demonstrated that the Earth is round. (In fact, his method of measuring the circumference of the Earth requires two assumptions: that the Earth is round and that the Sun is far enough away for its light to be considered parallel. An observer on a flat Earth would see a nearby Sun at a different height above the horizon at noon depending on 'latitude'.) Some order-of-magnitude estimates appear to be wrong probably due to typos or bad editing, but I can't figure out how she could conclude that two astronauts initially one metre apart would, due to their mutual gravitational attraction, be moving as fast as garden snails after only a few milliseconds. (The point was to demonstrate the weakness of gravity; fortunately it is so weak that overestimating it by several orders of magnitude still results in a relatively weak force.) It would have been nice to know why she thinks that the Universe is probably infinite.

Despite my minor quibbles this book was a very enjoyable read and for some could be a good first book on GR, giving not only a broad overview but also highlighting current work in the field and, *via* both unsolved puzzles and the author's own enthusiasm, explaining the beauty of falling for gravity. — PHILLIP HELBIG.

Reference

(1) https://quoteinvestigator.com/2011/05/13/einstein-simple/

Space Oddities: The Mysterious Anomalies Challenging Our Understanding of the Universe, by Harry Cliff (Picador), 2024. Pp. 285, 19·5 × 13 cm. Price £10·99 (paperback; ISBN 978 1 5290 9288 2).

Harry Cliff is a particle physicist at the University of Cambridge working on the *LHCb* experiment at CERN. This is his second popular-science book, and his interest in outreach also led to a joint post between Cambridge and the Science Museum in London (2012–2018).

Although David Bowie is not mentioned in the book, the title is an obvious nod to one of his songs. However, not all of the oddities concern space (*i.e.*, astrophysics); there are also chapters on anomalies in particle physics as well as in the overlapping field of astroparticle physics. The book begins with a quote from my childhood hero Isaac Asimov: "The most exciting phrase to hear in science, the one that heralds new discoveries, is not 'Eureka' (I found it!) but 'That's funny...'." Or, as Robert Pirsig put it, "The TV scientist who mutters sadly, 'The experiment is a failure; we have failed to achieve what we had hoped for', is suffering mainly from a bad scriptwriter."[1] After a prologue discussing anomalies in general *via* some specific examples — explored in more detail later — and the first chapter on the standard model of cosmology, Cliff takes us on a tour of about a dozen anomalies, starting with two, the anomalous precession of the perihelion of Mercury and the Lamb shift, the resolution of both of which turned out to be new physics (resolution (*a*)). If theory and experiment disagree, there are three possible explanations other than new physics: a mistake in the experiment (*b*), a mistake in the theoretical prediction (*e.g.*, a mathematical error or failing to take a significant effect into account) (*c*), or a statistical fluke (*d*).

The third chapter discusses, in addition to some background on statistics, two claimed detections which do not point to new physics: the *BICEP2* debacle (which was very bizarre but more or less falls into (*c*), though not for the usual reasons) and the *DAMA/LIBRA* experiment (for the direct detection of dark-matter particles in an underground laboratory), which presumably falls into (*b*) because other experiments, including one designed to match *DAMA/LIBRA* closely, have failed to confirm the result. We then move to the story of Linda Cremonisi and *ANITA*, which is a detector mounted on a balloon above Antarctica the purpose of which is to detect radio waves from neutrinos impacting the ice below. *ANITA* can also detect cosmic rays, and the anomaly is one which seems to have travelled through the Earth to emerge from the Antarctic ice. Here, the resolution is not yet clear, but since the *IceCube* detector (photomultipliers in holes drilled into the Antarctic ice) hasn't corroborated the findings, it looks unlikely to indicate new physics.

