REVIEWS

Women in the History of Quantum Physics: Beyond Knabenphysik, edited by Patrick Charbonneau, Michelle Frank, Margriet van der Heijden & Daniel Monaldi (Cambridge University Press), 2025. Pp. 470, 25 × 18 cm. Price £37·99 (hardbound; ISBN 978 1 009 53583 0).

This well-written and rigorously researched volume documents the career histories of 16 women who carried out critical experimental research for quantum physics during the 20th Century. It does more than describe their achievements (and occasional frustrations) in this budding discipline; science had already been grasping at the reality of quantum physics in counterposition to classical physics, and needed but high-quality experimental proof to verify theories that were being suggested. It was actually Williamina Fleming (an astronomer, no less) who set the ball rolling here by recognizing that the spectrum of singly ionized He in hot stars mimicks the pattern of a hydrogenic sequence, thereby contributing verification for Bohr's model of the atom. Others then built upon her result from numerous standpoints that particularly included laboratory experiments — a professional activity in which women definitely excelled.

These 16 women represent a fairly broad geographical spectrum, though with a greater emphasis on Spain, Portugal, and Latin America than was the case for the 40 female astronomers who emerged successful according to *The Sky is for Everyone*[1]. Despite the positive vignettes portrayed in astronomy by that publication, its review in *The Observatory*[2] concluded that concentrating on the minority who were either fortunate or favoured did a disservice to the discipline as a whole, since the majority of those initially aspiring to careers in astronomy research left the field for whatever reason, and that the 'leaky pipeline'[3] had not been closed. The same biasses have still seemed to prevail in quantum physics, regardless of ethnicity or background.

So what went wrong? Why the need for a book like this one? The sad evidence is that the disadvantages, discriminations, and negativity of gender-based instances influenced progress in this field every bit as much as they have done in astronomy. What is chronicled here should therefore be given a place in every library that features the history of science. Even though it specifically tries to avoid selecting only those who made it to the 'top', we see a common trend. Most of its subjects were high-fliers at school and university, but all too quickly discovered that, whether through the pettiness of local politics, the constraints of motherhood, or the common assumptions that the male partner in a two-body cooperation is the prime author, for them the career ladder had already become the career *cul de sac*, and for no other clear reason than their gender.

In quantum physics as in astronomy, beneficial changes may now be in sight but at a relatively glacial pace, and it will probably take many more books like this present one to paint the accurate picture as to where and why half of the incipient workforce and high-quality brain power silently disappears from sight. In some cases, the achievements of the women whose work proved so fundamental to the progress realized by quantum physics in the 20th Century are preserved in the name of the male partner alone, thus denying them due recognition even as researchers in their own right.

Will we never learn? — Elizabeth Griffin.

References

(1) V. Trimble & D. A. Weintraub (eds.), *The Sky is for Everyone: Women Astronomers in Their Own Words* (Princeton University Press), 2022.

(2) R. E. M. Griffin, *The Observatory*, **143**, 134, 2023.

(3) T. Rees (Rapporteur), *Science Policies in the European Union: Promoting Excellence through Mainstreaming Gender Equality* (European Commission), 2000.

Annual Review of Astronomy and Astrophysics, Volume 63, 2025, edited by E. van Dishoeck & Robert C. Kennicutt (Annual Reviews), 2025. Pp. 523, 24 × 19 cm. Price from $481 (print and on-line for institutions; about £360) (hardbound; ISBN 978 0 8243 0963 3).

Sadly, the latest volume of *Annual Review* does not start with the traditional autobiographical account by one of astronomy's grandees, but is nonetheless full of beautifully presented accounts of the hot topics in the field.

Planetary science looms large this year with the formation of giant planets discussed by Ikoma & Kobayashi, be they local or around more distant stars. With observations from ground-based and space telescopes, we can now examine the spectra of exoplanet atmospheres, as revealed by Snellen, while Vidotto models the interactions those exoplanets may have with their host stars. A further article on exoplanet research is that by Kenworthy & Haffert showing how high-contrast coronagraphy can now be used to probe such systems.

Moving on to stars, their formation processes, for both high- and low-mass objects, are compared and contrasted in the leading paper by Beuther *et al*. Perhaps the most interesting topic for me was the discussion of 'Blue Stragglers & Friends' by Mathieu & Pols, in which the results of binary interaction during evolution is now seen to produce not only blue stragglers — a field in which I once wandered — but also yellow stragglers.

Edging on to more massive objects still, a comprehensive study of how galaxies come together — entitled 'Extragalactic Archaeology' — is described by van de Ven *et al*., while the kinematics of the Local Group is considered by Strigari. Coming on to high-energy matters, the impact of ionizing radiation from galaxies on the intergalactic medium is outlined by Jaskot; X-rays from AGN due to super-massive black holes are considered by Kara & García; energy production by relativistic magnetic reconnection sparked by black holes and neutron stars is described by Sironi *et al*.; and the nature and origin of ultrahigh-energy cosmic rays are whimsically portrayed by Globus & Blandford. — David Stickland.

The Solar System, by William Sheehan & Clifford J. Cunningham (Reaktion), 2025. Pp. 407, 22 × 18 cm. Price £25·00 (hardbound; ISBN 978 1 83639 064 0).

This work published by Reaktion Books, one of thirteen volumes in a series edited by Peter Morris entitled *Kosmos*, investigates historical, contemporary and future developments in Solar System astronomy. Both authors are accomplished writers and researchers, uncovering many new insights into what could be considered a well-worn subject. They have created both a fine literary work and an accurate and authoritative account that has been a pleasure to read. Their commanding use of the English language is impressive. Be prepared both to be entertained by their prose and to learn some deeper truths about stories from the past. Evidence of their in-depth knowledge is provided by way of 19 pages of references covering the ten chapters of text and splendid illustrations.

In many places, they write to put the historical record straight given that 2025 provides the truest perspective yet of observational astronomy over the centuries leading up to the Space Age, and the almost seven decades of space-probe exploration of the Solar System since — a privileged vantage point indeed! A nice touch used throughout the book, which makes it very readable, is the wealth of apposite quotations and extracts from the literature, not only scientific but also many of literary merit. Some are verbal quotes — well-founded views of astronomers currently working in the relevant field.

