Southampton. She did save Penrose from future embarrassment, though, by rejecting funding from Jeffrey Epstein. By selling the family home, Woodlands, Penrose purchased a house for himself, one for Vanessa Thomas, and a flat for himself within walking distance of his office. The final chapter returns to the scene of the prologue and details how Barss and Penrose began the many interviews which played an important role in the book, with Penrose insisting that Barss read the correspondence with Judith, which her sister had found after Judith's death in 2005 and had returned, unopened, to Penrose. Many people close to him had recently died: Hawking in 2018, Rindler and Joan in 2019, Newman and Penrose's younger brother Jonathan (a chess grandmaster) in 2021.

A long author's note and acknowledgements section explain how the book came about, and who was involved. All is well documented. At the same time, the author is aware that memories might not be accurate. There are a handful of black-and-white figures throughout the book. There are no footnotes but 14 pages of endnotes (mostly citations to sources). A thirteen-page small-print index ends the book.

Of course, biographies of scientists often include a description of not just their scientific work, but also their 'life and times', including aspects of their personal lives, and it varies from scientist to scientist how important one aspect is for the other, and from reader to reader how interesting the various aspects are. A biography of Richard Feynman which ignored his personal life would not only be less interesting but also a misrepresentation, as his personal life is something which he himself often publicized. With Penrose, the situation is somewhat different, as he didn't publicize his private life. While that in itself might not be a reason to ignore it, or at least to devote less space to it, my impression is that Barss makes two mistakes: he paints Penrose's personal life as somewhat unusual, whereas as far as I can tell it was par for the course for a man of his generation, family, social class, *etc*., and one gets the impression that the 'mistakes' in his personal life were somehow the price he had to pay in order to excel academically. One might think that Penrose, who is old, somewhat blind, and lives alone, didn't realize what direction the biography would take. On the other hand, he often complained that the establishment (though, as detailed in the book, at one point it was pointed out to him that he himself had become the establishment) didn't appreciate his work enough, and on other occasions at least seemed to take the view that any publicity is good publicity. As the scientific and personal aspects are intertwined in the narrative (rather

*While earlier, more technical, books, such as the two volumes co-authored with Rindler[3,4] were not controversial as such, neither did they attain the popularity and influence for which Penrose had hoped.

than being separated by chapters or sections, say), readers not interested in the latter (I can't think of any who would be interested in the latter but not the former) can't easily read around them.

I learned much about Penrose which I didn't know before. How much I needed to learn (and about what) is another question, and I would have liked more in-depth descriptions of various aspects of his work, such as the singularity theorems, spinors, non-periodic tiling, *etc*.— but at a level less demanding than in his rather technical *magnum opus*[5]. (Other aspects of his work, such as his recent ideas on cosmology and his somewhat older ideas on consciousness, don't interest me as much, and also Penrose has documented them well at the desired level in other books[1,2,6].) As there is not much concrete description of science (Penrose's or others'), there was little opportunity to notice mistakes. However, an expanding Universe does not necessarily imply that it must have a beginning. A newborn certainly has more than two trillion atoms. I also doubt that Hawking had to pursue mainstream success because he needed money to cover medical and physical care.*

In summary, I didn't feel that reading the book, which is written well, was a waste of time, but I think that a shift of emphasis would have made that time more valuable. — Phillip Helbig.

References

(1) R. Penrose, *The Emperor's New Mind: Concenring Computers, Minds, and the Laws of Physics* (Oxford University Press), 1989.
(2) R. Penrose, *Shadows of the Mind: A Search for the Missing Science of Consciousness* (Oxford University Press), 1994.
(3) R. Penrose & W. Rindler, *Spinors and Space-Time. Volume 1: Two-Spinor Calculus and Relativistic Fields* (Cambridge University Press), 1984.
(4) R. Penrose & W. Rindler, *Spinors and Space-Time. Volume 2: Spinors and Twistor Methods in Space-Time Geometry* (Cambridge University Press), 1986.
(5) R. Penrose, *The Road to Reality* (Jonathan Cape, London), 2004.
(6) R. Penrose, *Cycles of Time: An Extraordinary New View of the Universe* (Bodley Head), 2010.
(7) R. Penrose, *Fashion, Faith, and Fantasy in the New Phusics of the Universe* (Princeton University Press), 2016.