The unexpected value of the magnetic moment of the muon is an anomaly of which perhaps many have heard. At first, the results from the measurement of the *Muon g-2* experiment increased the discrepancy between theory and experiment. The jury is still out, but there are indications that (*c*) could be the answer here, with more precise calculations involving hadronic vacuum polarization bringing theory in line with experiment. Like the previous chapter on *ANITA*, this one has many details of the day-to-day life of those doing such experiments. The story of neutrino oscillations being the answer to the solar-neutrino problem is perhaps the most recent example of new physics beyond what was then the standard model of particle physics.* That neutrino problem is solved, but another discrepancy between theory and experiment remains unsolved; the rest of the chapter discusses work by Bonnie Fleming and Chris Polly (who was also involved in the *Muon g-2* experiment), again a mixture theory, experiment, and the people involved.

The longest chapter, describing the author's own work, involves anomalies regarding the decay of B-quarks into muons. The resolution here is (*d*). While such a resolution is easy to effect in principle (just get more data), in practice it can consume the careers of several people. It's nice to have a detailed description of an anomaly which went away for a non-dramatic reason, as history tends to concentrate on the spectacular successes (and spectacular failures such as *BICEP2*). Somewhat more familiar to readers of this *Magazine* is the Hubble tension†, the discrepancy between different measurements of H_0, the value of the Hubble constant today, mostly between the value measured *via* 'local' sources such as type-Ia supernovae and the value predicted from the CMB. (The CMB doesn't measure the Hubble constant 'directly'; it is a derived parameter. However, that it can be measured at all involves assuming some cosmological model and calculating what the value should be today based on what is observed at the time of last scattering.) Some who remember when the debate was between values of 50 and 100, as opposed to 67 and 73, though with relatively smaller (claimed) error bars in the latter case (roughly, 1 per cent as opposed to 10 per cent), assume that the current Hubble tension will just go

*Although the mystery wasn't cleared up until 2001 when the results from the *Solar Neutrino Observatory* confirmed indications from *Super-Kamiokande* that the missing electron neutrinos had turned into mu and tau neutrinos (resulting in the PIs of those experiments, Arthur McDonald and Takaaki Kajita, receiving the 2015 Nobel Prize in Physics), in 1994 I had asked John Bahcall (who spent a large portion of his very prolific life on the solar-neutrino problem) at a conference whether he thought the resolution would be a problem with the experiments (*b*) or a mistake in theory such as inaccurate models of the Sun (*c*); he was confident even then that the answer would be new physics (*a*).

†Expect a review of an entire book about the Hubble tension in the next issue[2].

away, like many other anomalies. However, there are important differences. Fifty years ago, the value depended more on the astronomers than on the method, while these days it seems that the difference is due to the method (though of course different groups of people are experts on each method). My own impression is that all involved have also investigated the matter more closely, both their own work and that of those working on the other method. (There is also some tension between various groups working on 'local' methods; Chapter 8 highlights Adam Riess working with type-Ia supernovae (which he also used to measure the acceleration of the Universe, receiving a quarter of the 2011 Nobel Prize in Physics) and Wendy Freedman using the tip of the red-giant branch as standard(izable) candles.) Due to the large amount of data available and the fact that the tension seems to be increasing with time, (*d*) is probably not an option. If (*a*) is an option, that would indicate that something is wrong with the standard model of cosmology, in particular CMB physics. To me, though, that sounds unlikely, as that is well tested in other ways. With multiple observations, (*b*) doesn't look very likely either, though that might be the answer to the tension between various 'local' methods. Option (*c*) is a non-starter because there is no theory which can predict the brightness of standard(izable) candles to sufficient accuracy; those that are used are calibrated. The jury is still out on this one. (My best guess is (*c*) in the sense that a more realistic theoretical model could solve the problem, namely that our local part of the Universe is relatively underdense. That doesn't seem to be a very popular idea, perhaps because it contains no new physics.)