I would have liked more detail in the last chapter, 'The Outer Solar System', in that it covers a diverse range of topics, including interstellar objects, yet occupies only one-eighth of the main text. The style is necessarily more concise there than in the rest of the volume. Illustrations and new findings made possible thanks to the *James Webb Space Telescope* are included, as are many fine *HST* and space-probe images, but more could have been made of the future impact of high-tech ground-based observatories such as *Rubin* and the *E-ELT* that are coming on-stream in the present decade.

The writers have also between them authored other books in the *Kosmos* series covering the topics of *Mercury*, *Venus*, *Asteroids*, *Jupiter*, and *Saturn*. Bill Sheehan particularly has been a prolific life-long writer and his passion for Solar System studies is plain to see. It's not so surprising that this most recent publication is one of the very best to have been written with respect to the Solar System. — Richard Miles.

Discordance: The Troubled History of the Hubble Constant, by Jim Baggott (Oxford University Press), 2025. Pp. 328, 24 × 15 cm. Price £20 (hardbound; ISBN 978 019 286406 2).

Recently, I reviewed a book in these pages by Baggott & Heilbron[1]; this book is dedicated to John Heilbron, who died around the time their joint book was completed. In about 1975, I read one of the many books I've read by Isaac Asimov[2]; despite being the title of the book, the neutrino doesn't appear until about half-way through. Asimov spent the first half of the book on the history of conservation laws, which of course are essential for understanding why the neutrino was originally postulated, and why it was accepted long before it was actually discovered. Baggott follows a similar but more exteme approach, with the Hubble tension appearing only in the tenth and final chapter. The Hubble tension refers to the fact that 'local' measurements of the Hubble constant H ($\dot{R}/R$, where R is the scale factor of the Universe; often, H_0 is discussed, where, as with other cosmological parameters, 0 refers to the value today) tend to give a higher value (≈ 73 km/s/Mpc in the usual units) whereas deriving H_0 from measurements of the cosmic microwave background (CMB) tends to give a lower value (≈ 67). Older readers might remember when the tension was between 50 and 100. The situation today is different, though. The Hubble tension of a few decades ago was primarily between different groups (with Allan Sandage and his followers favouring low values, sometimes even lower than 50, and Gérard de Vaucouleurs and collaborators preferring high values), whatever methods they used. Today, it is primarily between different methods, the size of the error bars has decreased proportionally by more than the difference between the two values (resulting in a statistically significant tension), the cause of the tension is not as clear, and it is more common to see it as possible evidence of new physics. There is also tension *within* the high-value camp, with Adam Riess and collaborators preferring a somewhat higher value while Wendy Freedman and her team advocate a lower value with of course less tension with the CMB value but perhaps even without a significant statistical discrepancy.

I'm not sure why the zeroth chapter is a prologue rather than a proper chapter (at 15 pages, it is only slightly shorter than the other chapters, which average about 25); it introduces the basics of stellar astrophysics. From there, we get nine chapters which introduce enough cosmology (often in the form of a historical narrative, and including many quotations) to place the Hubble tension in the proper perspective: Leavitt's law; the scale of the Universe; the Hubble constant; Lemaître's cosmology, stellar populations, Big Bang nucleosynthesis, and the cosmic microwave background; cosmological parameters; the much larger Hubble tension of a few decades ago and the debate between the low value of Sandage and the high value of de Vaucouleurs; inflation; dark energy and the accelerating Universe; and the standard or concordance model of cosmology. Of course, many books have been written about each of those topics; the still rather long summary here is intended to set the background for the Hubble tension, but is a good summary in itself.

Baggott gets some things right which many authors get wrong, such as the explanation of the cosmological redshift. But he makes common mistakes (about which I've complained in many reviews in these pages) by recounting the relationship between geometry and destiny*

*If there is no cosmological constant, a spatially closed universe will collapse after initial expansion, whereas for a universe with no cosmological constant as if that applied in general (it doesn't, and in particular doesn't appy to our Universe) and by implying that the recession velocity of galaxies cannot exceed the speed of light c. The latter is especially strange in a book on the Hubble constant: $v = HD$ where v is the recession velocity and D is the distance; if D is large enough, v can exceed c [4,5]. He mentions that, trivially of course, a change in the rate of expansion would show up as a deviation from a straight line in a plot of the scale factor as a function or time, but also that that would lead to deviations from a straight line in "the plot of redshift vs magnitude or distance"; in the latter case, one would expect deviations from a straight line for other reasons as well. A few pages later is the huge mistake of claiming that the relativistic Doppler formula is somehow relevant for cosmology "as recession speeds approach the speed of light". While it is true that $v \approx cz$ is no longer valid at high redshift, that doesn't mean that the relativistic Doppler formula is, and it most certainly isn't. An easy way to see that is that the relativistic Doppler formula contains no cosmological parameters, not even the Hubble constant. Are we expected to believe that recession velocity as a function of redshift is independent of the cosmological parameters? (To be sure, the non-relativistic Doppler formula doesn't contain any cosmological parameters either, but it is valid because things are linear to first order.) If I were granted one wish, it might be that everyone interested in cosmology read and understand refs. 4 and 5. I give credit to Baggott for quoting from Dicke's Jayne lecture, but the discussion of the flatness problem ignores the literature on that topic after 1979, even though several well known cosmologists have questioned the standard interpretation (*e.g.*, ref. 6 for a review). Also annoying is the claim that inflation, dark matter, and dark energy were all introduced as *ad hoc* solutions to various problems. While the evidence for them might not be as strong as for other things, the truth is more complex. Other strange statements occur, such as that one can calculate the m–z relation for a flat universe with different values of the density parameter $\Omega_{\rm M}$ (clearly labelled on the example figure from the literature) "with no assumptions about the value of Ω_Λ"; for a flat universe, $\Omega_\Lambda = 1 - \Omega_{\rm M}$.

