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REVIEWS

Attention is Discovery. The Life and Legacy of Astronomer Henrietta Leavitt, by Anna Von Mertens (MIT Press), 2024. Pp. 256, 26 × 21 cm. Price £32/$34·95 (hardbound; ISBN 978 0 262 04938 2).

This is a biography with a difference: a life in science seen through the eyes of an artist. Henrietta Swan Leavitt is internationally known as the discoverer of what has long been known as the period–luminosity relation for Cepheid variables (officially renamed by the IAU in 2008 as Leavitt's Law), but this book makes it very clear what a laborious task it was to discover it — first noticed and published in 1908 (as a single sentence in a paper recording details of 1177 variables, with 16 variables in Table VI: "It is worthy of notice that in Table VI the brighter variables have the longer periods"), and confirmed four years later after more detailed study with more Cepheids.

In our day, it is hard to remember the revolution caused by the replacement of photographic records by digital ones recorded by CCDs. Miss Leavitt was one of the famous women 'computers' at Harvard College Observatory in the early 1900s who meticulously studied and recorded information contained on many of the more than half-a-million 8×10-inch glass plates in the Harvard Plate Stacks. The plates cover both the northern and southern hemispheres, the latter being taken at the Observatory's outstation at Arequipa in Peru, from where the plates were shipped back to Boston in many stages: mule train to the Pacific coast, by ship to Panama, over the isthmus by land, and finally by ship to Boston, providing many opportunities for damage; amazingly, very few plates were broken.

Von Mertens stresses the distinction between looking and seeing. Looking is a passive approach, seeing takes intensive and careful inspection and understanding. Seeing requires total concentration for hours at a time and must have taken its toll, physically, mentally, and emotionally. The results were faithfully recorded by Leavitt and her colleagues in many volumes of handwritten notebooks, all of which survive; many were consulted by the author. The plates were annotated by Leavitt, writing in pen on the reverse side of the plate, separated from the emulsion by a millimetre of glass. The plates are now being digitized and initially these markings were erased to give a clearer starfield, but their historical and archival importance has now been recognized and the most important ones are being preserved.

The book is lavishly illustrated by many photographs of plates (mostly negative), meticulous drawings of plates by the artist Jennifer L. Roberts (who also provides a ten-page illustrated essay on Leavitt), and by Von Mertens herself. There are also illustrations of Von Mertens' own artwork and photographs of Leavitt and her colleagues, some including their percipient and supportive Director, Edward Pickering. An essay by João Alves recounts his accidental discovery of Leavitt's work in the 1943 edition of Shapley's book *Galaxies*. He quotes Shapley as writing "Leavitt … had the gift of seeing things and of making useful records of her measures". Later, he says "It would only later dawn on me that looking at an image over a long period is far from an exercise in boredom: it's a *technique*. Repeated looking, day after day, gazing, contemplating. Looking for a sign, no matter how small." In his PhD thesis, he used this technique to uncover what he calls the Radcliffe Wave — the alignment of many very faint gas clouds running from the Orion Nebula towards the Galactic plane. It runs for more than 10 000 light-years from Taurus to Cepheus, unsuspected until Alves' painstaking work that followed Leavitt's technique of looking until you see.

There is so much in this book that I can't cover it all. But I really enjoyed the very different perspective and can strongly recommend it to anyone with an interest in art and/or the history of astronomy. At the modest price, it would make a good present for someone. At the very least, it would be a beautiful coffee-table book. — Robert Connon Smith.

The Milky Way Smells of Rum and Raspberries … and Other Amazing Cosmic Facts, by Jillian Scudder (Icon Books), 2023 (originally published 2022). Pp. 255, 19·7 × 13 cm. Price £10·99 (paperback; ISBN 978 1 83773 101 5).

Jillian Scudder is associate professor of physics and astronomy at Oberlin College, Ohio. As one might expect from the title, the book is a collection of interesting facts, the thirty-four chapters of about four to eight pages each discussing them in turn, starting with the entire Universe and moving in through galaxies, stars, and black holes to the Solar System (with which somewhat more than half of the chapters are concerned). Although chosen to be interesting, they are used as jumping-off points to explain various aspects of astrophysics.

Some examples: 'The Universe is beige, on average', 'The galaxy is flatter than a credit card', 'It rains iron on some brown dwarfs', 'Europa might glow in the dark'. Forty-five pages of small-print endnotes point the reader to more details, either technical papers (standard bibliographic references but including DOIs) or URLs; footnotes are proper footnotes. It is thus similar to other books[1–8] which select a (small, medium, or large) number of topics and discuss them in some detail without trying to cover too much ground, a welcome alternative to introductory books which cover all of (some branch of) astronomy but necessarily at a rather superficial level. There are a few black-and-white figures scattered throughout the book, but no index. This is a nice book suitable as an introduction to those interested in astronomy but with pointers to more information, but probably everyone could learn something new from it. — Phillip Helbig.

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Honoring Charlotte Moore Sitterly: Astronomical Spectroscopy in the 21st Century, edited by David R. Soderblom & Gillian Nave (Cambridge University Press), 2024. Pp.133, 25·5 × 18 cm. Price £110/$145 (hardbound; ISBN 978 1 009 35192 8).

I suppose it might just be possible, if you are not at all involved in spectroscopy, that you might not be entirely familiar with the name Charlotte Moore-Sitterly. I think, however, that anyone who has done any work in atomic spectroscopy would agree that Charlotte Moore-Sitterly was one of the greatest spectroscopists of the 20th Century, and, as this volume shows, her pioneering work extends far into the 21st. It is probably not possible to make any attempt at interpreting an astronomical spectrum without extensive reference to her tables of *Atomic Energy Levels* (*AEL*) and her *Revised Multiplet Table* (*RMT*) *of Astrophysical Interest*. The spectroscopic notations of atomic energy levels, terms, and multiplets, with which we are today so familiar, is largely the work of Moore-Sitterly, who, as Donald Menzel wrote, "turned chaos into order"

This slim (but exceedingly important) volume represents the Proceedings of the 371st Symposium of the International Astronomical Union, held in Busan, South Korea, in 2022.

