REVIEWS

The Barnard Objects: Then and Now, by Tim B. Hunter, Gerald O. Dobek & James E. McGaha (Springer), 2023. Pp. 344, 23·5 × 15·5 cm. Price £32·99/$44·99 (paperback; ISBN 978 3 031 31484 1).

E. E. Barnard has always been one of my astronomical heroes, and a reprint signed by him is a treasured possession. This new addition to *The Patrick Moore Practical Astronomy Series* has been compiled by three deep-sky enthusiasts and writers who all made practical observations of these objects. One recalls the excellent modern edition of the *A Photographic Atlas of Selected Regions of the Milky Way* prepared by Dobek a few years ago (see *The Observatory*, **131**, 320, 2011), while the many colour images by Hunter reproduced upon glossy paper in this new book look quite superb.

A comprehensive Foreword by William Sheehan admirably sketches Barnard's life. Barnard was a perfectionist who personally inspected all the prints intended to be bound into his atlases, and whom I have found from archival sources was overly fond of last-minute proof corrections. Barnard brought out a book of photos of the Milky Way and of comets in 1913, and a later Milky Way atlas appeared posthumously.

The term 'Barnard Object' refers here to anything the great man caught upon a photographic emulsion. They range from comets to deep-sky objects, and in particular the dark nebulae which he catalogued in such detail. It also should have been mentioned that he took some photographs of Mars in 1909 which were excellent for their time. He was well aware of the differential colour sensitivity of the plates of his day, so that stars would often not show up in the same order of brightness as they did to the naked eye. The authors provide very comprehensive lists and descriptions of the objects Barnard recorded, with modern colour images of many of them added for comparison alongside the plates and charts from Barnard's atlases. Barnard's photography was extensive but covered only a part of the sky.

Chapter 1 gives a potted history of photography and astrophotography, with details of the instrumentation used by Barnard. Chapter 2 gives an overview of nebulae in general. In the next chapter there are very useful lists of atlases, catalogues, and surveys covering all the different classes of celestial objects, not just the dark nebulae, right up to the present day. So we can find full details of the catalogues by Abell, Arp, Collinder, Gum, Lynds, Shapley-Ames, Sharpless, Van den Berg, and all the rest. To have all this information collected in one place is very useful.

Chapters 5 and 6, respectively, discuss visual observation and modern imaging techniques, while Chapter 7 examines and illustrates a selection of the Barnard Objects. Barnard's *A Photographic Atlas of Selected Regions of the Milky Way* was edited and published four years after his death by Frost and Calvert. Mary Calvert's charts showed 52 dark nebulae that had been identified from Barnard's notes, but which she did not label. Furthermore, for reasons discussed by the authors, catalogue numbers 176–200 were not used, the 1927 *Atlas* starting again at No. 201. As a result, the authors set out to assign objects to the missing numbers, and in Chapter 8 they make a good job in dealing with this historical omission. In Chapter 9 the authors in similar vein list the 31 objects described by Barnard in the *Atlas*, but which were neither catalogued nor charted therein.

The authors devote Chapter 9 to setting Barnard's work in a modern context. Many of his objects are known today as regions of active star formation, while the

term 'dark' is now limited to the visible spectrum. Some objects are recognized as Bok globules. A short summary of our current understanding of the Milky Way galaxy is given. Tables of the objects, a glossary, further references, and an index conclude the book.

If I have one small quibble it concerns the arrangement of the illustrations upon the pages. These, particularly where comparisons with the past are presented, are often spread over as many as five pages. But the captions are always collected upon the first of those pages, hindering their practical usefulness. Cost probably precluded a larger format, but it would definitely have been better. And for the British reader, I would have preferred the terms (photographic) fixer instead of fixator, and (sodium) thiosulfate for hyposulfite.

This small point aside, I can thoroughly recommend this book. It clearly is the product of a huge amount of research and observational effort. It is written with authority and has a flowing style, and crammed with the fascinating detail that only such practical specialists in this field can provide. Patrick Moore would have approved! — Richard McKim.

Models of Time and Space from Astrophysics and World Cultures. The Foundations of Astrophysical Reality from Across the Centuries, by Bryan E. Penprase (Springer), 2023. Pp. 305, 23·5 × 15·5 cm. Price £27·99 (paperback; ISBN 978 3 031 27889 1).

When you first leaf through this book, you get the impression of an all-around blow of the changes in knowledge about space, time, and matter. The extensive table of content ranges from Polynesian navigation, early star maps, Kant's philosophy, Einstein's relativity, quantum physics, dark energy to the multiverse. The cover symbolizes this mixture, showing a surreal collage of Tehran's monumental Azadi Tower, placed with shadowy persons on a lunar-like surface with the glowing Fingers of Creation in the background. How does the author manage to fit the wide-ranging topics into a 300-page book? Is he a polymath with a clear concept or are we faced with a hodgepodge of popular snippets of knowledge?

Bryan Edward Penprase has studied physics at Stanford University, receiving a PhD in astrophysics from the University of Chicago. Currently, he acts as Vice President of Sponsored Research and External Academic Relations at the private Soka University of America (SUA) in Aliso Viejo, California. We read in the introduction: "The deeper cultural roots of astrophysical reality and the ways in which space and time craft objective reality and our subjective experience are typically not part of the discussion in university classes." This deficit has motivated Penprase to offer a suitable course at SUA that "enables students to comprehend how physics and astrophysics shape our observable universe and how the process of building a cosmic perspective creates a deeper understanding of the human condition that transcends cultures and makes us all 'planetary citizens'." The book is based on his lectures and is aimed at readers "interested in the fields of historical and cultural astronomy, as well as for anyone interested in learning about the latest finds from the field of physics and astrophysics." Does it live up to these high standards?

The soft-cover book is printed on high-quality paper, a good choice given the many full-colour illustrations, showing historical charts, modern astronomical images, or graphics (some made by the author himself). Presentation and layout of the medium-format publication are convincing. The text is fluid, informative, and easy to understand. It contains a few mathematical calculations (*e.g.*, for time dilation) and formulae, like the Maxwell equations. The content

is organized more or less chronologically and reflects the current state of knowledge. There are 15 chapters with up to nine subchapters. References (literature, internet sources) are given below each chapter.