On the other hand, it is refreshing to see a discussion of flat galaxy rotation curves start with the work of Babcock. (But crediting Zwicky as the discoverer of dark matter makes sense only if that is qualified (which Baggott doesn't do): Zwicky was the first to suggest that there could be much more dark than luminous matter, though the importance of that was not appreciated until it was realized that most cosmological dark matter cannot be baryonic.) The discussion on CMB cosmology in Chapter 9 is very good. And Chapter 10, the one actually about the Hubble tension, gives a good overview.

Familiar is the story of Hubble finding a Cepheid in what is now known as the Andromeda galaxy and thus discovering that it is far enough away to be outside the Milky Way and be a galaxy (even larger than the Milky Way) in its own right. Baggott mentions that not only had that Cepheid been discovered by Humason, but that Humason had approached Shapley, suggesting that it could be used to measure the distance to Andromeda. However, before leaving for Harvard, Shapley erased Humason's marks from the plate. That story is also told by Christianson [7], but I had forgotten it, probably because Christianson recounts many episodes in which Hubble took more than his share of the credit. Other material is more familiar, such as Lemaître publishing in French in the "obscure journal" *Annales de la Societé Scientifique de Bruxelles*, a fact that has been mentioned so many times that it

one which is flat or negatively curved will expand forever. One might thus grant some poetic licence in referring to a universe which will collapse as 'closed' — perhaps closed in time, whatever its spatial curvature. However, describing the Einstein–de Sitter universe, which is spatially flat and thus infinite in extent but with a rate of expansion which asymptotically approaches zero as having "just enough density of matter to halt the expansion and close the universe after an infinite amount of time" is going too far. On another page, it is claimed that in the Einstein–de Sitter universe, not only will expansion stop, but the scale factor will go back to zero after an infinite time; there is no interpretation in which that make sense. Interestingly, there is a long history of referring to such borderline cases as closed. [3]

has made that journal one of the most famous in cosmology! (It was also not as obscure at the time as is sometimes claimed.) While it is true that his paper on relativistic cosmology[8] had little impact at the time, that is also true of Friedmann's papers[9,10], even though they were published in German, as was much of the astronomical literature at the time, and in *Zeitschrift für Physik*, a leading journal. (Baggott does note that Friedmann overlooked the flat $k = 0$ case, first discussed by Robertson[11].[*]) Baggott gives Lemaître credit for first calculating what would later be known as the Hubble constant[†], but misses the important detail that his "of no actual interest" is almost certainly a too literal translation of *actuel*, which means 'current' in French[12].

I found the discussion of the de Sitter universe (a universe with no matter and a cosmological constant; the expansion is exponential and the Hubble constant constant in time[‡]) somewhat confusing, as it is presented as a universe with positive spatial curvature, whereas most modern cosmology books describe it as being flat. Either is correct, depending on the coordinates chosen. However, the explanation is too complicated (*e.g.*, ref. 13) to be explained in such a book; the slightly ahistorical modern description might be more appropriate.[§]

The epilogue briefly discusses a few ideas which have been inspired by the Hubble tension and/or possible explanations for it. It is not intended to be a thorough discussion but rather to put the Hubble tension in context. Three appendices cover symbols and acronyms, cosmological distances, and lookback time as a function of redshift. There are several black-and-white illustrations scattered throughout the text. A page of acknowledgements and more than three of figure and photo credits indicate what a vast undertaking such a book is, even more so because the subject is very current. Somewhat unusual is that photos (of people) and other figures are numbered separately (though of course images of galaxies taken with photographic plates are certainly photos in the normal sense of the word). There are no footnotes but a bit more than seventeen pages of endnotes, most of which are references. The bibliography of about two-and-one-half pages is a list of books for further reading and/or background material used by the author (as opposed to the explicit references in the notes). A thirteen-and-one-half-page index ends the book.

I would like to have liked this book more. The introductory chapters on (the history of) astronomy and cosmology are interesting and useful and, though tailored to the theme of the book, often present more than just the standard material. The material on relatively new observational cosmology (CMB, baryon acoustic oscillations, and the Hubble tension itself) is good. The book is well written at an appropriate level and it is useful to have such books on current topics. However, any recommendation has to be tempered by several at best misleading statements about cosmology, most of which I've seen elsewhere. That is part of the problem: I doubt that most authors make the same mistakes independently. Rather, mistakes in the source material live on in newer works, and it would be a shame if an otherwise good book by a well-known popularizer of science keeps that trend alive. It provides a good overview of the Hubble tension, why it is important, and the necessary

[*] Although that model was later discussed by Robertson and others, his doctoral thesis is certainly more obscure than Lemaître's paper in French.

[†] While the IAU voted to rename the Hubble law the Hubble–Lemaître law, the constant is still just the Hubble constant.

[‡] In general, the Hubble constant is not constant in time. However, that is not a misnomer; it is the constant in the equation $v = HD$. Thus I disagree with Baggott who claims that it should be called the 'Hubble parameter' for that reason. By contrast, the cosmological constant *is* constant in time. The de Sitter model has other features which are not true in general, *e.g.*, the Hubble radius is also the radius of the event horizon.

[§] Readers of German might want to consult a doctoral thesis[14] by the same author as that of ref. 13 for more background on de Sitter's role in the early days of relativity and relativistic cosmology. Although Eddington is well known as a champion and popularizer of General Relativity, de Sitter was as well, *e.g.*, very soon after the initial paper by Einstein[15], he wrote a 'popular' summary in these pages[16] as well as more detailed explications[17–19].

background to understand it, but readers should get their overview of cosmology from elsewhere. — PHILLIP HELBIG.

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From Stars to Life: A Quantitative Approach to Astrobiology, by Manasvi Lingam & Amedeo Balbi (Cambridge University Press), 2024. Pp. 400, 26 × 21 cm. Price £59·99/$79·99 (hardbound; ISBN 978 1 009 41121 9).