The first two plenary papers in the volume are first, a brief biography of Moore-Sitterly (about whom relatively little has previously been written) and how her legacy extends into the present century. These two papers alone are surely of great interest to any spectroscopist interested in the history and development of the subject, and of Moore-Sitterly's role. How often has Moore-Sitterly's work been cited? That is impossible to calculate. For one reason, according to this volume, about 2500 different spellings of *Atomic Energy Levels* are to be found in the literature. Furthermore, since about 1995, the work started by Moore-Sitterly in her three *AEL* volumes has now been hugely expanded into and cited as NIST ASD (National Institute of Standards and Technology, Atomic Spectra Database).

Of course there have been tremendous advances this century and literally billions of spectrum lines have been measured or calculated by someone or other. How far have we succeeded this century in turning "chaos into order", as Moore-Sitterly did in the last? There have been many compilations, some small, some vast, of spectroscopic data, and the modern user of spectra has to know where to turn to find these data. It is for this reason that any user of laboratory astrophysical data (atomic and molecular spectroscopy, astrochemistry of small and large molecules, oscillator strengths, collision rates, aerosol data) will need this book. Herein are to be found descriptions and whereabouts of all such compilations and how to use them. Also described are the many intrinsically useful quantities for which accurate laboratory data are not yet determined. There is much work yet to be done in laboratory astrophysics, and this volume should give young researchers some profitable ideas.

I have only one tiny disappointment. I see that most of the authors are still using the old term "transition probabilities" for what are better termed Einstein A coefficients. The Einstein coefficient is not in any sense a "transition probability" such as is used in probability theory. It is much more akin to the decay constant of a radioactive nuclide with dimensions T^{-1}.

Included as well as compilations of laboratory data are the capabilities of large telescopes (such as the *Very Large Telescope* (*VLT*) and the *Extremely Large Telescope* (*ELT*)) and their associated spectrographs. For example, one of the échelle spectrographs of the *VLT* is capable of measuring radial velocities with a precision of 10 cm s^{-1}. In units that we can understand, that is about 0·22 miles per hour, corresponding to a Maxwell–Boltzmann kinetic temperature of hydrogen atoms of 0·4 μK. I don't know whether astronomers can really make use of such exquisite precision.

This book will cost you about 83 pence or US$1·45 per page, and it is well worth every penny of it. I don't know how many copies were printed in excess of those needed by delegates to the symposium, but you should hurry to get a copy before they run out. — Jeremy B. Tatum.

Robert Hooke's Experimental Philosophy, by Felicity Henderson (Reaktion), 2024. Pp. 183, 22 × 14·5 cm. Price £17·95 (hardbound; ISBN 978 1 78914 954 8).

The latter part of the 17th Century was an exciting time for science in Britain. The freedom of thought encouraged by the Restoration led to many things, including the foundation of the Royal Society, the establishment of the Royal Observatory at Greenwich, and the remarkable advances made by Isaac Newton. It also witnessed the rise to prominence of the amazing polymath Robert Hooke, often just remembered for his Law (on the extension of springs) and the row he is said to have had with Newton over the Law of Gravity. There was, however, much more to Hooke than that. He was interested in *everything* and his Experimental Philosophy was built on applying his vast knowledge to every problem. His practical expertise came from his work as the Curator for the Royal Society, which meant demonstrating all manner of experiments and processes before an audience of his peers; for that task he was perhaps the first salaried scientist. He gained insights from innumerable conversations with manufacturers in their factories and fellow scientists in the coffee houses of London. And he was a first-rate artist as shown by the astonishing drawings of a range of subjects viewed through his microscope.

The present delightful book by Felicity Henderson details Hooke's career from his birth on the Isle of Wight to his death in London at the age of 67. It's a fascinating read and very modestly priced — DAVID STICKLAND.

Lunar. A History of the Moon in Myths, Maps + Matter, edited by Matthew Shindell (Thames & Hudson), 2024. Pp. 256, 37 × 27 cm. Price £50 (hardbound; ISBN 978 0 500 02714 1).

This is a very magnificent book to own in terms of its historical coverage, Moon lore, graphics, and the sheer scale of this work. You certainly need widely vertically spaced shelves in order to fit this book onto a book shelf, and it's good value at just £50. The main theme of the book celebrates the pioneering efforts by United States Geological Survey (USGS) geologists and cartographers to map the Moon's geology in the 1960s–1970s, initially through Earth-based telescopes, and later using *Lunar Orbiter* and Apollo imagery. So these maps are not surprisingly the main colourful theme pervading the book; I only wish they were larger at times in order to make their wealth of detail more visible. But in view of the large size of the original maps, this is not possible. Interspersed between the map pages are nuggets of fascinating information about old telescopic observations, spacecraft imagery, the Moon in multi-cultural folklore, paintings, and movies, *etc.* Unsurprisingly, with modern-era lunar missions, there are now more up-to-date geological maps, but what is shown here is still a good basis for selenophiles to brush up on their geology and a great place to find nuggets of interesting facts for lectures or the media. Although the book is very comprehensive and wide-ranging in terms of its coverage, it may have missed out, though, on the opportunity to mention the work of US Army and USAF cartographers, such as James Greenacre, who, spent many hundreds of hours, often during very cold nights, sketching the Moon at the eyepiece end of the Clark refractor at Lowell Observatory, Flagstaff. Their work formed the basemaps on which the colourful geological maps were overlaid. However, I guess it is not possible to mention everyone who contributed to the USGS map series and the author had to be very selective.