The first three chapters deal with early views on geography and the starry sky. We learn a lot about ancient cultures, the first astronomical instruments, and historic star charts. Many illustrations may be new to the reader. However, some (like Morden & Berry's 1690 world map) are too detailed for the format chosen. Chapter 4 profiles important figures in astronomy for their practical and theoretical achievements, featuring objects, innovative instruments, and methods. We meet Hevelius, Huygens, Cassini, Bradley, Descartes, Newton, Wright, and Kant. They are followed in the next chapter by other giants — people and telescopes. Herschel and Lord Rosse are celebrated for their revolutionary reflectors that revealed the nature of the Milky Way and the spiral structure of galaxies, respectively. We have now arrived at the transition from the 19th to the 20th Century with their large refracting telescopes erected at Lick, Yerkes, and Lowell Observatory. Chapter 5 covers the revolutionary achievements of astrophysical methods, especially spectroscopy. The Mount Wilson Observatory with the 100-inch *Hooker* reflector is representative of the enormous development. Hubble determined the distance of the Andromeda Nebula, confirming the extragalactic nature of galaxies, and discovered the expansion of the Universe, represented by Hubble's law. This led to the idea of a Big Bang.

Penprase now turns to an essential source of astronomical information: light. Its finite and invariant speed paved the way for Einstein's Theory of Special Relativity. It ultimately led the genius to General Relativity, treated in Chapter 8, the largest in the book. Newton's ideas about space, time, and gravity were changed fundamentally. We learn about the strange predictions of Einstein's theories and how they were tested. Black Holes and relativistic cosmology close the chapter. Another giant instrument symbolizes this era: the giant 200-inch *Hale* reflector on Palomar Mountain. It proved Hubble's law to enormous distances, where extreme objects, like quasars, were discovered. The instrumental progress, driven by new questions arising from the data, was unstoppable. It led to satellite astronomy, represented by the *Hubble Space Telescope*, the *James Webb Space Telescope*, and *Gaia*. The latter instrument revealed the construction of the Milky Way, finalizing Herschel's work. The following chapter shows how telescopes on Earth and in space revealed the large-scale structure of the Universe. In this course the author discusses the existence of a cosmic horizon, 46-billion light years away, which limits our observable universe. On the other hand, detailed ideas about the early Universe were developed due to the discovery of cosmic background radiation and new theoretical concepts such as inflation.

In the next three chapters, Penprase turns the attention to the microcosm. The quantum world is a strange place, governed by uncertainty and probability. The works of Curie, de Broglie, Heisenberg, and Schrödinger are discussed, leading to quantum mechanics. Photons, electrons, and protons were just the first members of a fast-growing zoo of particles, found experimentally and eventually arranged in the Standard Model. Its keystone is the Higgs boson, predicted in 1964 and detected at CERN in 2012. The author also addresses the essential role of quantum physics in the Big Bang and black holes — this is where the microcosm and macrocosm meet.

Chapter 14, 'Exploring the Invisible Universe', is a collection of speculative objects or concepts that have arisen from observations or theoretical

considerations. Examples are Sirius B, planet X, neutrinos, black holes, gravitational waves, and dark matter/energy. Some cases are closed, others are still open, like a ninth planet (in place of poor Pluto) or the dark fractions of the Universe. The book ends with the 'Physics of the Vacuum and Multiverses'. That chapter contains an interesting review of Freeman Dyson's important essay, *Time without End: Physics and Biology in an Open Universe*. Published in 1979, *i.e.*, before the discovery of accelerated expansion, it offers an astonishing look at the future of an ever-expanding universe.

The wide range of topics obviously fits into a 300-page book — the content is anything but a hodgepodge. Penprase provides a competent and up-to-date overview of important scientific and historical aspects of astronomy and astrophysics. He succeeds in turning his ambitious university lectures into a book for the general reader. The common thread is the cultural anchoring of ideas about space, time, and matter. That's the bright side of the book — but sadly there is also a dark one.

In my private hit list of reviewed books with the most errors found, Penprase's unfortunately ends up in one of the top places. If they arose during the publication process, the author must be blamed for not carrying out a thorough final check. In the opposite case, one would have to question his expertise. Since no systematic pattern can be seen in the occurrence of the errors, I suspect that both Penprase and Springer are responsible for them. The severity of the errors ranges from mere typos to wrong content. We find them in the ordinary text, figures/captions, references, and index. Some are systematic in nature, particularly when it comes to incorrect spelling of names or inconsistent capitalization. For reasons of scientific seriousness and historical accuracy, I cannot dispense with my findings. So, the review has a perhaps boring but necessary second part.

Let's start with incorrect first/last names (the correct one is given in [ ]). In almost half of the cases, the text contains both the correct and incorrect spelling, sometimes just a few lines apart. We have: Bernard [Barnard], Curtiss [Curtis], Durer [Dürer], Francois Englert [François], Francois Arago [François], Friedman [Friedmann], Harlowe Shapley [Harlow], Herchel [Herschel], Johan Galle [Johann], Johann Hevelius [Johannes], Joannes Regiomentanus [Johannes], LangevinJolliot [Langevin-Jolliot], Leibnitz [Leibniz], Lemaitre [Lemaître], Martin Schmidt [Maarten], Michelle [Michell], Nevill Maskelyne [Nevil], Nicolaus Visscher [Nicolas], Percivall Lowell [Percival], Rene Descartes [René], Roemer [Rømer], Roentgen [Röntgen], Scrobosco [Sacrobosco], Schrodinger [Schrödinger], Steven Hawking [Stephen], Wein [Wien]. The last case appears as "Wein Displacement" on page 170, which should read "Wien's displacement law". The index contains 11 of these names, four are incorrect, three correct, and four indifferent (*e.g.*, Shapley, H.). The references mostly give the correct spelling, exceptions are "Schrodinger", "Lemaitre", and "Rene Descartes".

