in the fall. The book is, however, not an easy read. An index would have helped. The list of abbreviations is very nearly complete, one is told that CZ is Chang Zheng, DF is Dong Feng, and FB is Feng Bao. Now, if only I knew, what a Chang and a Dong and a Bao were ... . If there are a few native speakers of Chinese in that fall class, one of their homework choices will be to provide some insight on those matters.

It was a remarkable insight on the part of Tom Lehrer, long before that 1970 first launch, to recognize the enormous potential of the Chinese space programme, though he chose to credit it to a mythical version of the founding genius of the US space programme:

> "In English and German I know how to count down,
> And I'm learning Chinese", said Wernher von Braun.

— Virginia Trimble.

New Windows on the Universe. Advances in multimessenger astronomy, by Saeqa Dil Vrtilek (IoP Publishing), 2022. Pp. 179, 26 × 18·5 cm. Price £120/$190 (hardbound; ISBN 978 0 7503 3729 8).

This book is an introduction and overview of astrophysics as it is practised today, aimed especially at students with some background who want to learn their way into the subject. In the first chapter the author goes directly to the multimessenger nature of astrophysical research, and uses angular resolution to show how observational techniques have improved and are improving. There is a quick treatment of a variety of these techniques, from optical imaging to gravitational waves, which includes many of the standard ranges of electromagnetic radiation, and takes in cosmic rays and neutrinos.

The rest of the chapters are organized in terms of specific astronomical themes, and how the different techniques are applied to each. Starbirth gives rise naturally to discussion of infrared and millimetre-wave astronomy, and is illustrated by combining images from infrared satellites with optical counterparts from the *Hubble Space Telescope*. The author cannot be blamed for writing the book before the launch of the *James Webb Space Telescope*, which would clearly have enhanced this section (and will have to be included if there is a new edition). In the same chapter the deaths of stars point the reader at planetary nebulae and supernova remnants, and the techniques move on to include radio and X-ray images. This use of specific cases to allow the author to show where the different techniques are being applied is a strong point.

Another positive point is the chapter on planet formation and exoplanets. Starting with the historical question, verging on the philosophical, of whether the Solar System is unique, we can see the need to study exoplanets and their formation in order to understand better the formation of our own planetary system (much as the comparative meteorology of other Solar System planets has given us a better framework to study the Earth's meteorology and climate). We are told about the two basic methods for detecting exoplanets: planetary transits and periodic spectral shifts, described with brief physical detail, and given a description of specific exoplanet detections. The chapter concludes by explaining what we will need to do in order to detect Earth-like planets.

A chapter with the title 'New Characters on the Cosmic Stage' allows the author to show how high-energy electromagnetic radiation, above all X-rays and gamma-rays, are letting us see how the highest-energy objects and processes work. Here we find pulsars, both individual and binary, magnetars, gamma-

ray bursters and their host galaxies, collapsars, hypernovae, and kilonovae, a veritable zoo of phenomena. In this *pot pourri* I will pick out one interesting case, the observation of the gravitational-wave event involving merging neutron stars by observers using the full range of electromagnetic radiation. This enabled a missing piece of the nucleosynthesis puzzle, the *r* process (which among other elements produces gold), to be put into its context: the merging of neutron stars, which will be a fruitful field as gravitational-wave observations become routine.

The author uses energy production to link, in a single chapter, solar physics and the processes which produce X-rays in binaries, and in the zones around the supermassive black holes at the centres of galaxies, which we most often observe as quasars. She has a neat description and explanation of superluminal motion in some of these types of objects. The chapter also includes the analogy between stellar binary X-ray sources and quasars, and tells us of the detection of a high-energy neutrino from a blazar with the *IceCube* neutrino telescope in the Antarctic ice. The question of what sources produce the highest-energy cosmic rays is asked, to close this discussion of high-energy phenomena.

Cosmology is given its place, with a historic look at how our horizons have expanded. The story of the discovery of the expanding Universe in the early 20th Century leads on to the essentially optical observations of distant galaxies, reaching the point where dark matter and dark energy have been introduced, and showing how the cosmic microwave background now underpins the commonly accepted ΛCDM cosmological scenario. As this is pre-*JWST* we are shown only questions about the first stars and galaxies which should lead the reader towards a Google search for the latest imagery and spectroscopy of these objects. The general topic of how the Universe may end is briefly noted under the umbrella of General Relativistic scenarios. We are also given an explanation of why it is a mistake to consider that the Universe is in expansion from a specific central point.