Anyway, I am sure that *Lunar*, through its addictive graphics and illustrations, will inspire many readers to take a greater interest in the Moon, especially now with the run up to Project Artemis in the next few years. — ANTHONY C. COOK.

Einstein and the Quantum Revolutions, by Alain Aspect (University of Chicago Press), 2024. Pp. 95, 19 × 12·5 cm. Price £13/$16 (hardbound; ISBN 978 0 226 83201 2).

Alain Aspect shared the 2022 Nobel Prize in physics with John Clauser and Anton Zeilinger for their independent but complementary work involving entangled photons, which experimentally demonstrated the Bell inequalities and led the way to quantum information science. That is certainly one reason for the publication of this little book (less than eighty pages of main text, small format, large print). However, it was originally published as an essay, in French, in 2019 in the collection *Les Grands Voix de la Recherche* which presents the work of the winners of the CNRS Gold Medal (given in all fields of science and one of the highest scientific awards in France). It is nice to have a description of this very topical subject in the (translated) words of one of the main players in the field. It is aimed at a very general readership and in terms of style, level of content, and even with regard to the physical book, reminds me of another book[1] reviewed in these pages[2], also a book for a general readership written by a practising physicist.

There were two quantum revolutions, in both of which Einstein played an important role. The first was quantum mechanics itself, in particular the aspect of wave–particle duality, as developed during the first three decades or so of the 20th Century. The second can be defined to start with John Bell's publication of his famous inequalities; measurements on entangled particles more correlated than the upper limit set by Bell's inequality demonstrate that quantum mechanics is not compatible with local realism, though the latter was the hope of Einstein, Schrödinger, and Bell himself. Einstein had laid the groundwork for the second quantum revolution in his famous paper[3] with Podolsky and Rosen (EPR) almost thirty years earlier, though their hope was that a hidden-variable theory could be constructed in order to avoid spooky action at a distance. Bohr is famous for rebutting Einstein's arguments about Bohr's view of quantum mechanics, and most physicists agree with Bohr in that respect. Aspect makes the point that Bohr's rebuttal of the EPR arguments is much less convincing, but nevertheless there was little further debate during the next thirty years or so due to the practical successes of quantum mechanics, which are independent of its philosophical interpretation.

There is a bit more material on the second quantum revolution, also covering topics such as the manipulation of quantum objects (*e.g.*, single ions), quantum cryptography, and the question whether experiments similar to those discussed will show a limitation to quantum theory. I haven't read the original, but it all seems to have been translated well. There are a few black-and-white figures, but no notes, bibliography, or index; the book is very well produced and would make a nice gift. Those wanting to explore the themes of this book in more detail should read *Quantum Drama*[4] (reviewed in these pages[5]), which is a bit longer and more technical than a typical popular-science book, while this book is a bit shorter and less technical, but provides an easily digestible summary of the topic, in keeping with Einstein's dictum to make everything as simple as possible but not simpler. — PHILLIP HELBIG.

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Parallel Lives of Astronomers: Percival Lowell and Edward Emerson Barnard, by William Sheehan (Springer), 2024. Pp. 687, 24 × 16 cm. Price £44·99 (hardbound; ISBN 978 3 031 68799 0).

In this massive and copiously illustrated biography, William Sheehan constructs a meticulous comparison of the lives of two very different personalities. Percival Lowell (1855–1916) was born with the proverbial silver spoon in his mouth into a Boston family that had grown rich upon the textile industry, and for whose education no expense was spared, whereas E. E. Barnard (1857–1923) had an extremely humble origin in Nashville, with almost no schooling, and he would become a self-made man through sheer necessity. His employment as a photographer's assistant was to prove fortuitous.

Lowell started his career as an Orientalist, but after reading Flammarion's monumental Mars book, turned his attention to the heavens. A born wordsmith and superb mathematician, yet hampered by his preconceived ideas about the

Red Planet, he extended the existing Schiaparellian canal network far beyond its credible limits, and thereby came into conflict with many leading scientific figures. But Lowell won lasting popular acclaim through his compelling and voluminous writings, which would continue to influence gullible American (and other) readers decades after the canal question had been settled in 1909.

Starting off as an amateur astronomer, Barnard began his professional career at Lick Observatory, where he used his considerable experience in photography and visual observation to good effect. His visual discovery of Amalthea and his comet and Milky Way photographs soon won him scientific acclaim. Barnard never saw canals upon Mars, but with the Lick 36-inch refractor under excellent seeing he had a glimpse of the true nature of its irregular surface.

Neither he nor Lowell had any children, and both were completely devoted to their Muse, often at the expense of their health. Spending entire sub-zero nights in the dome at Yerkes took their toll upon Barnard, while Lowell had a complete nervous breakdown from overwork only a few years after his observatory had opened.

Barnard could never get on with E. S. Holden at Lick, the Director being more of an antiquarian than an astronomer. His move to the new Yerkes Observatory was timely, even if he would never again enjoy excellent seeing for his planetary work. Instead he obtained access to state-of-the-art facilities for wide-field deep-sky photography. Lowell of course never had to work for anybody. Some of his assistants at Flagstaff had very short careers there, unable to deal with their autocratic master's bouts of bad temper, or for being unable to see the planets in the approved Lowellian manner.

All of this detail and far more is described in a story in which the parallel lives of the two great astronomers are cleverly woven together and critically examined. Sheehan has previously given us a biography of Barnard, and has written extensively about Lowell and the history of Mars observations generally, and so is well placed to have produced such a comprehensive study. But still it must have required a monumental amount of research.