Next some examples of inconsistent capitalization (often concerning proper names): lick / Lick, Yerkes observatory / Observatory, black body / Black Body, Higgs boson / Boson, helium / Helium, hydrogen / Hydrogen, general relativity / General Relativity, dark energy / Dark Energy, Hubble Space telescope / Telescope, dark ages / Dark Ages. On page 203 we read "The Discovery of the CMBR…" and in the author's Fig. 13.2 we find "Quarks Combine" (but "nuclei form"). An interesting case appears in the references of Chapter 7: "Phillips, T. (2022). *James cook and the transit of venus*". Aperture is not given consistently, writing 36″ and 36". The focus length issues on page 55 look like typos: "150-long lens telescope" [150-feet long lens telescope] and "150 feet-" [150-feet].

Other cases are "WIMPS" [WIMPs], "TypeIa supernovae" [Type Ia] and "2015" [1915] for the year of Einstein's Berlin talk. Some terms look cryptic, like $\pi + > = ud >$ on page 236; it should be $\pi^+ = < ud >$.

Examples of errors concerning figures and captions: Fig. 4.5 presents "drawings of Saturn" — we see Jupiter. Fig. 5.1 should show "Herschel's 48-inch diameter reflecting telescope" — this is his 18·7-inch reflector. On page 80 the captions of Fig. 5.3 and Fig. 5.4 are swapped. Fig. 10.2 shows our emitted radio signals, now reaching a distance of 125 light years. The circular region (looking more like an oval) correctly contains nearby stars like Capella, Aldebaran, and Arcturus, but curiously also the Coma Cluster of galaxies, 330 million light years away! In Fig. 10.7 we see data of the *Wilkinson Microwave Anisotropy Probe* (*WMAP*), called "Wilkinson Microwave Anisotropy Explorer" in the caption, while the text on the facing page gives the correct name. According to the author, Fig. 10.10 shows "the shape of the light cone". Actually, the popular graphic does not show the light cone, but the scale function R(t), giving the distance between remote objects depending on cosmic time. In an expanding universe the light cone is pear-shaped. This error is systematic. Fig. 12.4 shows the particles in Gell-Mann's diagrams of the SU(3) symmetry group (the theory is incorrectly termed "8-fold path", instead of "eightfold way"). Among them is the Ω (a fermion), called "W-boson" in the caption (the same appears in Fig. 12.5). In Fig. 12.7 the shown Λ hyperon is wrongly called "L particle". Obviously, there is a problem with uppercase Greek letters.

Finally, we come to content errors, the most critical category. Here is a selection. On page 25 we read that Aristarchus has placed the Moon "at a distance of about 70 Earth radii" — the canonical value is 19. On page 49 the author writes: "Flamsteed's chart pioneered the use of labelling stars in order of their brightness with a number, a designation which we now call 'Flamsteed numbers'." The British astronomer did not label the stars. Moreover, the numbers (later introduced by Bode) order the stars by right ascension and not brightness. This is particularly strange because Penprase cites my paper on the subject in the references, which gives the correct version! Newton's *Principia* was published in 1687, not in 1686 (p. 67). On page 74 it is claimed that Herschel has developed a "catalog that included the positions of thousands of galaxies and faint stars". Actually, he published three catalogues, listing in total 2500 nebulae and star clusters — but no faint stars. Object positions (coordinates) are not given. It is also claimed that Herschel used a platform "where he could lay flat for many hours with a view of the sky". He never did this, but always stood on the platform and looked through the eyepiece at the tube opening. We further read that he "discovered many new comets" — there were none! In the references to Chapter 8, Herschel's 1785 paper is cited, writing "*Read at the royal society*" (note the lower-case letters); the journal *Philosophical Transactions of the Royal Society* (plus volume and page) is not mentioned. On page 81, Penprase claimed that the Fourth Earl of Rosse observed "Mars' two moons in 1877". Only the outer moon, Deimos, was seen (by Dreyer and Rosse). Obviously, this error is due to an often-used source (N. English, 2018*). On page 82 we read that a white dwarf has an "inert core of Helium and Carbon" — there is no helium in the core. Fig. 8.9 and Fig. 8.10 on page 144 are misleading. The former plots a "beam of light in a curved space" as a straight line, which makes no sense; light must follow the curved coordinate lines! The latter shows the case in flat space. On page 174 the author writes that Bessel and Fraunhofer measured star positions. Fraunhofer constructed an excellent refractor for

* See review in *JAHH*, **26**, 964, 2023.

Bessel, but his own measurements are neither mentioned in his publications nor in the surviving manuscripts. On page 183 we learn that the galaxy NGC 7320, located in the foreground of Stephan's Quintet in Pegasus, is a member of the Virgo Cluster. This is ridiculous — the galaxy cluster is located on the opposite side of the sky! On page 255 the violation of "CP parity" is mentioned. However, because CP already stands for "charge and parity", we have an unnecessary repetition. Chapter 13.3 is titled "Supersymmetry and Symmetry Breaking" but the latter subject is not treated.

It looks like I'm pretty pernickety. Some problems are certainly a matter of opinion, but ultimately there are too many errors for such an ambitious book. The reader should expect a flawless and consistent presentation. — WOLFGANG STEINICKE.

More Than Curious: A Science Memoir, by William H. Press (Darwin-Finch Publishing Company), 2023. Pp. 589, 22·9 × 15·2 cm. Price $15 (about £12) (paperback; ISBN 979 898954972 6).

I've never met Bill Press. I've never corresponded with him. I've seen him once.* But after having read this book, I feel that I've known him all my life, or even all his life. At 589 pages, this is a rather long memoir, but it is the short version. A longer one, with more details on things probably of interest only to his family but also containing things he doesn't want made public until after all concerned will have died, is in escrow and will be made available "someday... but not soon". Maybe I'll live that long. At times, I thought that I must have got the long version by mistake, as the memoir is very candid. (Whether it is honest can be judged only by those involved, though I do recognize many of the names and have met some of the corresponding people and in those cases Press's descriptions usually jibe with my experience, even if separated by decades — some folks never change — so perhaps I can assume that the rest is equally honest.) Feelings are probably mutual, as I've heard some stories about Press which I won't repeat here.