Astrobiology is perhaps the most multidisciplinary science that can be imagined. Everything, from cosmology to biology, planetary science to astrophysics, is involved at some level, and a detailed understanding of the history of life on Earth is also necessary since we have but one place where the emergence and evolution of life can be studied. In fact, if we go so far as to include the search for extraterrestrial intelligence, we must add human history and sociology to the mix. This extreme multidisciplinarity means that many textbooks that cover astrobiology take separate chapters written by multiple authors and edit them together to produce the final work. That is not the approach taken here as the authors bravely take on the vast epic that is the story of life in the Universe from the Big Bang to the present day and beyond. And in doing that they are largely successful, maintaining a coherent voice and approach throughout. The book starts with the large-scale boundary conditions provided by cosmology and then moves to the astrophysics of stars and planet formation. The Earth is then studied in detail, including its early conditions, then looking at the possible routes through which life might have originated here, and how life both affects and is affected by the terrestrial environment. The lens then zooms out to look at broader questions of habitability elsewhere, before potential astrobiological targets, inside and outside the Solar System, are discussed. The astrophysical techniques for detecting life elsewhere, including intelligent life, are then examined. The book's subtitle is 'a quantitative approach' and there is indeed a decent amount of quantitative analysis both in the text and in the included problems. However, the squishy and at times speculative nature of the field makes it inevitable that a fair fraction of the problems are more wordy than quantitative, and try to send the reader off to the broader literature to come up with their own hypotheses and analyses. Such explorations would certainly be rewarding, but, in a world where students increasingly use Large Language Models to answer such homework questions, they may be less useful in a formal teaching environment. The goal of the book, to cover the field of astrobiology in its true breadth, from stars (and even from before stars form) to life, is fully achieved, and there will almost certainly be something new here for anybody involved in astrobiology. Highly recommended, and already added to the reading lists of relevant courses that I teach. — Dave Clements.

The Blue Straggler Mystery, by Martin Beech (World Scientific), 2026. Pp. 271, 23·5 × 15·5 cm. Price £55 (hardbound; ISBN 978 981 98 2008 5).

Blue stragglers are stars that lie in the vicinity of the main sequence in a cluster colour–magnitude (or HR) diagram, but bluewards of the cluster turn-off. The 'mystery' is, or rather, was, how they come to be there when, in the simplest scenarios, they should've evolved away to the red. This nicely produced little hardback (also available as an e-book) pursues that question, using the device of allusion to detective fiction (particularly Sherlock Holmes) to frame the chase.

This is more a scholarly book than a 'popular' one, though written in a relaxed narrative style. The first two chapters — roughly half the page count — present a primer in basic stellar astrophysics ('The measure of the stars', 'How the stars work'), with the third ('Making blue stragglers') reviewing the historical development of solutions to the 'mystery'. A final 50-page chapter ('And finally. . . ') is a speculative ramble touching on topics as diverse as alien civilizations, black holes, artificially engineered stars, and much else that seemed to me to be only tenuously linked, at best, to blue stragglers. Simple equations are sprinkled throughout the text (minimal calculus and no derivations), as are graphs and other diagrams, along with a few astronomical images. Colour is used to good effect, and each chapter is supported by a page or two of references. There is no index.

The acknowledgements don't include a nod to anyone for proof-reading the manuscript, which may explain the smattering of infelicities and oddities. Pretty much all are harmless (*e.g.*, are radio astronomers really not observers [p. 34]? Was a wide-field, shallow image of the Pleiades really obtained with *HST* [p. 57]?) or even amusing (stars "sliming down" [p. 88]), although the naïve reader may wrongly infer that neutron-star magnetic fields are a proximate consequence of convection [p. 137]. A forceful editor may've also reined in the author's rather intrusive predilection for the word 'indeed'.

Regardless of these trivial quibbles I found the book to be an engaging and pleasant enough read, even if the content of the last chapter wasn't much to my taste. The real mystery for me was: for whom is the book intended? It's too technical for a general readership; didactic, but not suitable for use as a textbook; and the principal topic is so narrow that the interested researcher is likely to go directly to the primary literature. I therefore turned to the World Scientific website, where I learned that, apparently, the "target audience for this book is the undergraduate science student, and the informed, general-reader on topics relating to astronomy and physics." Elementary. — Ian D. Howarth.

Crush: Close Encounters with Gravity, by James Riordon (The MIT Press), 2025. Pp. 287, 23 × 15 cm. Price $29·95 (about £22) (hardbound; ISBN 978 0 262 05098 2).

This might be the only book to discuss both event horizons and the anatomy of snakes.

The name James Riordon seemed familiar to me, but probably because I was thinking of James Riordan, who played a role in the *Apollo 13* mission. Or perhaps because I had come across something else by the author, NASA-affiliated science writer James Riordon. Confusingly, the author's father (also James Riordon) also worked for NASA, on the Apollo and Space Shuttle programmes. (Finally, an internet search for 'Riordon' and 'Apollo' will probably find Rick Riordon, author of *The Trials of Apollo*, who has written many books for children which adapt ancient Greek and other mythologies for a modern readership.) This is a book about gravity, but, compared to the books about General Relativity (GR) I've reviewed in these pages, it takes a very broad view of its topic.

It starts off familiar enough, with a short zeroth chapter on Newton. The next two chapters discuss the effects of gravity on humans and other animals. (The position of the heart in a snake depends on whether it lives mostly underwater, crawls on land, or climbs trees; the different positions are adaptations to the different effects of gravity on blood circulation.) While its effects on humans are of course familiar to me, there is much fascinating information on various experiments involving animals and their relation to gravity (mice suspended by their tails, leaping nematodes, *etc*.). The fourth chapter (Chapter 3) brings us back to astronomy, discussing the effect of gravity on the properties of planets. The next three chapters are a more-or-less standard overview of the history of gravity in physics, but with many details on Maupertuis, Cassini, and measuring the shape of the Earth. Special Relativity and GR are introduced, and there is a good discussion on measurements of the gravitational constant G, which is still the physical constant with the least-precise value.

We are then introduced to the flowing-space interpretation of GR.* That is a simple example of the otherwise rather technical idea of 'analog gravity', and for many might provide a more intuitive understanding of GR. There is also an appendix describing concrete experiments one can do in a kitchen sink, with flowing water standing in for flowing space.