Starwatchers: Our Journey of Discovery in the Night Sky, by Joanne Baker (Bloomsbury), 2026 (first published 2025). Pp. 271, 20 × 13 cm. Price £10·99 (paperback; ISBN 978 1 5266 0801 7).

I remember Joanne Baker from cosmology conferences in the second half of the 1990s. After a good career start in academia (doctorate from the University of Sydney, NASA Hubble Fellow at Berkeley, Royal Society University Research Fellow at Oxford), she moved into writing (books) and editing (for *Nature* and *Science*). This book has three (long) chapters (divided into sections) on the Moon, the Solar System, and the rest (stars, galaxies, the Universe). Like a few other books[1–4] I've recently reviewed[5–8] in these pages, it is not about just astronomy but also the relationship between humanity and the heavens. The emphasis on the latter is strongest in the first chapter and weakest (but still present) in the third. I particularly enjoyed the first part, perhaps because I learned the most from it. While many expected topics are explored, we also get details on James Nasmyth and his lunar models, 'Moon madness', and non-Western cultures. The second chapter is the longest. It is not a systematic survey of the Solar System, but a mixture of planetary science, the history thereof, and the role the planets have played in human history. Like the rest of the book, the aim is to explore selected topics in a bit more detail, rather than give a superficial survey of many more. The third chapter covers astrometry, stellar distances, the Milky Way, spiral galaxies,

*Hawking has stated that he was happy with NHS care. Much later, after his tracheotomy in 1985, the NHS would have paid for nursing-home care or less than round-the-clock care at home, but as his wife wanted him to remain at home with round-the-clock care; the bill was footed by the MacArthur Foundation.

and the 1920 'Great Debate' between Shapley and Curtis*, before shifting gears somewhat to discusss the influence of modern physics on astronomy, radio astronomy, extraterrestrial life, radio astronomy, black holes, the dark sector, philosophical aspects of cosmology, and the possible fates of the Universe. The epilogue, like the introduction, provides details of Baker's own quest to connect with the Universe.

As usual, I have a few complaints about the discussion of cosmology. While some of them concern what are probably just careless typos or bad editing (on the whole, though, the book is written and edited well), the claim that "there was no need for a repulsive force to counter gravity, or to fling bodies apart" in Einstein's original cosmological model, and thus astronomers struggled to explain the expansion of the Universe, is essentially backwards: *without* such a force (a positive cosmological constant), Einstein noticed that he could not have the static model he wanted, so introduced such a repulsive force, though to keep the universe from collapsing, rather than causing it to expand. (It was later realized that there are non-static cosmological models both with and without a cosmological constant.) Perhaps the confusion stems from the wrong idea (which I've noted in some other reviews) that the cosmological constant (or dark energy) somehow causes the expansion of the Universe (not just its acceleration). Later on, she writes "Back in the 1910s, Einstein set [the value of the cosmological constant] to zero and it was effectively dropped: there was no need for it, and it made no difference to the calculations." Again, essentially backwards. (Later on, Einstein did drop the cosmological constant once he realized that the Universe is expanding, and of course it can make a profound difference to the calculations.) Another blunder is lumping different sorts of Multiverse into the same category; Tegmark[9,10] spells things out clearly. However, that is made up for by alerting me, in the suggestions for further reading, to a book on the Multiverse I hadn't yet heard of[11].

The book is written well and there are fewer typos and questionable style choices than in most books I've reviewed in these pages. There are 16 pages of high-resolution colour plates at the middle of the book, a useful addition. There are neither footnotes nor endnotes. The main text is followed by two pages of acknowledgements, four of suggestions for further reading grouped by chapter (about 20 suggestions, mostly books, for each), a particularly thorough ten-page small-print index, and a page of picture credits. I've read several of the books suggested for the topics in the third chapter, and reviewed some of them here.