Press was born in 1948 in New York City, of Ashkenazi Jewish heritage, moved with his parents to California in 1955 (his geophysicist father Frank becoming a professor at Caltech; in 1965 he moved back east to MIT), attended Harvard as an undergraduate, was a doctoral student at Caltech (with Kip Thorne), briefly a postdoc at Caltech, an assistant professor at Princeton, a professor at Harvard from 1976 (when he became the youngest professor up until that time) to 1998 (and 1982–1985 chair of the astronomy department). He then went on to become deputy laboratory director at the Los Alamos National Laboratory (LANL) before moving to the University of Texas at Austin in 2007 and switching fields somewhat, becoming a professor with a joint appointment in the computer-science and integrative-biology departments. He and his first

*That was at a conference in Melbourne in 1995 where, before his talk, he introduced himself to the audience as the front end of the Press–Schechter horse. Paul Schechter was sitting in the audience behind me. It was a conference on gravitational lensing. There was a debate about the value of the time delay between variations in the two images of the gravitationally lensed quasar 0957+561, the first gravitational-lens system discovered[1], with a shorter delay implying a larger Hubble constant and *vice versa*. (That mirrored the general debate about the Hubble constant; at the time the 'tension' was between 50 and 100 km/s/Mpc.) Press was wrong in that case. I was watching from the wings while the Hamburg group got it right[2,3]. Most have probably forgotten that now; perhaps more will remember his quip, still true today, that someone knows the Hubble constant to two significant figures, but we don't know who that person is. To his credit, Press, in an aside to another story involving potential extraterrestrial intelligence, admits that his two papers on this topic were "just incomprehensibly *wrong*" [his emphasis].

wife Margaret were both children of Caltech professors. He also worked at the Lawrence Livermore National Laboratory as a doctoral student, working for, among others, Edward Teller. He was later science advisor to Obama (his father had been the same for Kennedy, Johnson, Nixon, and Carter). He was one of the players in the revitalization of relativistic astrophysics in the 1960s and 1970s, working on a wide variety of topics. He is perhaps best known, at least to those outside of his fields, as one of the authors of *Numerical Recipes* (a book about various numerical algorithms, including explanations and working coded examples).

The book consists of seventy chapters centred around various topics, though they usually refer to more than just the topic in the title. It is mostly chronological, though occasionally there are flash-forwards. It is well written, funny, and provides an insider's view of many interesting events. The more one knows about the fields Press has worked in and the people involved, the more one will get out of it, but probably most readers of this *Magazine* would enjoy reading it (except perhaps those bits about themselves which are perhaps a bit too candid). Unlike many (auto)biographies with many more pages per year when the subject was young than later on, the level of detail is roughly constant throughout the book, though the emphasis is sometimes different (for example, the reader learns much more about Press's first wife than about his second).

Press fills us in on topics such as internal discussions of hiring committees in academia, field trips with the CIA as a member of JASON (a group of advisors to the US military), conferences behind the Iron Curtain, and internals from various consultant groups to the US Government, although it is never clear if all the reasons as to why he was selected to so many posts are actually mentioned; connections certainly played a role: "I always found the level of inbreeding at this level of scientific leadership staggering, even when benefitting from it." The following anecdote describes his status in such circles: "When I walked around the table to introduce myself, Gene Fubini was amused. 'Bill, you've reached a level where you don't have to say who you are. Just sit down and say, General, I am glad that you can be here with us today.' "

Membership in various advisory committees at times gave Press, as far as protocol was concerned, the rank of a one-star general or admiral. As the years go by, Press spends more time on government consulting and less on science, hob-nobbing with the elite of US society in business, the military, and academia; his memoir might set a record for name-dropping. But he is also honest about himself: when invited to a black-tie affair, he asks the CIA if there is a rosette associated with the gold-plated medal so that he could wear the former. There wasn't, as "most recipients don't want to advertise the fact".

His extracurricular activities meant that by the time he was gently kicked out of LANL, he had become out of touch with astrophysics. While still at LANL he had joined a statistics group in order to do 'real work' after his management career had ended. His long-time mentor John Bahcall encouraged him to talk to the biologists at the Institute for Advanced Study, possibly because Bahcall was suffering from a rare, fatal blood cancer (though his colleagues didn't know it at the time). His background as "an astronomer doing biology in a statistics department", together with his connections, led to his being recruited by the University of Texas at Austin by someone (the dean) whom he had never met, in an effort to re-establish a statistics department, getting tenure and $1 million start-up money (in addition to a chair endowed to the tune of $2 million) despite having only two published papers in biology. His connections pulled him, in 2009, into membership (and later one of the two Co-Vice Chairs) of

the President's Council of Advisors on Science and Technology, meeting with Obama for an hour or so about three times a year, and later to the post of treasurer of the American Association for the Advancement of Science. The last two chapters provide a close look at the transition from the administration of Obama to that of Trump and Press's response to COVID (with which he might have been infected), which included writing the book during the lockdown, before a twenty-one page small-print index ends the book. (The book otherwise consists of a preface and seventy occasionally sectioned chapters; there are no footnotes or figures, and language and style are very good; Press credits Kip Thorne with teaching him how to write.)

Although also published as a traditional book, Press has chosen to publish it *via* Creative Commons License CC BY-NC-ND 2.0, which means that anyone can redistribute it (even commercially) as long as credit is given and it is reproduced in its entirety. It is thus legally available as an eBook in various formats (including PDF — which I have — which presumably corresponds in appearance to the printed version). I'm sure that he doesn't need the money, and the book will thus reach an even wider readership.

All interested in the history of academia in general and astronomy in particular in the last sixty years will surely benefit from this memoir, a real page-turner which is not only highly entertaining but also from which almost everyone will learn something interesting. There isn't much time left, but I would like to see similar works by others of Press's generation (and, later, by younger people, though my guess is that, for various reasons, Press's generation of astronomers probably had the most fun). — Phillip Helbig.