With the benefit of hindsight, we might ask why Lowell blindly accepted the diagrammatic Mars of Schiaparelli and not the natural-looking world sketched by other astronomers. But Lowell was always sure of himself, and his version of the Solar System was a hierarchical one in terms of age. Mars must have cooled faster than the Earth, and its civilisation must therefore be older and wiser, and had of course become canal-builders out of necessity. We might ask many questions about Lowell. What if he had discarded social norms of his day to marry his devoted Secretary and assistant Wrexie Louise Leonard, rather than the lady who would prove such a financial disaster to the Observatory after his death? Despite all of Lowell's wealth and education, in the end it was the poor boy from Nashville who not only found the perfect life partner in Rhoda Calvert, but who would better comprehend the true nature of the Martian surface.

Under Lowell's directorship Flagstaff became a centre of excellence in the fledgling field of planetary photography. And he conducted a serious search for a trans-Neptunian planet. Pluto, discovered years after his death at his own observatory, would bear his initials, PL. And the radial-velocity work upon extragalactic nebulae conducted at Flagstaff by V. M. Slipher would pave the way towards an understanding of the expanding Universe. For his part, Barnard produced the most accurate micrometrical measures of the bodies of the Solar System, made several cometary discoveries, gave accurate descriptions of planetary features, and undertook important contributions to stellar astronomy with his numerous papers and Milky Way photography which mapped out so clearly its structure, and the intricate dark patches and lanes of interstellar dust. We also remember him for the discovery of Barnard's Star, with its record-breaking proper motion.

Parallel Lives is always fascinating, and is a real work of reference. There are plenty of striking illustrations, including many not previously seen. Just in a few instances the publisher has slipped up with the placing of an illustration, or has left an unexplained gap, on part of a page. Nor has the publisher provided an index; given the enormous number of names (let alone events) scattered throughout the text, I would have considered one essential. Apart from its coverage of the lives of Lowell and Barnard, this book addresses so many aspects and personalities of the astronomy of a century ago that it must have a wide appeal to institutions and individuals. I can warmly recommend it. — RICHARD MCKIM.

Origins: The Cosmos in Verse, by Joseph Conlon (Oneworld), 2024. Pp. 158, 19·7 × 13 cm. Price £11·99 (hardbound; ISBN 978 086154 911 5).

At the 2024 Moriond cosmology meeting, Joseph Conlon, professor of theoretical physics at the University of Oxford, gave an invited talk on string theory, a topic rather far removed from the work of most of those at the conference. My impression, and that of many others, was that it was the best talk of the conference. Still looking much younger than his forty-three years and sometimes mistaken for a student, before a rather traditional career with BA and PhD from Cambridge then moving to Oxford as a Royal Society Research Fellow and moving up the ranks, Conlon had obtained a BSc in mathematics from the University of Reading (part-time alongside schoolwork). His popular-science book *Why String Theory?*[1] (near the top of my pile of books to read) was the *Physics World* Book of the Year in 2016. I was thus intrigued when I learned that he had written a book of poetry. The book contains two long poems about physics. Although currently out of fashion (though Max Tegmark does have an *ApJ* paper with the abstract in couplets[2]), poetry about science has a long tradition, going back at least to Lucretius's *On the Nature of Things*. Both Dante and Kepler wrote poetry about astronomy and cosmology[3,4], and Milton visited Galileo; Maxwell and Lovelace wrote poetry, and Keats was a licensed surgeon[5].

So what do we get? The first, somewhat longer, poem is 'Elements', which covers Big-Bang nucleosynthesis, star formation, basics of stars, Cecilia Payne (-Gaposchkin), B^2FH (ref. 6), the production of elements heavier than iron, life, and the author himself. 'Galaxies' starts off with some history of astronomy (especially the homogeneity of the Universe on large scales) before moving to inflation, General Relativity, and the cosmological constant, then moves down the scale to the subatomic realm and a discussion of quantum mechanics (important for inflation, spectroscopy, and X-rays, among other things) and its history, followed by a coda ("an extended simile") covering everything from Oxfordshire pubs to social networks to galaxies. Each poem is preceded by a preface of a page or so describing the structure and contents. The poems are followed by twenty-eight pages of notes adding more conventional scientific detail to the pages indicated (except for the coda in 'Galaxies'). Of course, like jokes, most poetry works best when nothing has to be explained, though some will find the notes helpful. A four-paragraph note on the formation of elements heavier than iron reads in part "...there are two possible ways the r-process can occur, both associated with exploding stars, and it is not yet fully known how each contributes to the formation of heavy elements in the present universe."

Though set in stanzas making the 'abab' rhyming scheme and the (mostly) iambic pentameter obvious, if formatted differently it would sound almost like normal prose — no mean feat! As such, this is a unique book, at least in modern times; I certainly haven't come across anything similar. At times, the style reminded me of Pope, Ginsberg, Whitman, Wordsworth, Blake, or Carroll (Lewis, not Sean). It is not clear to me who the target readership is: the union of those interested in poetry and physics? The intersection? Those who want to try everything? A nice gift for the person who has everything else? I'm not sure, but I think that many will get something out of this book. — PHILLIP HELBIG.

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Cosmic Masers: Proper Motion toward the Next-Generation Large Projects, edited by Tomoya Hirota, Hiroshi Imai, Karl Menten & Yiva Pihlström (Cambridge University Press), 2024. Pp. 514, 25·5 × 18 cm. Price £120/$155 (hardbound; ISBN 978 0 009 39892 3).

The purpose of this review of IAUS 380 is presumably to give those who did not attend an impression and overview of the current state of the field. For this your reviewer is familiar enough with maser astronomy but has been away from the centre of action for some time. He therefore apologises for any misapprehensions in what follows. The overall personal impression is that work on, and using, celestial masers is very much in line with the astonishing change and progress in physics and astrophysics over the last half-century.