This book should be added to a list of books to read on the history of the relationship between humanity and the heavens. While modern astronomy gives us more data than ever before, even many astronomers, not to mention non-astronomers, don't have the emotional connection to the sky which was common in the past. While observations improve almost automatically due to better technology, the emotional bond, in the past part of the culture, is something for which today one has to take the time to form on one's own. The rewards might not be conventional ones, but nevertheless worth pursuing. — Phillip Helbig.

References

(1) M. Capaccioli, *The Enchantment of Urania: 25 Centuries of Exploration of the Sky* (World Scientific), 2024.
(2) R. Trotta, *Starborn: How the Stars Made Us—and Who We Would Be Without Them* (Basic Books), 2023.
(3) L. Gamwell, *Conjuring the Void: The Art of Black Holes* (MIT Press), 2025.
(4) H. S. Kragh, *The Universe: A Guide to Everything* (Reaktion Books), 2026.
(5) P. Helbig, *The Observatory*, **145**, 42, 2025.
(6) P. Helbig, *The Observatory*, **145**, 180, 2025.
(7) P. Helbig, *The Observatory*, **146**, 2026, 211.
(8) P. Helbig, *The Observatory*, **146**, 2026, 214.

*Baker describes Curtis as "working just up the road" from Shapley. At the time of the debate, Shapley was at Mount Wilson and Curtis at Lick (moving to the Allegheny Observatory later in the year). After his move to Harvard the following year, Shapley perhaps became more famous, but at the time Curtis, more than 13 years older, was the senior figure.

(9) M. E. Tegmark, *Our Mathematical Universe* (Allen Lane, London), 2014.
(10) P. Helbig, *The Observatory*, **134**, 150, 2014.
(11) M.-J. Rubenstein, *World Without End: The Many Lives of the Multiverse* (Columbia University Press), 2014.

Weird Universe: Everything We Don't Know About Space (and Why It's Important), by Erika Hamden (Mango), 2025. Pp. 189, 20·5 × 13 cm. Price £15·99 (paperback; ISBN 978 1 68481 728 3).

Erika Hamden is professor of astrophysics at the University of Arizona, where she is also director of the Space Institute. In 16 chapters (plus introduction and conclusion), this is an 'interesting facts' book, in that respect similar to a few[1–3] I've reviewed[4–6] in these pages, though the chapters here are longer. One could group them into 'General Relativity and Cosmology', 'Stars', 'Planets' — moving in — before moving out to the early Universe, the future of the Universe, and the dark sector, concluding with a couple of summary chapters. The topics are perhaps 'weird' in the sense that they differ from our day-to-day experience, but are thoroughly mainstream science. (Of course, the book doesn't really include *everything* we don't know.) By choosing only a few topics, somewhat more depth is possible than with typical popular-science-level introductions to astronomy.

Sometimes good things come from mistakes. In this case, her clear statement (p. 90) that 'revolution' in the political (or similar sense) is due to Copernicus's 'revolutions' (the *revolutionibus* in the title of his famous book) having a similar effect on science caused me to investigate the etymology. Both stem from the Latin term for 'turn around', but both meanings arose independently. (In fact, in the political sense the original meaning was more that of a cycle or return to the 'good old days' than the violent overthrow of an *Ancien Régime*, the latter becoming common only after the French Revolution.) Thus, 'Copernican revolution' is a pun or loaded metaphor. But sometimes they don't. As is often the case, some common cosmological misconceptions are repeated, such as the ideas that dark energy is responsible for the expansion of the Universe (p. 158). A very charitable reading could make a case for a confusing passage (p. 165) being correct, but most readers will probably take from it that a 'coasting universe' "in which the expansion continues forever, but at an unchanging rate" would be substantially younger than our Universe. Actually, by what appears to be coincidence, the age of our Universe is almost exactly the same as that of such a 'coasting universe'[7,8]. It's not the first time I've wondered why an author is so confident (p. 165) that our Universe is spatially infinite (though of course the observable Universe is not). Observationally, we don't know, since it is very close to being spatially flat, which is the border between finite and infinite. Theoretically, there are various arguments favouring a finite Universe. Similarly, I've often read that it is possible to measure the recession velocity of a galaxy (p. 167); it can be calculated *via* $v = H_0 D$ (the Hubble constant relates the expansion rate to the proper distance, independently of the cosmological model — but if we already know the distance, we don't need the velocity to do cosmology.*) A somewhat rarer claim (p. 168) is that "the most distant galaxies . . . were moving away from us *faster* than they should have been if the expansion of the universe were constant" [emphasis in the original]. Actually, it is the other way around, as the present expansion rate is fixed by H_0; acceleration thus implies that distant galaxies were moving *more slowly* when the light we detect today was emitted. (The current expansion rate is of course given by $v = H_0 D$.) On p. 176: "Dark matter was first discovered and observed by the American astronomer Dr. Vera Rubin in the 1960s." The concept of dark matter and observational evidence for it goes back much further (*e.g.*, ref. 10 and references therein). (Also, "in the 1960s" is stretching it a bit; presumably the first flat-rotation-curve paper co-authored by Rubin[11] described some work which might