References

(1) D. Walsh, R. F. Carswell & R. J. Weymann, *Nature*, **279**, 381, 1979.
(2) J. Pelt *et al.*, *A&A*, **286**, 775, 1994.
(3) J. Pelt *et al.*, *A&A*, **305**, 97, 1996.

Accreting White Dwarfs: From exoplanetary probes to classical novae and Type Ia supernovae, by Edward M. Sion (IoP Publishing), 2023. Pp. 233, 26 × 18·5 cm. Price £120/$159 (hardbound; ISBN 978 0 7503 2040 5).

Author Edward M. Sion of Villanova University begins this volume beautifully, with a chapter on what is known about non-accreting white dwarfs. There are all the familiar equations for degenerate matter (relativistic or non-relativistic), the Chandrasekhar limit but Chandra is not cited, only a 2007 book ascribed to Ostlie & Carroll (though the reference list says Carroll & Ostlie), the historic cooling curve, ways of holding metals in atmosphere *versus* letting them sink, and so forth. There is also a wonderful colour–magnitude diagram for 15 000 white dwarfs as observed by *Gaia*. The bright ones track a cooling curve for CO stars of 0·8 $M_{\odot}$; a second concentration appears at around A0 following a track for a mass around 0·75 solar masses; and the cool, faint end turns up, as expected from extra energy input when the CO core starts to crystallize. The author claims this as the first empirical evidence for the phenomenon.

This chapter, the ensuing six, and two appendices, however, suffer from the now-common problems of no unified list of references and no index of any kind. Those 15 000 white dwarfs do not all appear individually, but very many stars do, and I was left wishing that Chapter 1 had included a paragraph on "naming of white dwarfs." Quite a few of the accreting ones are variables, with decodable names like WZ Sge, V471 Tau, and U Gem. SDSS is recognizable as

Sloan Digital Sky Survey, and some memory-dredging yielded EG = Eggen–Greenstein (who are not cited anywhere for their then-enormous lists) and LTT = Luyten Two Tenths (meaning the proper motions), but is G for Giclas or Gliese, and who are GD, HE, and HS? Oh, yes! One of those non-existent indices should surely have listed the more prominent stars by name.

Topics treated in some detail include (*i*) metals in WD atmospheres (ground up planetary material has replaced accreted interstellar stuff as the best-buy explanation), (*ii*) "Roche-Lobe detached Post-common Envelope Main Sequence-White Dwarf Binaries" candidate for longest list of modifiers, but also a good discussion of weak, strong, and very strong magnetic fields, with plausible mechanisms for creation of the strong fields, and (*iii*) the zoo of cataclysmic-variables, historically introduced with initial basic understanding of explosions and the importance of donor companions, properly credited to Leon Mestel, Willem Luyten, Robert Kraft, and John A. Crawford (not any of the Crawfords we knew). Not a word, however, for the Gaposchkins, who apparently coined the cataclysmic variable name, and who over decades compiled very many light-curves of eclipsing binaries and other variable stars. Chapter 7 ends with the 'single degenerate' scenario for producing type Ia supernovae. The double-degenerate case is barely mentioned, and perhaps "accreting a whole other star" would not be the best description of the process of two merging. The dedication on page *vii* tells us that the book was written during a two-year period when the author was mourning the death of his wife of 52 years. I therefore refrain from a compilation of grammatical and similar infelicities, but the volume contains some excellent and very useful material, and one might wish for a second edition with a publisher who values whole books and not just downloadable chapters. —Virginia Trimble.

Galaxy Formation, Third Edition, by Malcolm S. Longair (Springer), 2023. Pp. 798, 24 × 16 cm. Price £89·99 (hardbound; ISBN 978 3 552 65890 1).

A volume of Springer's *Astronomy and Astrophysics Library*, this third edition brings previous editions up to date without leaving out too much history of the field. The result is a very long book, perhaps the reason why the preface ends with "Good Luck!" Probably no stranger to most readers, Longair is a prolific scientist, has written several books, and is an excellent lecturer. (I had the pleasure of hearing him, along with Allan Sandage and Richard Kron, at the 1993 Saas-Fee course *The Deep Universe*[1] (reviewed here[2]) — his second stint as a lecturer there, after 1978 with Martin Rees and Jim Gunn[3,4]. Some of his lectures can be found in good audio and video quality on YouTube.) The first edition has also been reviewed in these pages[5].*

Others have noted, confirming my impression, that Longair's presentations are often much more general than their titles. That is also the case here, with, of the twenty chapters, arguably only one complete chapter and one section of another actually about galaxy formation. However, rather than much forest and few trees, it surveys the entire landscape including the forest and many other types of tree (as well as other plants and animals) within it. As such, this book, aimed at final-year undergraduates and/or first-year postgraduates, would be a good introduction to a number of topics: theoretical cosmology, observational cosmology, the cosmic microwave background, star formation, dark matter, the early Universe, large-scale structure, General Relativity, Big-

*A sentence from Pagel's review in this *Magazine* is quoted on Springer's web page for the book, where one can also learn that it is available in paperback for $69·54 and as a PDF file for $53·49.

Bang nucleosynthesis, galaxy evolution, the intergalactic medium, and so on. I see that as an advantage rather than a disadvantage: it is good to have all that material presented in a uniform fashion at a uniform level by someone who actually knows it all. The reader is referred to more detailed accounts when necessary (in particular, the books by Peacock[6,7] and Baumann[8] are often mentioned, as well as other books by Longair). An additional advantage is that both theory and observation are covered.

The twenty chapters are collected into four parts: 'Preliminaries' (large-scale structure, galaxies, galaxy clusters, though starting off with a summary of the entire book), 'The Basic Framework' (theoretical and observational cosmology), 'The Development of Primordial Fluctuations Under Gravity' (including dark matter, correlation functions, and the CMB), and 'The Post-recombination Universe' (galaxy formation and evolution, the intergalactic medium, the early Universe). There are several figures, some in colour, scattered throughout the book, most taken (with attribution) from the literature. Each chapter has its own bibliography, often several pages of small print. Also in small print are a thirty-page(!) main (subject) index and a five-page author index. There are a few footnotes (fortunately no end notes) and references are provided in author/year style within the text.