We are back in more-standard territory with the discussion of gravitational waves, which starts with a quote from Joseph Weber: "They'll put a bullet in my head." That is from one of the first interviews in the author's science-journalism career; it was also the last interview ever with Weber, who was willing to talk but only after being promised strict confidence as long as he was alive. (Weber died not long after the interview, but from lymphoma†, rather than a bullet from the National Science Foundation or anywhere else.) When an undergraduate at the University of Maryland, Riordon knew Weber, who features prominently in the acknowledgements, as one of his professors. Riordon notes, though, that "Joe Weber may not have detected gravitational waves" and that his Lunar Surface Gravimeter, placed on the Moon by the *Apollo 17* astronauts, never worked either.

Chapter 9 gives an overview of various ideas for quantum gravity, and the next one of dark matter and dark energy. Those are familiar topics for myself and presumably many readers of this *Magazine*. Like the rest of the book, it is well written and essentially correct (see below for a few common mistakes in other areas). However, despite mentioning Milgrom and Finzi and their ideas of modified gravity — rarely mentioned in popular-science books — , the dark-matter story is essentially limited to Rubin (and — also rare — her long-time collaborator Ford) and Zwicky; Babcock, Bosma, and Roberts should at least be mentioned. There is the familiar trope of Rubin not getting enough credit for her work and even being overlooked for a Nobel Prize (though the common claim that that was due to sexism is not repeated).‡ Interesting, though, is a quotation from Rubin: "Only the future will tell us

*In contrast to various interpretations of Quantum Mechanics, different ways of looking at GR, such as the standard way involving curvature, the flowing-space interpretation, the membrane paradigm, *etc*., do not differ in their claims about the underlying physical reality, but rather are just different approaches, with a certain approach more mathematically convenient for certain problems.

†I survived lymphoma twice; the first time in 2004. At least for my type of lymphoma, much progressed had been made in the few years immediately before, in particular the introduction of rituximab.

‡No Nobel Prize has been awarded for the discovery of dark matter; had one been awarded while she was still alive, my guess is that she would have been one of three recipients, though which of the three still alive then would have been a difficult decision — but the difficulty of such a decision is almost certainly not the reason for not awarding a Prize at all. Ford died in 2023, Roberts in 2024; of the obervational pioneers, only Bosma is still alive. To some extent, the award to Peebles recognized his theoretical work on the role of dark matter in astrophysics and cosmology.

what dark matter is, or whether our lack of knowledge of gravitation on the largest scales has fooled us." In other words, Rubin herself wasn't sure whether she had discovered dark matter. (She also cited her predecessors in the field of flat rotation curves.) Other methods of finding evidence for dark matter are covered, such as 'direct' detection in the lab (*via* a rare interaction between a dark-matter particle and an atomic nucleus), observing radiation from the decay or annihilation of dark-matter (anti)particles, and creating such particles in an accelerator. (Those methods are often dubbed 'shake it', 'break it', and 'make it'; if modified gravity rather than dark matter is responsible, then that would be 'fake it'.) The discussion of dark energy is brief, but that topic is only mildly relevant to the main subject of the book.

The next chapter covers more speculative aspects of GR: white holes, worm holes, naked singularities, time machines, and warp drives, and points out the impossibility of anti-gravity devices. Other cutting-edge topics such as 'dark stars' (not dark, but rather powered by the annihilation or decay of dark matter as opposed to fusion), the Multiverse, and theories of everything ("the Moby Dick of gravity") are briefly mentioned.

The last chapter on astrophysics concerns the origin of the elements. While of course many elements are made in stars and gravity plays an important role in stellar structure, gravity plays a more direct role than was assumed until recently as several heavy elements appear to be formed in the collision of neutron stars. One of those is iodine, which is essential for life as we know it. Keeping with the theme of the broad spectrum of the book, the next chapter explores the role of gravity, or the lack of it, in dreams, and the final chapter ties the falling sensation common in dreams to Einstein's 'happiest thought', namely realizing that a person in free fall feels no gravity. The previously mentioned appendix proves that this book contains everything, *including* the kitchen sink. Another appendix contains the only real maths in the book, using the flowing-space interpretation to derive common formulae in GR. I'm surprised that that interpretation is not better known, especially since to most it is probably easier to understand than the concept of spacetime curvature. (It is far from new, having been proposed independently by Painlevé in 1922 (a mathematician who was also prime minister of France) and Gullstrand (a Swedish* ophthamologist) in 1925.)

The breadth of topics covered is also demonstrated by the facts that for the second time in recent book reviews of popular-science books (which normally don't cite the technical literature at all), papers on the long-term future of the Sun[1,2†] are cited — the other book[3] was reviewed[4] in the 2026 February issue of this *Magazine* — as well as three works on life on other planets written by Dirk Schulze-Makuch[5–7] (see the review[8] of another of his works[9] in these pages). Unusual for a book on gravity, there are also references to papers in *Developmental Psychology*, *Clinical Psychology Review*, *Western Journal of Emergency Medicine*, and *Brain Research Reviews*.

Of course, most books I review have a few mistakes, and an honest review must mention them. Kepler's Laws, numbered, are stated, but the second is not the usual one, but rather the (correct) claim that "the Sun isn't at the center of the Solar System, but instead moves on its own, small elliptical orbit". An image of a distant blue galaxy gravitationally lensed into an almost perfect Einstein ring would of course be more impressive if in colour, but the caption mentions those colours with respect to the black-and-white image. The text at least implies that Hulse and Taylor were both at Princeton when they discovered the binary pulsar; they weren't. (Similarly, Adam Riess is now at Johns Hopkins, but wasn't when he did the work leading to his share in the 2011 Nobel Prize.) In contrast to claims in the text, Einstein

*The book makes him Swiss, reminding me of my friend from Vienna who used to wear a sweater with 'There are no kangaroos in Austria' on the front. Ironically, Gullstrand thought that relativity is wrong and used his influence on the Nobel committee to prevent Einstein from receiving the prize for relativity. Even more ironically, Gullstrand was known for his highly mathematical writing, much of which concerned the bending of light — but within the eye.