The structure of the volume reporting on IAUS 380 is that it comes in seven chapters relating to separate topics plus Chapter 8, 'Concluding Remarks'. Each chapter opens with a longer review paper and for the most part the succeeding papers report more individual work mentioned in the review. The work described in all of the chapters except Chapter 6 is concerned with the use of celestial masers as astrophysical probes rather than with the masers themselves. I attempt to make some comments about each chapter.

Chapter 1: 'Cosmic Distance Scale and the Hubble Constant'. There are just three papers in this chapter. The chief result is that megamasers may be used to measure the distance to some edge-on galaxies directly without using standard candles or distance ladders. H_0 for the late Universe is given as 73·9 km/s/Mpc with 4% precision. We are told that 1% precision is in prospect. This is important for work to resolve the so-called "Hubble Tension".

Chapter 2: 'Black-Hole Masses and the M-Sigma relationship'. The key point here is that super-massive black holes appear to be a feature of most, if not all, galaxies. Interesting relationships are discussed between these black holes, AGN, and rapid star formation in starbursts, which may co-evolve. Very high luminosities are made possible by the high energy-generation efficiency of mass accretion, tens of percent compared with 0·7% for nuclear fusion. However, all this is a bit obscure — literally. The surrounding medium is often optically thick to visible and IR radiation and the properties of the SMBH must be inferred from observations at sub-millimetre and longer wavelengths. Fortunately there are megamasers of water at 22 GHz, 183 GHz, and 321 GHz, which turn out to be useful. The M-Sigma relation is not much discussed.

Chapter 3: 'Structure of the Milky Way'. This opens with a masterful and full review by K. Rygl. The following papers are concerned with astrometry and measurements of distances to objects within the Galaxy. Both of these aspects are obviously crucial to understanding its structure, dynamics, and evolution. Currently we are short of data about the 1st and 4th quadrants of the Galaxy, *i.e.*, those that lie largely on the far side, beyond the Galactic Centre. The paper by Mark Reid is therefore of interest, 'Mapping the Far Side of the Milky Way'. The novel method uses "3-D kinematic distance estimates" requiring "only Doppler velocities and proper motions".

Chapter 4: 'Dynamics of Formation of Massive Stars'. The opening review paper by J. S. Urquhart highlights the importance of understanding high-mass, and therefore bright, stars because their properties are likely to dominate our observations of other galaxies and therefore on cosmological models that may depend on those observations. Unfortunately it is not so easy from our point of view, as there are few high-mass stars close by, and anyway they tend to form in clusters. Good progress has therefore depended on various Galactic Plane surveys and a useful table of 22 of those is presented. There follow more than 30 papers presenting various observations and aspects of this important topic.

Chapter 5: 'Pulsation and Outflows in Evolved Stars'. This section consists of some two dozen varied and interesting papers beautifully introduced by the review of L. D. Matthews, 'Mass Loss in Evolved Stars'. Although the basic framework for understanding mass loss from AGB stars is now half a century old, challenges remain. Winds are believed to be driven by radiation pressure on opaque dust grains formed in the cool outer atmospheres of such stars. Whilst this model works well enough for carbon stars as the carbonaceous grains have high opacity, this is not true for the majority of AGB stars that have oxygen chemistries. It is not clear what determines whether the C/O is greater or less than unity in the first place. Furthermore, the outward flow is not uniform but is subject to turbulent variations. It may be not possible to model this in detail but only in terms of scales in time and space. Nevertheless the overall process has regularities as shown by the famous movie of TX Cam by Gionidakis *et al.* of SiO maser emission over 78 epochs. Indeed, studies of both maser emission and thermal radio-line and continuum radiation are needed to observe these winds. Winds from AGB stars are believed to be a major mechanism by which the ISM becomes enriched with all elements up to iron. It is perhaps good to note that our own existence therefore depends on such processes in the past.

Chapter 6: 'Maser Theory'. This section has six interesting talks on the physics of masers rather than how they might help in understanding celestial objects. The opening talk revisits Dicke's super-radiance theory and discusses its complementarity with maser emission. This work is reflected in modelling maser flares in real sources: S255IR-NIRS3 with results shown and G9·62+0·2E with work in progress. The other papers discuss maser effects in recombination lines, the pumping of flaring masers, and two papers on polarization of maser emission, modelling and simulation.

Chapter 7: 'New Projects and Future Telescopes'. The opening paper discusses the valuable work of the Maser Monitoring Organization (M2O), set up around the time of the previous IAUS devoted to masers. As discussed in Chapter 6, flaring is a notable feature of celestial maser emission. By its very nature, it is easy to miss them unless they are watched for. The M2O has found an average of 1 to 2 per year. The new facilities and upgrades to present ones discussed in the following papers are a sign of a lively research community and interesting results to be expected in the future.

Chapter 8: 'Concluding Remarks'. In some ways, this section does the work of a reviewer for them. Two quotations may suffice: (*i*) "Seven major topics on maser sciences were presented and discussed: theory, cosmology, galaxies, Milky Way, star-formation, evolved stars and future prospects. Just as in previous meetings, the details of high-mass star formation continue to stimulate extensive research through primarily methanol and water maser studies. …"; and (*ii*) "In recent years, accurate Galactic astrometry has been done and the Milky Way rotation curve has been verified (*e.g.*, Rygl, Honma, Reid, Ellingsen). It is clear that we can now study the 'unreachable' — *e.g.*, the Bulge (Sjouwerman, Lewis), the Long Bar (Kumar), the Galactic Centre (Paine, Sakai) and we can learn about kinematics in extremely obscured Luminous Infra-Red Galaxies (*e.g.*, Aalto)."