Although perhaps setting a record for missing hyphens in two-word adjectives, otherwise the style and language are very good (though, of course, even better is a lecture in Longair's Scottish accent) with very few typos, and one could either read the book from cover to cover or dip into it for information on particular topics, as the chapters are to a large extent self-contained and necessary references to others are given. Previous editions have sold well, and that will surely be the case for this one too. The book is a good introduction to its many topics for those wanting to go further and a good summary for those for whom the almost eight-hundred pages are enough. Essentially everyone interested in any of the topics should have a copy of this book. — Phillip Helbig.

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(6) J. A. Peacock, *Cosmological Physics* (Cambridge Univ. Press), 1999.
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Winds of Stars and Exoplanets (IAU S370), edited by Aline A. Vidotto, Luca Fossati & Jorick S. Vink (Cambridge University Press), 2023. Pp. 290, 25 × 18 cm. Price £98/$130 (hardbound; ISBN 978 1 009 35278 9).

The organizers of the symposium behind these proceedings have sought to cover a great variety of processes associated with 'winds': radiatively driven mass loss by the most luminous stars carrying $\sim 10^{-5}\ M_\odot\ \mathrm{y}^{-1}$ steadily (and an order of magnitude more in eruptions), flows from cooler, solar-type stars having mass-loss rates nine orders of magnitude smaller, and the erosion of atmospheres of exoplanets, caused mostly by activity of their host stars. For some decades, the communities studying the first two subject areas have been well catered to separately by, *e.g.*, the biennial 'Cambridge Workshops on Cool Stars, Stellar Systems and the Sun' and the series of IAU Symposia focussing on massive and Wolf-Rayet stars; here, they and the newer exoplanet communities are

brought together. To what extent members of the different communities interacted at the symposium is not evident from these proceedings: there is no record of discussion (just a 'Q&A' embedded in one of the contributions) nor a conference summary.

The very diverse strands are, however, brought together in a comprehensive, magisterial survey by Stan Owocki of the physical processes driving the outflows from stars and planets — ranging from the CAK formalism of the line-driven winds of massive stars, through the solar corona and wind, spin-down, planetary winds and mass loss, followed by a discussion of magnetospheres of stars and planets. The proceedings continue with a section on observational evidence for winds, led by reviews on low-mass stars, high-mass stars, and planets. Unlike high-mass stars, where there is an abundance of mass-loss diagnostics, the greatly smaller mass-loss rates of lower-mass stars and planets restricts possible observables, primarily to the Lyman-α line profile, observable only from space and much impacted by interstellar absorption, or the weaker but more easily observable 10830-Å He I line. These reviews are accompanied by a number of shorter papers on individual objects or topics. The following section entitled 'Ingredients of Winds' again leads with reviews covering the three subject areas complementing and often expanding on material presented earlier. I am acquainted with only one of the subject areas but found all these reviews to be informative and well referenced. The lead review in the fourth part of the Proceedings, 'Flow-Flow Interactions', considers interaction of stellar winds with the ISM — but a colliding-wind system is the subject of one of the short contributions. The fifth part considering the relevance of winds contains mainly shorter papers touching on a variety of topics.

The production of the proceedings is mostly acceptable, but the editing could have been tighter. There is a problem with the diagrams. Many of them were produced in colour, which are referred to in the captions, but these are not always discernable on the printed page. This is not a new problem. Many of us have used colour for the on-line versions of our papers but taken care to choose symbols and line styles so that the figures would also be useful to the reader of the monochrome printed page. The authors should have been encouraged to do the same: although colours can be seen on the on-line version or preprints, it is the printed volume that is being reviewed here. Conference proceedings containing reviews and short communications giving a snapshot of current work are often suggested as a good means for beginners to get started in a new field; the present volume gives entry to three. — Peredur Williams.

The Philosophy and Practice of Science, by David B. Teplow (Cambridge University Press), 2023. Pp. 391, 25 × 18 cm. Price £54·99/$69·99 (hardbound; ISBN 978 1 107 04430 2).

In 1931, the UK government first published the now familiar *Highway Code*, an advisory booklet which formalized the system of road users' signals and behaviours that had evolved through the increased use and popularity of all varieties of road transport in the early decades of the century. Four years later (1935) a compulsory practical test for drivers of motor vehicles was introduced. Sixty-one years later (1996), a theory test as precursor to the practical test, and based to a large extent on the *Highway Code*, was also made compulsory.

I mention this history because as I read the current tome, for it surely does meet the essentials in the definition of that word with 770 references and 752 footnotes, I was fleetingly, but all too often, drawn to the analogy with UK road users and their regulation. All analogies are imperfect, but as this work

discusses the Philosophy (Highway Code?) and Research Practice in science (actions of all road users?) it may not be a totally inappropriate one. Few research scientists as eminent as Teplow have ventured into what might be considered the dangerously choppy waters in which philosophers of science like to sail. As a result, I wonder if the philosophizers have all too often been looked upon as 'meddlesome priests' in the hard-nosed world where real work is being done. As Dylan wrote, "You don't need a weatherman to know which way the wind blows." Or do you?