†I heard lectures from the first author when he was an assistant professor and I was a student in Hamburg; the second is a frequent contributor to and former Editor of this *Magazine*.

wasn't directly inspired by the negative result of the Michelson–Morley experiment, perhaps not even indirectly. Nor is inflation characterized by the Universe expanding faster than the speed of light, nor has the Universe "been expanding at a steadily accelerating rate" ever since. (At least he does clearly (and correctly) state that the Universe will expand forever even though we don't know whether it is exactly flat or even the sign of the curvature.) "The fact that something is running down toward an end implies that it also must have had a beginning." No. See ref. 10 for a detailed historical study (which mentions the fact that many *believed* such a claim) and ref. 11 for more recent thoughts on an eternally old cosmos with ever-increasing entropy. There might be a lot of dark matter in the Universe, but its average density is several orders of magnitude less than that corresponding to a small virus in a typical living room as claimed in the book. Although stated just briefly, the text implies that an infinite universe with stars distributed throughout would be infinitely bright and thus that the darkness of the night sky suggests that the Universe has limits. The latter is true, but the limits are temporal; the Universe is not infinitely old. As is the case with most issues in cosmology about which people are confused, Edward Harrison clears them up nicely.[12,13*] (I'm willing to put the comparison of the masses of *two* atoms of hydrogen to one of helium in the context of stellar fusion down to an oversight.) "A tiny bump on a neutron star, roughly as tall as a grain of sand, would result in a detectable signal in LIGO, provided the star is spinning faster than 200 times per second anywhere within a few thousand trillion kilometers of us." Misleading at best: the spin rate is not unrealistic, and the distance is only somewhat closer than the nearest known pulsar. A mountain of height 1 mm, say, might be just possible, given what we know about the crust of neutron stars. But to be detectable by *LIGO*, its area would have to be much, much larger than that of a grain of sand, which doesn't seem very realistic, again based on what we know about the crust of neutron stars.

On the other hand, it was a pleasure to learn some new things, such as Benjamin Franklin showing how a spoonful of oil tossed into the water of Mount Pond in Clapham Common could smooth wind-induced ripples of hundreds over square metres[14]; Franklin was so fascinated by that property of oil (which was known to Pliny the Elder) that he carried a supply of oil in a chamber of his bamboo cane, so that he could demonstrate the effect whenever desired. That was mentioned because the site is near where Cavendish conducted his experiments to measure G and thus the mass of the Earth. Cavendish used an improved version of a pendulum developed by John Michell, usually (and in this book as well) mentioned as probably the first person to come up with the idea of a black hole in the sense of an object with an escape velocity exceeding the speed of light. (While the 'Schwarzschild radius' turns out to be the same, one can move outward across the 'event horizon' of such a 'Newtonian black hole', just not escape to infinity ballistically even if moving at the speed of light when leaving the surface; the event horizon in GR is much stricter.)

There are a few black-and-white figures scattered throughout the text, some due to his daughters (who are also mentioned in the text, one also the subject of a photograph with her head angled down by six degrees to simulate some of the effects of space flight on humans). There are no footnotes; their function is covered by the endnotes, most of which, however, are references (including titles of articles). A couple of pages of 'Further Reading' contain short descriptions of eight books. Sadly, I've read only one completely, parts of another three, and an earlier version of a fifth; the other three are on my (very long) list of books to read before I die. (One of the ones which I've read partly is Newton's *Principia*: "A challenging read due to dated language [not to mention the original Latin], long-winded explanations, and roundabout derivations. Still, it's worth looking over the law of universal gravitation in the words of the genius who revolutionized physics.") A seven-page index ends the book.

Despite my complaints above, I enjoyed reading the book. It is well written and offers a

*I'm aware of almost a dozen articles as well in which Harrison makes his point, published in a variety of places, including very well-known journals.

fresh take on a subject about which very much has already been written. The few personal anecdotes add to the book rather than detract from it. From biology to Gullstrand–Painlevé coordinates to the psychology of dreams, there is something for everyone here. — PHILLIP HELBIG.

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Machine Learning in Astronomy: Possibilities and Pitfalls (IAU Symposium 368, edited by J. McIver, A. Mahabal & C. Fluke (Cambridge University Press), 2025. Pp. 147, 25 × 18 cm. Price £98 (hardbound; ISBN 978 1 009 34519 4).

Similar to a book[1] reviewed[2] a while back in these pages, this volume of proceedings of an IAU symposium is a mostly bad record of what was probably an interesting meeting. Machine learning (ML), a more prosaic name for artificial intelligence, is all the rage now. However, the symposium took place almost four years ago, and as Ofer Lahav points out in his very good contribution, it was used already in the early 1990s for galaxy classification (at least by Lahav himself and his collaborators). His contribution is perhaps the most interesting for those who don't work in the field, giving a good overview, helped by the fact that he has a background in traditional astronomy but is up to date on the latest ML techniques. Other contributions are more specialized, which is to be expected from the proceedings of a specialized meeting. I have no qualms with that and am not really a member of the target readership. However, starting with the too thin paper (the two covers are almost as thick as all the pages) through which the print on the other side is visible, other production mistakes such as bad editing, lack of consistent formatting, mentioning colours in a book in which all figures are in black and white, and too detailed references lead to a book which is distracting to read, which is unfortunate because the material is new and interesting and relevant not just to astronomy; I found many of the contributions interesting, even though they are far from my own work.

The twenty-seven contributions range from two to seventeen pages and cover topics such as exoplanets, spectra, stars, star clusters, galaxies, gravitational waves, galaxy clusters, and cosmology. The longer contributions can provide a good overview, especially those intended as such, such as Lahav's piece on ML in cosmology or 'An Astronomer's Guide to Machine Learning' by Webb & Good; the two panel discussions also offer something more typical of a conference than the normal literature. Most of the shorter contributions (presumably originally posters) are too short to be of much use: too brief for those not familiar with the topic, and unnecessary for those who are. (While many of the items end with a mostly blank page, the fact that many of the short contributions do so leads to much wasted space.) Interesting to me was that the first contribution, on using ML in exoplanet surveys, starts off by mentioning the exquisite precision of modern spectroscopy, "approaching that needed to detect the motion of a Sun-like start due to the gravity of an Earth-mass planet in its habitable zone", a topic recently discussed in these pages[3]. There are also articles about ML itself; the contribution by Hložek highlights aspects important for astronomy, and the abstract is a good summary of the aims of the entire book. A common theme is not just using ML but understanding how it works, at least at some level of abstraction, though of course the whole point is that ML very probably works differently from human thinking; in that respect it differs from conventional uses of computers, which essentially carry out human-thinking algorithms much faster and/or with much more data.