The book itself is nicely produced by CUP, but there are serious downsides when it comes to the reproduction of the figures which are so important to the text. A large fraction of them are quite complex and authors have used colour to simplify matters. Having them reproduced in black and white makes them much less than easy to interpret. Also in some cases the figures are made too small making it hard to read text on them, although this may be due to how the authors presented their papers for publication. In all cases the figures are at least as important as the text and they deserve to be shown in the same clear style as the text. — M. R. W. MASHEDER.

Before the Big Bang: Our Origins in the Multiverse, by Laura Mersini-Houghton (Vintage), 2023 (first published 2022). Pp. 248, 19·7 × 13 cm. Price £10·99 (paperback; ISBN978 1 784 70934 1).

Laura Mersini-Houghton's doubled-barrelled surname reflects her Albanian origin and her British husband. That would normally not be worth mentioning in a book review, but in this case the book is not only a popular-science book with an emphasis on the author's own work, but also something of a personal memoir, recounting her life in Albania (where she received her BS degree), the USA (MSc and PhD), and Italy (postdoc) before moving up the ranks from non-tenured assistant to tenured full professor at the University of North Carolina at Chapel Hill. The book starts out asking whether our Universe is special, particularly with respect to the low entropy at the beginning. Following that is a standard discussion of inflation and the early Universe and then an overview of quantum mechanics. The next three chapters discuss fine-tuning, the many-worlds interpretation of quantum mechanics, and the string-theory landscape. Those first six chapters (of eleven altogether) are necessary background for the introduction of her own idea: "quantum mechanics on the landscape of string theory".

She arrives at the conclusion that our Universe is, in contrast to the famous objection by Penrose[1], not unlikely despite its low entropy at the beginning, the difference due essentially to taking quantum de-coherence into account. I don't know whether her book will convince anyone that her reasoning is correct, but I, despite familiarity with concepts such as cosmology in general, the Multiverse, fine-tuning, the Anthropic Principle, and so on[2], found her argument hard to follow. Of course, her technical papers should be the deciding factor, but in a popular book it should be possible at least to make the case so convincingly that readers with the necessary background are moved to explore it in more detail (whether or not they are still convinced after such an exploration). Neither is it the case that her many papers on such topics have led to a consensus in the field. That doesn't mean that they are wrong, but readers might get the impression that they are more mainstream than they are. When cheering for one's own theory, it is important to avoid the impression that one is being deliberately side-lined, since that is usually not the case. However, though she sometimes mentions swimming upstream, it seems to me that Mersini-Houghton goes too far in the other direction, claiming support for her particular view from some who work on anything involving the Multiverse, quantum cosmology, or whatever. Her claim that Hawking was sympathetic to the Multiverse towards the end of his life is in contrast to that of Hertog[3,4], Hawking's closest collaborator up intil the latter's death. (There are many types of Multiverses[5–10]; Mersini-Houghton mentions those due to eternal inflation, the many worlds of Everett's interpretation of quantum mechanics, and the string-theory landscape. Evidence for one type is not necessarily evidence for another type. An understanding of the relationship between different types of Multiverse, a topic which is still evolving, would be of help in understanding how her ideas related to other ideas involving the Multiverse.)

Of course, experimental confirmation is the gold standard by which any scientific theory should be judged. After a chapter on 'The Origin of the Universe' which brings all of the strands together, she discusses the possibility that interactions between various bubble universes could leave traces in the cosmic microwave background (CMB). Several anomalies in the CMB have been known for a couple of decades now and are the topic of a large number of papers. Mersini-Houghton points out that she had predicted six of them, all of which were later confirmed by observations. Though she does mention cosmic variance and the fact that the statistical significance of such anomalies is marginal, the message is that her theory has been confirmed observationally. My impression as an outsider who has followed the discussion somewhat is that her idea is one of many and the jury is still out. Again, that doesn't mean that it is wrong, and certainly confirmation of a firm prediction belongs in the 'interesting if true' category. I'll continue to follow the field, and the status of her ideas, but am somewhat put off by the sound of an axe very obviously being ground. For example, her discussion of the Anthropic Principle essentially amounts to dismissing a cardboard version of it, and connecting it to Descartes seems far-fetched; similar remarks apply to the discussion of Boltzmann brains.

For some reason, her description of the standard Big Bang picture gives too much space to Gamow; he was an important figure, but one of many in the story. The idea that not just his but all Big Bang models "[depend] on hot radiation to make the universe expand" is garbled at best. I recently reviewed[7] a book[8] about the history of the idea of the Multiverse, and more recently read another[9,10] going back over several millennia; though I read the latter book after this one, still I found her claim of a strong rejection of the Multiverse throughout history at best exaggerated, and doubt that the fate of Hugh Everett III is what persuaded most who didn't work on it to avoid it. (Interestingly, while she alludes to Everett's fate several times, it is not clear what she means: his early death (mainly due to an unhealthy lifestyle)? the fact that he didn't have an academic career after his doctorate (something which shouldn't necessarily be regarded as a failure*)? his daughter's suicide (long after her father's death)?) I found her discussion of quantum entanglement too vague to

*Both Alpher and Herman, who had worked with Gamow on early Big Bang ideas, left academic employment (though not research entirely, and both returned to academia to some extent later in life), but I don't think that their fate turned anyone away from working on Big Bang cosmology.

be useful, though of course that is an inherently difficult topic. The statement that Planck, Einstein, Bohr, Heisenberg, and Schrödinger all "laboured until the end of [their lives] to disprove the implications of quantum theory" is at best very misleading. Statements about Big Bang nucleosynthesis, the size of the horizon of the Universe, spatial curvature, and so on are, as stated, just wrong, but I'm willing to put them down to oversimplifying and/or bad editing, but perhaps they are due to unfamiliarity with other branches of astrophysics than quantum cosmology; certainly there is no other explanation for claiming that Tycho found that the Earth moves around the Sun. (That last claim is found in the epilogue, which contains a history of cosmology in a few pages. That is otherwise more or less correct, though the tendency to interpret some current debates in the light of that history seems dubious to me.)