In this respect, the current text is a comprehensive, informative, and sympathetic introduction to the view from both sides ('nowhere' might philosophically be more appropriate!) and as such is to be lauded as an exceptional and welcome act of diplomacy. It begins with discussion of such philosophical fundamentals as, what is science?, what is a fact?, what is knowledge?, what is truth? There follows a substantial treatise on the evolution of the so-called Scientific Method, with a timeline covering no fewer than five millennia and featuring no fewer than twenty six 'influencers'. Not until late on in the timeline, in the 16th Century, did many of the names become familiar to me and, unrepresentative as they might be, my highlights were firstly noting Robert Boyle's (1627–1691) ten rules of good scientific writing (all of which, as Teplow notes, remain entirely relevant today) and particularly in wondering if his eighth item presaged the practice of meta-analysis, a technique only relatively recently in vogue. The other highlight was the final entry, that of Paul Feyeraband (1924–1994) — jester, savant or, in modern parlance, just an archetypal disruptor? After a full seventy-six pages of carefully catalogued, albeit not entirely linear, 'progress' to distil the essence of the, or perhaps more realistically, *multiple* Scientific Methods, for the final entry to be a philosopher who proposes that there is no such thing and that in science practice anything goes, or should go, in an anarchistic maelstrom, cannot fail but raise a smile. Needless to say this is not where Teplow leaves the discussion and the nuanced position of horses for courses (Methods for Disciplines) is well made.

The middle section of the book (160 pages) is devoted to an exposition of 'Science in Practice'. This ranges from guidelines for the initial selection of research topics, *via* the development of theories and their testing (verification, falsification, or even the possibility that neither is possible) through to the more philosophical aspects of knowledge and understanding, if indeed any at all are claimed to result from the research. In the later sections, detailed practical issues such as statistical significance are discussed (unshakeable believers in $p<0{\cdot}05$ beware!) and although the 'c' word is vastly overused these days, the 'Replicability Crisis' comes under appropriate scrutiny.

The somewhat shorter final chapter (40 pages) discusses 'Science as a Social Endeavor'. Despite its relative brevity, it shines a focussed light on many hard questions and home truths, some of which, inevitably, are not easily reconciled. How does one guard against future Replicability Crises when the ethos of "no one remembers who is second" prevails? Can scientific research always be immune to non-epistemic values and be the value-free ideal that many wish it to be, or, more dangerously, assume it is? Indeed, in some circumstances would such immunity even be desirable? Another example, too recent for inclusion in this book, which would be ripe for discussion in this context is how the scientific community should in future avoid, or vigorously respond to, the reported "extremely productive author" phenomenon[1]. In the age of ubiquitous AI, these questions and others surely have an extra special relevance and urgency.

Beyond the attention of the two main participants in this saga (philosophers,

researchers) this last chapter is the one that should be thrust into the public gaze. With public trust in science on a knife edge in some disciplines, these are important concepts and tensions to be appreciated. Airing them more widely might help bridge the sometimes barren chasms between those sceptical of all received scientific wisdom, the unthinking 'follow the science' herd, and those in danger of infection by scientism.

Overall the book is a dense, encyclopaedic *tour de force*, which cannot be taken or read lightly. I assume it is aimed primarily at those starting out on a research career, although as a refresher for the longer-in-tooth it will contain some surprises and even more sobering reminders. For anyone willing to invest the time and effort, it is hard to see anything but significant reward resulting.

But what of the nagging road-user analogy? The UK government's Road Traffic Act (1988) Section 38 contains the following paragraph: "A failure on the part of a person to observe a provision of *The Highway Code* shall not of itself render that person liable to criminal proceedings of any kind but any such failure may in any proceedings (whether civil or criminal...) be relied upon by any party to the proceedings as tending to establish or negative any liability which is in question in those proceedings."

Although it would no doubt be a policy in danger of being labelled as draconian, what if nascent researchers were required to pass a formal 'theory test' on their knowledge and understanding (whatever those two are!) of the concepts, both philosophical and practical, presented in this text before setting out on the practicalities of post-graduate research? Their subsequent thesis and its defence would represent the final 'practical driving test', cognisant of the principles already imbued by the theory test. From a quick trawl of the internet and personal contacts, it seems that some training akin to a theory test is indeed already offered in the UK, but it appears to be sporadic and very much a minority sport at the moment. However, without such a scheme one might wonder if the awarding of the degree of Doctor of Philosophy is bordering ironic and acceptable merely as an innocent, quirky anachronism, somewhat akin to the persistent titles of some of the awards in the UK's honours system. Teplow's teaching at UCLA of courses featuring this book's material promises to be an educational green shoot heading in the right direction. Hopefully it will not be another 61 years before others catch up! — Dave Pike.

Reference

(1) John P. A. Ioannidis, Thomas A. Collins, & Jeroen Baas, 2023. bio Rxiv https://doi.org/10.1101/2023.11.23.568476

White Holes: Inside the Horizon, by Carlo Rovelli (Allen Lane), 2023. Pp. 157, 19·8 × 11·8 cm. Price £14·99/$19·49 (hardbound; ISBN 978 0 241 62897 3).

This book is a quick read, not only because of the small format (and not all that many pages), but because, like Rovelli's other books, it is very well written (more precisely, I can judge only the translation, by Simon Carnell, at least as far as the language goes; like his other popular-science books, the original is in Italian). Rovelli, an active researcher in the field of loop quantum gravity, has written several popular books, and even landed a bestseller[1] (reviewed in these pages[2]). Like many of his other popular-science books, it is a mixture of standard knowledge and his own work. The table of contents lists only the three parts, though each has five or six chapters.

The first part is mainly about *black* holes, mostly standard stuff, though it would be difficult to find a better presentation of the basics. White holes are taken up in the next part. Most readers will probably have heard of them, but most also probably have some misconceptions, which Rovelli clears up (for example, their gravity is attractive; time reversal reverses the first derivative of spatial coordinates, not the second). In practice, it is difficult to distinguish black from white holes from outside the horizon. While nothing can come out from behind the horizon of a black hole, nothing can cross the horizon of a white hole from outside. However, just as a distant observer, due to the gravitational redshift and time dilation, never actually sees anything cross the horizon from outside (and hence doesn't see the actual collapse to form a black hole), neither does such an observer actually see anything emerging from a white hole. Where Rovelli departs somewhat from standard lore is his idea that when the matter forming the black holes has been sufficiently compressed that quantum-gravity effects play a role, quantum tunnelling can transform a black hole into a white hole.