Apart from the contents, there is a preface, basic information about the editors and the conference, a list of participants, and an author index. Presumably most of the black-and-white figures are originally in colour; that and the fact that some are too small limits their usefulness. The book is produced *via* LaTeX and my hope is that the participants are using BibTeX rather than wasting time; I was thus surprised to see a mismatch between an author name in the text and in the reference list.

In such a fast-moving field, many details will be out of date four years after the meeting, but nevertheless proceedings can provide interesting historical snapshots. However, for a book to fulfill that role, it needs to be produced as a book, or at least in a format (such as that of this *Magazine*) which works both on screen and on paper. All of the contributions are available online, with colour figures, active HTML links, and so on, and that is clearly the preferred format for these proceedings.* Especially considering the price, most buyers of the book will probably be libraries with subscriptions — a common observation in many recent book reviews of such proceedings.

I enjoy going to conferences and well-produced proceedings are both a good record for those who attended an also useful for those who didn't. I think that there are reasons to continue to produce conference proceedings, even if there are fewer such reasons than in the past (*e.g.*, they are no longer practically the only way to get results in advance of publication in the refereed literature — not just the proceedings, but the conferences themselves). Smaller conferences might have to make do with on-line-only proceedings (ideally instead of or in addition to just putting the presentations on the web), which are fine as long as they are permanent. Bigger conferences can justify publishing a book (as well), but if so, it needs to be able to stand on its own. Despite my qualms, I enjoyed reading the book and learned a lot, but am annoyed by the fact that with not much more effort it could have been much better. — PHILLIP HELBIG.

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Dynamical Masses of Local Group Galaxies (IAUS 379), edited by Piercarlo Bonifacio *et al*. (Cambridge University Press), 2025. Pp. 398, 25 × 17 cm. Price $155 (about £116) (hardbound; ISBN 978 1 009 39911 1).

This is the proceedings of the IAU Symposium held in Potsdam in 2023 August. It contains 60 papers, each of reasonable length (no one-page précis), divided into five sections. There are no specific review papers, though a few do cover some history of their topic, and there is no conference overview or afterword, which might have been interesting. The topics are at the same time niche (ostensibly covering just one physical property for a small number of galaxies), yet wide ranging, across *Gaia* surveys, ΛCDM (and other) halos, theoretical stellar dynamics, mergers, and chemical signatures, among others. The final section actually

*However, only three are open access. Checking which three after I had written this review, I found that — surely not coincidentally — they are the three the authors of which I mention by name.

goes beyond the title of the meeting/book to include near-field cosmology and masses of galaxies outside the Local Group. A drawback of using the book itself is the fact that all the orange circles, blue lines, pink contours, *etc*. are rendered in monochrome, except for one paper with full-colour figures. Also, the review copy I received was poorly constructed, with the first few and last few pages detaching from the binding of the rest. However, as the papers from the meeting are already available online, that hardly matters. Given the price, though the papers themselves are interesting, it is hard to see anyone purchasing this volume beyond libraries with subscriptions to the series. — Steve Phillipps.

Solar Eclipses, by William Sheehan (Reaktion), 2026. Pp. 253, 23 × 18 cm. Price £25 (hardbound; ISBN 978 1 83639 169 2).

With two geographically-close total eclipses of the Sun anticipated during the next 18 months or so, a substantial number of eclipse watchers are expected to travel to Iceland, north-eastern Portugal, Spain, and the Balearic Islands for the event on 2026 August 12, as well as to Gibraltar, southernmost Spain, northernmost Morocco, northern Algeria, central Tunisia, north-eastern Libya, Egypt, and south-western Saudi Arabia for the subsequent eclipse on 2027 August 2. In this context, the release of a new volume on solar eclipses is particularly timely. *Solar Eclipses*, published by Reaktion Books and authored by William Sheehan — a well-known astronomical historian and author of four previous works in Reaktion's *Kosmos* series — distinguishes itself by focussing on the historical dimension of eclipses, rather than merely offering summaries and maps of forthcoming events, as is common in recent publications.

The opening chapter explores the author's personal experiences observing eclipses, providing foundational information on the various types of solar eclipses. Chapter two places eclipses within the context of ancient history, examining how such phenomena may have appeared to nomadic peoples, with discussions spanning Stonehenge, ancient China, South Korea, Egypt, and the Babylonians, before shifting to the Greeks in chapter three. The fourth chapter addresses the complexities involved in calculating the positions of celestial bodies and the prediction of eclipses throughout history. Chapter five delves into the challenges of modelling the motion of the Sun and Moon during the 16th and 17th Centuries, highlighting figures such as Jeremiah Horrocks — who famously described the Sun as "The Impudent Star" —and Edmund Halley's prediction for the 1715 total eclipse. The sixth chapter transitions into the 19th Century, documenting the evolution toward a more scientific approach to eclipse observation, including phenomena such as Baily's Beads and solar prominences, as well as the solar chromosphere. Chapter seven investigates Le Verrier's proposal of the planet Vulcan as a solution to anomalies in Mercury's orbit, and its eventual dismissal with the advent of General Relativity. The concluding chapter outlines the 'coming of age' of eclipse science, detailing the adoption of modern observational techniques on expeditions such as Eddington's experiment during the 'Einstein Eclipse' of 1919 May 29, which prompted the iconic New York Times headline, "Lights all askew in the Heavens". This volume also sheds light on the pivotal role eclipses have played in advancing related fields such as chemistry and physics. Notably, the book includes several rarely seen photographs (at least to me) of influential figures in eclipse science.