My usual complaints about style apply, and there are a few nasty typos (I'm sure that a universe complex enough to support life must have many more than 10^{15} particles). There are a few black-and-white figures scattered throughout the book, which fortunately has footnotes rather than endnotes and ends with a seven-page small-print index. Despite my qualms, I found the book to be an interesting read, both with respect to her work and to her personal odyssey, though in both cases I wouldn't draw the same conclusions in all cases. — Phillip Helbig.

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Annual Review of Astronomy and Astrophysics, Volume 62, 2024, edited by E. van Dishoeck & Robert C. Kennicutt (Annual Reviews), 2024. Pp. 645, 24 × 19·5 cm. Price from $460 (print and on-line for institutions; about £357), $126 (print and on-line for individuals; about £98) (hardbound; ISBN 978 0 8243 0962 6).

Annual Review was a particular treat this year since it seemed to be mainly about *stars*, which is the pond in which I dabbled as a young astronomer, and indeed for the remainder of my career. And it begins in splendid fashion with an autobiographical account by Michel Mayor, famed not only as the discoverer of the first star to show signs of an exoplanet but honoured with a Nobel Prize for his work. Based on the principles of radial-velocity measurement pioneered by long-time Editor of, and contributor to, this *Magazine* Roger Griffin, Professor Mayor and his colleagues have pushed the technique to amazing precision — less than 1 $m\,s^{-1}$.

Starting with our own private star, the Sun, Fletcher gives an in-depth account of solar activity revealed by spectroscopic examination of flares over a range of wavelengths. Then staying with stars even cooler than the Sun, Henry

& Jao pick over the characteristics of M-type dwarfs, stars that have not really started to evolve in any dramatic way yet. The composition of such stars and any putative Earth-like exoplanets is discussed by Teske. And spectrum synthesis of stellar spectra is described by Lind & Amarsi in which many factors, like convection, are included — so much more sophisticated than my dabblings in the late 1970s.

Star and planet formation is considered in several chapters. Schinnerer & Leyroy start with the examination of molecular gas in nearby galaxies, while Hunter *et al.* study the ISM in dwarf irregular galaxies, and Birnstiel looks at dust growth in planetary discs, with *ALMA* now a valuable tool; related work on proto-stellar systems is reviewed by Tobin & Sheehan. And at the end of it all, *Gaia* results examined by Hennebelle & Grudić give us the IMF that should be produced!

On the larger scale, how galactic development is affected by the products of massive-binary evolution is described by Marchant & Bodensteiner, with Thompson & Heckman viewing an even bigger picture featuring winds from star-forming galaxies.

Away from the observatory and in the laboratory, Cuppen *et al.* make a study of the ices found in the ISM, adding detail for the observers to hunt down.

And last but not least it is time to see, in the company of Verde *et al.*, where we are in the determination of the Hubble Constant. Not a pond in which I ever poked a toe! — David Stickland.

The Short Story of the Universe: A Pocket Guide to the History, Structure, Theories & Building Blocks of the Cosmos, by Gemma Lavender (Laurence King), 2022. Pp. 224, 21·5 × 15·5 cm. Price £14·99 (paperback; ISBN 978 0 85782 938 2).

After studying astrophysics in Cardiff and holding various jobs in publishing, Lavender now works in Communications, Content & Outreach at the European Space Agency and has written a few other books. This book is one of a series 'The Short Story of…', others including photography, architecture, film, *etc.* Obviously, such topics, much less the Universe, will not fit into one book, especially if it's just the short story. The strategy is to choose a wide range of topics and offer a summary of each. It is thus similar to other books[1–8] which select a (small, medium, or, as in this case, large) number of topics and discuss them in some detail without trying to cover too much ground, a welcome alternative to introductory books which cover all of (some branch of) astronomy but necessarily at a rather superficial level. The many chapters are collected into four parts: 'Structure' (two pages per chapter), 'History and Future' (one), 'Components' (usually two), and 'Theories' (one). Some examples: 'Spacetime', 'Stars', 'Elements'; 'Forging the Elements', 'Birth of the Moon', 'The Future of the Universe'; 'Elliptical Galaxies', 'Wolf-Rayet Stars', 'Uranus'; 'Multiverse', 'Stellar Spectroscopy', 'Galaxy Evolution'; the second part is by far the longest.

Each chapter contains a picture (usually colour; exceptions are historical black-and-white images) and a few paragraphs of text. At the bottom of the page are references to related chapters. Otherwise, the format depends on the part. In the 'Structure' part, each chapter mentions one or more scientists together with a relevant topic, place, and time; a brief biography (sometimes of a 'key scientist', sometimes of some other relevant person); and key publications (authors, titles, and years). 'History and Future' has key scientists and a key development as well as the time since the Big Bang of the corresponding event; 'Components' has a list of notable examples of the corresponding component and a brief biography of someone who has worked in that field; 'Theories' is like 'History and Future' but without the timeline. I'm reminded of the professor (whose main job was theoretical particle physics and who looked very much like James Clerk Maxwell) who taught me classical mechanics: for the exam at the end of the course, he allowed us to bring one sheet of paper containing anything we wished to write on it. (Of course, and that was probably the intent, the act of thinking about what is important and writing it down meant that it wasn't actually used as much as we might have thought would be necessary.) This book is similar but covers more than a hundred topics. All of the parts range over (but, of course, don't really cover) essentially the whole of astronomy in about the expected proportions except that 'Components' devotes about half of its chapters to the Solar System, which reminded me of the previous book I had read[7].