The final chapter is devoted to upcoming instruments and the impact they are likely to have on astronomy as whole. These include the two telescope arrays making up the *Square Kilometre Array*, for radioastronomy, the *JWST* in the infrared, the *Vera Rubin* optical survey telescope, and the *Cherenkov Telescope Array* for gamma rays and high-energy cosmic rays. This latter instrument is already partly constructed and one of the four major dishes in its northern observatory is already producing data. Future upgrades to existing gravitational-wave detectors and neutrino detectors are explained, as are coming developments in time-domain astronomy. The author might have mentioned the *E-ELT*, which will be the largest optical/infrared telescope in the world when it is completed before the end of this decade.

I found the book easy to read, but this may not be a fully relevant remark, since I am a practising professional astronomer. As a supplementary text for general courses in physics it should work well. There may be other ways to organize the material but the way the author has picked individual cases to illustrate general principles, rather than in the other direction, may well be easier to assimilate for a reader with little previous knowlege. The contents are quite comprehensive, and the only sub-field which is not touched on is that of the contribution of meteorite, lunar-sample, and cometary-sample science to chronology of the Solar System and beyond. I also missed a little more use of spectroscopic results to describe and explain the astronomy. The extension of the term multimessenger astronomy to the whole gamut of electromagnetic radiation as well as to neutrino and gravitational-wave astronomy is clearly justified.

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The book is well produced, the text is clear, and the illustrations are appropriate. The book would be a good choice for libraries. But the single negative point about it is the price. It is true that the edition I have reviewed is in hardback, but I have recently seen texts which cover a similar range of topics at less than one third of the price of this book. I do not understand the pricing policy of the IoP in this case. — JOHN BECKMAN.

The Large Scale Structure of Space-Time. 50th Anniversary Edition, by Stephen W. Hawking & George F. R. Ellis (Cambridge University Press), 2023. Pp. 391, 25 × 18 cm. Price £27·99 (hardbound; ISBN 978 100 925315 4).

This is a 50th anniversary re-issue of the classic book on General Relativity from 1973, with a new foreword by Abhay Ashtekar and a new preface by George Ellis, which delightfully recalls the historical context, as well as giving some personal recollections. Partly inspired by the ground-breaking work of Roger Penrose, for which he was subsequently awarded the Nobel Prize, the book focussed on the global structure of space-time, and in proving singularity theorems, which went beyond the special symmetries that were considered might be necessary. Equally important was its influence in changing the direction of thinking of many relativists to contemplating geometrical terms, away from local formulations of General Relativity in terms of partial differential equations. What is particularly interesting is the coverage of the collision and merging of black holes, especially prescient in the light of their subsequent discovery, but curiously there is nothing on gravitational waves. In terms of what has changed in the intervening years, in the new preface George Ellis notes that the introduction of inflation theory affected the singularity theorems in that the required energy conditions don't necessarily hold. Interestingly, the book discusses de Sitter and anti-de Sitter space-times when they were presumably rather niche, but now of course are mainstream in the light of inflation and the accelerating Universe on the one hand, and AdS-CFT correspondence on the other, advancing our understanding of string theory and quantum gravity. Amusingly, the notion of de Sitter space-time as due to a fluid was not considered reasonable in 1973 since the pressure would be negative. It is a book well worth reading today — its clarity and mathematical rigour ensure its longevity, and notwithstanding the topics that it does not cover, it is as much a classic in the physics literature now as it was 50 years ago. — ALAN HEAVENS.

ASTRONOMICAL CENTENARIES FOR 2024

Compiled by Kenelm England

The following is a list of astronomical events, whose centenaries fall in 2024. For events before 1600 the main source has been Barry Hetherington's *A Chronicle of Pre-Telescopic Astronomy* (Wiley, 1996). For the 17th to 20th Centuries lists of astronomical events came from wikipedia and other on-line sources, supplemented by astronomical texts made available through the NASA Astrophysics Data System. Discoveries of comets, asteroids, novae, and other objects for 1924 appeared in the February issue of *Monthly Notices of the Royal*