*See the more detailed discussion in another review[9] in these pages.

have been done in the late 1960s, but that paper did not claim evidence for dark matter.*) Equating fine-tuning with the Anthropic Principle (p. 183) is at best misleading. (To be fair, much confusion exists around those topics (*e.g.*, ref. 12 and references therein).) The claim that the early Universe was dense enough to be a black hole (p. 180) is at best misleading. On the other hand, she doesn't make the common mistake of claiming that Wheeler coined the term 'black hole' (p. 28). My guess is that, as in most popular-astronomy books, most of the mistakes concern cosmology, but I noticed some in other areas as well. Especially because of its historical importance in the discovery of asteroids (which *is* discussed), I missed a mention of the Titius–Bode rule for planetary distances; "every planet is about twice as far from the Sun as the planet before" is a much worse approximation (slightly more accurate only for the distances of Saturn and Uranus). I also wondered why "we don't have a deeper understanding of why" the conservation of angular momentum exists; surely Noether's theorem and the isotropy of space are sufficient.

A few other errors I put down to carelessness or bad editing. On the whole, though, the book is well-written and I have only about my average number of complaints concerning style and so on. I did find it rather distracting, though, that the text is in a sans-serif font with relatively large interline spacing (similarly to another book recently reviewed[13] in this *Magazine*). There are only a handful each of black-and-white photos and footnotes; there are neither references/bibliography/further reading nor an index nor any acknowledgements, but a short biography of the author.

Despite my qualms (which refer to only a minority of the subjects discussed), in particular my standard complaints about cosmological misconceptions, this is an interesting book which provides a good overview of many interesting topics in astronomy. — Phillip Helbig.

References

(1) J. Mitton *et al.*, *The Astronomy Book* (DorlingKindersley), 2017.
(2) J. Scudder, *The Milky Way Smells of Rum and Raspberries: dots and Other Amazing Cosmic Facts* (Icon Books), 2023.
(3) G. Lavender, *The Short Story of the Universe: A Pocket Guide to the History, Structure, Theories & Building Blocks of the Cosmos* (Laurence King), 2022.
(4) P. Helbig, *The Observatory*, **138**, 339, 2018.
(5) P. Helbig, *The Observatory*, **145**, 65, 2025.
(6) P. Helbig, *The Observatory*, **145**, 77, 2025.
(7) P. van Oirschot, J. Kwan & G. F. Lewis, *MNRAS*, **404**, 1633, 2010.
(8) A. Avelino & R. P. Kirshner, *ApJ*, **828**, 35, 2016.
(9) P. Helbig, *The Observatory*, **144**, 38, 2024.
(10) P. Helbig, *The Observatory*, **140**, 225, 2020.
(11) V. C. Rubin, W. K. Ford, Jr. & J. S. Rubin, *ApJ*, **159**, 379, 1970.
(12) P. Helbig, *Found. Phys.*, **16**, 93, 2023.
(13) P. Helbig, *The Observatory*, **146**, 99, 2026.

Here and There

MAKES THE BLOOD BOIL

And this being June, when the sun is closer by, as it makes its presence felt the mercury will rise quickly.
—*The Sunday Telegraph, 2026 June 14, p. 32*

*In that paper, Rubin and Ford also mention earlier work by others; the claim that Vera Rubin discovered dark matter is certainly not due to her claiming that, as she acknowledged previous work.