'Paperback' is a bit of a misnomer; the cardboard cover (with somewhat thinner front and back flaps) is a bit stiffer than is the case with most paperbacks, and the binding is more like a hardcover. The paper is slick, the images are in high resolution, there are almost no typos, and I noticed no factual mistakes. Apart from the chapters (including a couple of introductory ones) and the seven-page index, that's it, but that is all that is needed. This is a beautiful and well-produced book and would provide not only a good introduction to astronomy, astrophysics, and cosmology but also, despite the lack of full traditional references, enough information so that the interested reader could easily find further information on the topic. — Phillip Helbig.

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The Universe, by Andrew Cohen (William Collins), 2023 (originally published 2021). Pp. 272, 19·5 × 13 cm. Price £9·99 (paperback; ISBN 978 0 00 838935 2).

Andrew Cohen is Head of the BBC Studios Science Unit and this book is based on the BBC series of the same name, which is presented by Brian Cox (who contributes a foreword). I haven't seen the programme, but the book stands well on its own. The title is something of an exaggeration, as there are only five major topics (each with its own chapter). However, any book broad enough to cover the entire Universe would be very shallow. It is thus similar to other books[1–8] which select a (small, medium, or large) number of topics and discuss them in some detail without trying to cover too much ground, a welcome alternative to introductory books which cover all of (some branch of) astronomy but necessarily at a rather superficial level. The areas covered — exoplanets, stars, galaxies, black holes, and the early Universe — are a mixture of major subjects in the field and those with a large public interest (or both). At about fifty pages each, the chapters are long enough to explore the corresponding topics in some detail. Of those covered, I know the least about exoplanets, and learned a lot from the corresponding chapter. The book is a good introduction to various fields of research, some of which some readers might want to explore further *via* more detailed books on one or more subjects.

Like the book with respect to the included chapters, each chapter concentrates on a few aspects rather than trying to cover too much. The chapter on exoplanets concentrates on the *Kepler* mission, water, and life; 'Stars' is mainly about stellar nucleosynthesis, the lives of the stars (including the Hertzsprung–Russell diagram), the Sun, and the final stages of stellar evolution. 'Galaxies' is of course a very big topic; the chapter concentrates on *Gaia*, the dynamics of galaxies, dwarf galaxies, collisions, tidal tails, and so on. The chapter on black holes covers the most ground: Sgr A*, X-ray binaries, the Schwarzschild solution, the Chandrasekhar mass limit, gravitational waves, the *Event Horizon Telescope*, Nobel Prize winners Andrea Ghez and Reinhard Genzel and the Milky Way's central black hole, the presumably related *Fermi* bubbles, and Hawking radiation (the corresponding equation for the Hawking temperature is one of only two in the book). The emphasis is mainly on astrophysics rather than the mathematical aspects of black holes. The final chapter delves into the early Universe and its evolution: high-redshift galaxies, the Hubble constant and the Hubble tension, Lemaître's ideas of the early Universe, the singularity theorems of Penrose and Hawking, and inflation. The story of Koichi Itagaki and the discovery of SN 2018gv in NGC 2525 is recounted in some detail, leading on to more general discussion of supernovae and their use in cosmology.

The book is very well written, has comparatively few typos or other goofs, and, though non-technical, does not oversimplify. There are twenty-six colour figures on ten plates about two-thirds of the way through the book (one of which, showing a galaxy cluster acting as a gravitational lens, mistakenly has a caption about globular clusters). There are a few black-and-white figures scattered throughout the text as well as a few boxes, which are long quotations from various people on a subject discussed in the neighbouring text. There are neither footnotes nor endnotes. The book ends with an eight-page small-print index. A few things are a bit confusing, such as that the Sun is more than a hundred times larger than the Earth — its *diameter* is somewhat more than a hundred times larger than that of the Earth, but most readers would probably think of the much larger difference in volume. Somewhat annoying is referring to the equivalence of mass and energy in Special Relativity as the 'equivalence principle', which of course has a different meaning in General Relativity, and the garbled idea that microlensing is caused by "a massive object like a supernova" as the gravitational lens — supernovae as *sources* in gravitational-lens systems exist but are rare, but there are no cases of them being *lenses*. While it is true a star with about half of the mass of the Sun has a lifetime of about a hundred billion years (actually somewhat more), the smallest hydrogen-burning stars are an order of magnitude smaller with much longer lifetimes.

Despite my few quibbles I recommend the book as a good introduction to those interested in various aspects of our Universe which, by limiting the breadth of topics covered, goes into somewhat more depth than is usually the case in otherwise similar books. — PHILLIP HELBIG.

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OBITUARY NOTICE

Helmut Arthur Abt (1925–2024)

One of the most prolific astronomical spectroscopic observers of the last century, Helmut Abt passed away peacefully on 2024 November 22 at the ripe old age of 99. Born in Germany, Helmut arrived in the United States as a child and went on to be awarded the first PhD in astrophysics at Caltech in 1952. Known for his work on metallic-line stars, I first met him at a workshop in Tucson in 1969 dedicated to Am and Ap stars. Later I was to encounter his many papers on radial velocities, binary stars, and other stellar topics, so many of which were invaluable in much of my work. But his herculean observational work was accompanied by his long stint as Managing Editor of the *Astrophysical Journal* and its *Supplement* series and his work with the American Astronomical Society and the Kitt Peak National Observatory. His autobiography is presented in *A Stellar Life*, which was reviewed in these pages by Virginia Trimble (**142**, 13, 2022). A truly stellar astronomer indeed. — DAVID STICKLAND.

[A more substantial obituary can be found at https://baas.aas.org/pub/2024i023/release/1]