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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(7) P. Halpern, *The Allure of the Multiverse: Extra Dimensions, Other Worlds, and Parallel Universes* (Basic Books), 2024.
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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