Additionally, two appendices address safe eclipse-observation techniques and provide a synopsis of eclipses occurring between 2026 and 2029, both of which are highly commendable and practical. The book is further enhanced by an informative reading list and a comprehensive bibliography. In summary, this is a valuable and well-illustrated addition to any eclipse enthusiast's library, particularly for those interested in the historical and scientific context of eclipses. However, it may not fully meet the requirements of individuals seeking detailed guidance for planning eclipse expeditions in the distant future. Priced at £25, this hardbound edition represents excellent value. As an avid eclipse observer and someone actively involved in almanac calculations and production, I found this work highly rewarding. — Steve Bell.

The Secret Life of the Universe: Searching for the Origins and Frontiers of Life, by Nathalie A. Cabrol (Simon & Schuster), 2025 (originally published 2024; originally published in French 2023 as *À l'aube de nouveaux horizons*). Pp. 315, 20 × 13 cm. Price €16·99 (about £14·89) (paperback; ISBN 978 1 3985 3132 1).

The hardback edition has the subtitle 'An Astrobiologist's Search for the Origins and Frontiers of Life'. In any case, it was translated by the author from her own best-selling book in French. I haven't read the French book, but the English version is extremely good, and based on the text alone I would not have suspected it of being a translation. (Lack of knowledge of the topic is what usually indicates a translation, though occasionally insufficient knowledge of one or both of the languages does so; neither is the case here.) Born, educated, and initially working in France (Observatoire de Paris-Meudon and the Sorbonne), Cabrol and her husband, Swiss-born hydraulic engineer (and after retirement and further studies planetary scientist) Edmond A. Grin (1920–2022), moved to the US, worked for NASA, and became US citizens. She later moved to the SETI institute, becoming the director of the Carl Sagan Center in 2015. Cabrol has 426 entries (135 refereed) at ADS and has been the PI of several NASA projects involving Solar System exploration (including life in extreme environments on Earth).

The book is not just written in good English; some of it is almost poetic: "Rocks made of solid water ice rolled and rounded by time in torrents of liquid methane." ". . . a world where everything looks familiar, yet nothing is really what it seems, and where we could be given a chance to explore side-by-side life as we know it and life as we don't." Having said that, the book is a down-to-Earth (and/or some other Solar System body) account of the one known and many possible abodes of life, starting (after a brief autobiographical sketch) with Earth and moving to Venus, Mars, the Jovian satellites, Titan and Enceladus, the outer Solar System, extra-solar planets (after a chapter on six methods of detecting them). After that tour in nine chapters, discussion turns to the Drake equation, the Fermi paradox, and whether the solution to the latter is some sort of great filter*; and the Kardashev scale, SETI, METI, and UFOs/UAP. Cabrol is clearly someone who would like there to be extraterrestrial life, thinks that it is probable, but, whether regarding microbes on other worlds or visiting aliens, remains true to Sagan's dictum that extraordinary claims require extraordinary evidence. The final chapter is concerned with various attempts at a definition of life (perhaps it is easier to explain the origin of life or to describe what it does than to define it) and related ethical questions. While the earlier chapters give an up-to-date account of topics I was already somewhat familiar with, much of the last chapter, while not always covering completely new ground, introduced me to things such as xenobots. The epilogue is similar to two others[3,4] I've reviewed[5,6] in this *Magazine*, but without the complaint that it seems tacked on; rather, it seems like a logical conclusion, the difference being that it is more related to the main text.

Most of the book is concerned with the Solar System, which is at the opposite end of the scale from my main astronomical interest, cosmology. Nevertheless, I really enjoyed reading the book, and it's good to be brought up to date on topics such as planetary missions by someone actually involved in them. We now know that many Solar System bodies contain water, though not necessarily liquid and on the surface, and Ganymede has more than Earth. Cabrol has a knack for including interesting details without losing sight of the overall picture. I was reminded of many popular-science books which I read as a child and how they inspired and reinforced my interest in science; this book is a fine addition to that illustrious collection.

*See a somewhat complementary book[1] reviewed[2] in these pages for more on the concept of 'filters' as bottlenecks of evolution.

There are a couple of mistakes which are probably just careless errors and probably most readers won't notice them. I almost always quibble about style, though here less so than is usually the case, and there are few actual typos. There are sixteen pages of colour 'plates' near the middle of the book as well as several black-and-white figures scattered throughout. The former are fine, but the latter could use more detail. Even several years ago I encountered books with high-resolution colour figures printed on regular (as opposed to slick) paper, so I wonder if printing prices really still play a role. Three pages of acknowledgements mention, among others, Frank Drake and Carl Sagan, both of whom she knew personally, as well as her husband. As is to be expected, the four pages of image credits often mention NASA. Somewhat unusually for a popular-science book, there are eight pages of 'Notes' (all references rather than endnotes; neither are there any footnotes); the index of somewhat more than twenty pages is especially thorough. The book is not as long as it looks since it is essentially double-spaced, with enough room for a line of text between two others (by contrast, interline spacing in this *Magazine* is less than 19% of the height of a line; the font size is about the same).

The fact that the French book is a best-seller confirms my impression that there should be a wide readership for such a book, from somewhat older children to the proverbial 'interested layman' to professional astronomers (at least those who don't work in planetary science, but maybe some of them as well). Even those who have read many books on the topic will probably learn something new from this well-written up-to-date book. — PHILLIP HELBIG.

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Here and There

HOW ABOUT PLANET EARTH, FOR EXAMPLE?

Planets smaller than Neptune with a gaseous atmosphere don't exist in the solar system, but they're plentiful around other stars. —*Sky & Telescope*, February 2026, p. 11.

A LUCKY REGION?

MARS can still be seen in the evening sky, although the length of time during which it is visible is rapidly decreasing. After the middle of the month it will be difficult to still see the red planet without binoculars or a telescope. In northern Germany one will search for it in vain. [Original: **MARS** kann noch am Abendhimmel gesehen werden, wenngleich seine Sichtbarkeitszeiten rapide abnehmen. Nach der Monatsmitte wird es schwierig, den roten Planeten noch ohne Fernglas oder Teleskop zu erkennen. In Norddeutschland wird man ihn vergeblich suchen.] —*Kosmos Himmelsjahr 2025*, p. 156