The last of the main chapters introduces the σ_8 tension, though that rather technical term is not used. Basically, some measurements, especially those using the slight distortions of background galaxies due to weak gravitational lensing by foreground matter, indicate that the Universe is less clustered than one might expect from theory or indeed from other observations. (Actually, weak lensing measures a somewhat degenerate combination of the clumpiness parameter σ_8 and the density parameter Ω, so one could also say that the value of Ω from lensing is too low and σ_8 as expected. However, other constraints on Ω are stronger than those on σ_8.) It's unclear what the resolution will be. Since lensing is sensitive to all matter, not just that which is visible, perhaps luminous matter is more clumped relative to dark matter than in the standard model (in which, however, luminous matter is already more clustered than dark matter, a phenomenon going by the name of bias). This chapter ends with the discussion of the BOAT: the Brightest Of All Time gamma-ray burst. The short summary chapter starts off with a brief description of perhaps the most productive anomaly of all time, 'A Measurement of Excess Antenna Temperature at 4080 Mc/s'[3] and concludes with the author's look back on anomalies in physics, not just those mentioned in the book.

After a couple of pages of acknowledgements, the book ends with three pages of 'Notes', which are sources for information in the text, listing the corresponding page. They are not cited in the text, though. There are no figures, no index, and just a few footnotes. I didn't notice any serious mistakes and the number of typos and so on is somewhat less than is usually the case for similar books. (I did chuckle a bit after wrongly parsing a sentence: "A few weeks later, I flew to CERN for the first time after the pandemic had begun to present our results to the outside world.") I really enjoyed reading this book, which takes a somewhat different approach than most popular-science books *via* the scarlet thread of anomalies rather than being about some more or less clearly defined topic. Although of course all the anomalies are documented elsewhere, it's nice to have some of them (there are more, such as the puzzle of different methods to measure the half-life of the neutron giving different values) collected together and presented in a lively manner by someone involved in one of them, already knowledgeable about some others, and having well researched those outside of his field. — Phillip Helbig.

References

(1) R. Pirsig, *Zen and the Art of Motorcycle Maintenance* (William Morrow and Company), 1974.
(2) P. Helbig, *The Observatory*, **146**, 2026 (in press).
(3) A. A. Penzias & R. W. Wilson, *ApJ*, **142**, 419, 1965.

From the Library

A Fire on the Moon, by Norman Mailer (Penguin Classics), 2014 (originally published 1970 by Little, Brown and Company). Pp. 421 (including 8-page introduction by Geoff Dyer), 20 × 13 cm. Price £10·99 (paperback; ISBN 978 0 141 39496 1).

Yes, *that* Norman Mailer (1923–2007), the great American novelist (by whom I've read one other book[1]). With a degree in aeronautical engineering (Harvard, 1943) and already a reputation as both journalist and novelist, Mailer was certainly qualified to write about the *Apollo 11* mission. The book (finished when *Apollo 13* was returning to Earth) is an expanded version of a three-part series in *Life* magazine, for which Mailer was paid somewhat less than $450 000 ("this ... figure, while certainly too generous, was not vastly inaccurate"). By contrast, in 1969, Armstrong, as a civilian, was paid an annual salary of $27 401, Aldrin and Collins (both Air Force officers) $18 623 and $17 148, respectively (multiply by a factor of 8 or 9 for the modern equivalents). As expected, the book is well written, sometimes reminding me of Dickens, Whitman, or Ginsberg. Mailer (who refers to himself as Aquarius) appears as a character in the book, much of which is in the New Journalism style.

Taking the number of pages and the small size of the print into account, there is very much information in the 15 chapters (grouped into three parts): technical information about the space programme, comments on the social and political situation at the time, long quotations from the radio communications between the astronauts and Mission Control, the geography and hotels of Florida and Texas, contemporary news coverage, and so on, all written essentially as the story unfolded. The first part sets the stage with a broad-brush overview and contains more on Mailer's own perceptions and activities; the second (making up about half of the book) is a detailed chronological account from lift-off to the docking of *Eagle* and *Columbia* after ascent from the Moon; the third (and shortest) includes the splashdown and related events but is more concerned with Mailer's philosophical reflections on the event. Mailer tells the story like a modern myth, except that it really happened. As one of the most significant events of the 20th (or perhaps any) Century, much has been written about *Apollo 11*, both from a technical and from a sociopolitical point of view. Mailer manages to cover both areas seamlessly, and is equally at home whether writing about how liquid oxygen is cooled and transported or about contemporary politics (also in 1969, Mailer finished fourth of five in the Democratic primary