In the third part, Rovelli discusses his resolution of the black-hole information paradox as well as the concept of time and the relation between time-reversible microphysics and the macroscopic arrow of time. Hawking radiation is such a phenomenon which provides an arrow of time, and as a result white holes are not exactly time-reversed black holes. According to Rovelli, while large white holes are unstable, turning into black holes, small ones are stabilized by quantum-gravity effects. To the 'extremely interesting if true' category belongs his idea that dark matter could consist of Planck-mass white holes, which is certainly compatible with observations. Unfortunately, such dark matter would be more difficult to detect directly than most other dark-matter candidates.

The book is non-technical but takes care not to over-simplify things. Rovelli justifies leaving out technical details because the non-expert reader could not follow them while the expert reader would be bored by them; both can benefit from his personal takes on various topics. (In one case, a long end note is devoted to providing a technical explanation to a qualitative description in the main text.) There are many references to Dante's *Paradise Lost*, not just in relation to non-Euclidean geometry (something other authors have also noticed) but also in a more general sense. Those tie in with Rovelli's general view of the world, also mentioned in his other books. Whether one shares it is perhaps a matter of taste; I find it to my liking, at least as long as it regards physics. Personal reflections which stray a bit further from the main text are set apart by their lack of capitalization; while both such reflections and setting them apart are good ideas, I would have chosen another way to indicate them.

While not all might share Rovelli's more speculative ideas about physics, I noticed no actual mistakes in the book* and the language and style are a cut above most books I've reviewed in these pages. There are a few black-and-white figures throughout the text. There are no footnotes, and end notes provide footnote-style comments and/or references (usually to technical literature). The

*Well, Karl Schwarzschild didn't exactly "lose his life on the Eastern Front" in the First World War. He contracted pemphigus while serving in the army (for which, at over 40 years old, he had volunteered). Since that is an autoimmune disease, it probably had nothing to do with the war. He left military service, returned to Göttingen, died a couple of months later at 42, and was buried there. All the same, writing three papers (including one with the famous Schwarzschild solution) while suffering from pemphigus and "despite the incessant artillery fire" is impressive enough.

seven-page small-print index is especially thorough considering the length of the book.

This is a well-written and interesting book accessible to a broad readership. Although one might not agree with his more speculative points (which might turn out to be wrong), most will probably learn something from it and might be inspired to follow up the references in order to learn more. — PHILLIP HELBIG.

References

(1) C. Rovelli, *Seven Brief Lessons on Physics* (Allen Lane), 2015.
(2) P. Helbig, *The Observatory*, **136**, 155, 2016.

Io: A New View of Jupiter's Moon, edited by Rosaly M. C. Lopes, Katherine de Kleer & James Tuttle Keane (Springer), 2023. Pp. 375, 24 × 16 cm. Price £129·99 (hardbound; ISBN 978 3 031 25669 1).

Io After Galileo: A New View of Jupiter's Volcanic Moon, edited by Lopes and J. R. Spencer, appeared as a 'first edition' in 2007, but was not reviewed in these pages. This little world is a fascinating place, and all that molten sulphur takes me back to my career in the chemical laboratory. Tidally squeezed and heated, Io exhibits active volcanism and sports an exotic atmosphere. It emits 100 terawatts. Some light elements form a tail around its orbit. The sodium component of the tail is remarkably bright, and by 2023 was being successfully imaged by amateur astronomers even with small-aperture telescopes equipped with narrow-band filters.

That Io's darker poles had first been spotted by Barnard is mentioned in an historical summary early on, but the first low-resolution map made by the Pic du Midi observers in 1943–44 is not mentioned. The latter shows seven or eight intriguingly circular dark patches, of which several actually coincide with volcanoes, and I feel that it should be better known.

Early chapters discuss the moon's formation and evolution. Next comes Io's surface, where geological processes have eliminated the cratering record. I was particularly interested in Chapter 6 where Katherine de Kleer and Julie Rathbun show how, after the close of the *Galileo* mission, hotspots continued to be mapped by the limb-occultation technique, or imaged directly (with adaptive optics) by the *Keck* telescope. These data revealed four persistently active volcanoes. Different classes of eruption are now recognized, with even a suggestion of explosive or Strombolian-type activity.

Further chapters review the bulk composition of Io, its plumes, atmosphere, and magnetosphere. In Chapter 10 the authors discuss how Io can serve as a model for a tidally heated exoplanet, in particular planets b and c in the TRAPPIST-1 system. Future investigations by telescope and spacecraft feature in Chapter 11, written by Alfred McEwen *et al.* The latter missions include *JUICE*, scheduled to arrive in 2031.

A multi-author work such as this one needs a very detailed index, and I don't believe five pages are quite good enough. There are few names: 'Galileo' could equally be the philosopher or the space probe. 'Sulfur' is not indexed, although S_2, SO, SO_2, and sulphur ions are included. 'Volcano' and 'volcanic' are conspicuous by their absence. It would also have been convenient to have had (at the front or back) a full page (cylindrical?) reference albedo map of Io showing all the features named in the text: the maps on pages 149 and 250 only include a few names. Another issue is the high price. These drawbacks aside, this latest review of Io is full of fascinating data, richly illustrated, crammed with references, and is much to be welcomed. — RICHARD MCKIM.

OTHER BOOKS RECEIVED

Fundamentals of Particle Physics: Understanding the Standard Model, by Pascal Paganini (Cambridge University Press), 2023. Pp. 532, 26·5 × 18·5 cm. Price £54·99/$69·99 (hardbound; ISBN 978 1 009 17158 8).

A modern introduction to the Standard Model of particle physics, this substantial volume is intended for graduate and advanced undergraduate students, and includes exercises at the end of each chapter, thus providing lecturers with a useful text for courses.

Here and There

SOME CONFUSION HERE

... we live in the solar system of the Milky Way in which the centre is the sun. The sun has a large diameter of 864,000 miles and is 8·3 kiloparsecs from the earth. — *Theoretical and Natural Science*, **10**, 79–84, 2023.

OUT OF THEIR DEPTH

A way to augment existing power dam infrastructure, particularly during droughts, is to have floating solar systems on reservoirs. — *Victoria Times-Colonist*, 2023 December 23, p. A10.