Inside the Stars, by Hugo Van Horn (IoP Publishing), 2023. Pp. 252, 26 × 18·5 cm. Price £30/$50 (hardbound; ISBN 978 0 7503 5792 0).

Our understanding of the Universe today, and in particular of the structure and evolution of stars, is vastly different from what it was when I started as a research student in 1963. The classic textbooks on stars, which I acquired early in my research career, were those by Eddington (1926), Chandrasekhar (1939), and Schwarzschild (1958), with the latter describing how to make numerical models of stellar structure by the laborious 'fitting method'. Van Horn's book starts with a masterly introduction to those early days, starting with the first attempts in the 19th Century to understand what a star is and how it works. As an American (as one can deduce from the spellings), he makes more of the pioneering work of J. Homer Lane than I have seen elsewhere. During Lane's time at the US Patent Office (shades of Einstein!) he began to wonder whether the Sun might be gaseous (a liquid or even solid interior was a more common view at the time) and thought about the balance between gas pressure and gravity that we take for granted today. He later (1870) produced what were probably the first polytropic models of a star, which may have inspired the later work of Ritter and Emden in Europe.

By the time of Schwarzschild's book, the modern view of a star had emerged, and our understanding of stars progressed rapidly. Van Horn's stated aim is to explain how we know about the interiors of stars and how we can deduce the internal properties from surface observations. At first sight, the structure of the book is similar to that of any other modern text on stellar structure, 19 separate sections, the longest of which are the early ones, but it is different in its approach and style. In Section 1, the first short chapter gives a broad overview of what a star is before discussing observations of the Sun as a star in the next chapter. Van Horn then turns to the physics, with short chapters on radiation, composition, and energy sources before describing the properties of the material inside stars — equation of state, opacity, and nuclear-reaction rates. In all the chapters, he introduces the principal players in the field, often with short anecdotes and a photograph, many of which were new to me. His writing style is informal but precise, making for easy reading, and he often quotes from an interview with Martin Schwarzschild by the oral historian William Aspray in 1986.

In Part 2, a closer look at the interior of the Sun covers three important topics — how we came to understand the present Sun, the detection of neutrinos, and the use of helioseismology. The first of these describes the improvement in computations once digital computers became available* and once Henyey had introduced his method using an approximate model and then using difference equations to find a converged model, Schwarzschild happily gave up his fitting method in favour of this more efficient procedure.

I remember the agonizing in the physics community over the 'solar neutrino problem', where all the predictions came out 2 or 3 times the observed flux. It was not finally resolved until 2004 when the *SNO* device in Canada measured the total neutrino flux and it was realized that the Sun emitted the predicted number of electron neutrinos but that neutrino oscillations between the Sun and the detector turned about two thirds of them into mu and tau neutrinos, which only *SNO* was set up to measure. My then-Sussex colleague David Wark (now in Oxford) was part of the *SNO* consortium, so we heard all the details at that time.

*I remember Roger Tayler telling me once of the months he spent in the 1950s calculating stellar evolution on a manual calculator for his PhD.

We are all familiar now with the concept of asteroseismology, but the 'five-minute oscillations' of the Sun were a surprise when they were first discovered by Robert Leighton in 1960. It took a decade before they began to be understood as the p-modes (sound waves) predicted by Tom Cowling in 1941. Like neutrinos, these sound waves gave us a way of discovering conditions inside the Sun, including the temperature, density, and rotation distributions and the existence of a transition layer (the tachocline) between the differential rotation in the convective envelope and nearly uniform rotation in the radiative core. UK contributions to helioseismology (*e.g.*, the BiSON group in Birmingham and Douglas Gough in Cambridge on the theory of interpreting the observations) are well described.

In Part 3, Van Horn turns to stars, using the Sun as a reference point and starting with the properties of main-sequence stars. That leads naturally on to discussions of star formation and of brown dwarfs, stars that are too cool to burn hydrogen at their centres. In Part 4 the action moves to stellar evolution and death. These seven chapters cover what happens to stars of low mass when they run out of hydrogen to burn (the 'He-flash'), how intermediate-mass stars become white dwarfs, the properties of white dwarfs, the evolution of high-mass stars, supernovae, neutron stars, and finally stellar-mass black holes, which are introduced with an account of the detection of gravitational waves from a pair of merging black holes. This part is the meat of the book, and proceeds in the same style, following the development of ideas from the 1950s to the present day and mentioning in passing such items as Hoyle's 1950s prediction of a resonant level in the ^{12}C nucleus to explain how the triple-alpha reaction to form carbon from helium works fast enough, and Faulkner's 1966 explanation of the horizontal branch in globular clusters.

Van Horn gives a lot of detail of how a star evolves, both for low-mass stars like the Sun and for intermediate-mass stars, including careful discussion in the latter case of the various stages of dredge-up as the convective envelope extends down into zones of mixed composition produced by previous convection in material processed by nuclear burning. He mentions thermal pulses on the asymptotic giant branch, mass loss, planetary nebulae, and neutrino emission. He then turns to stellar remnants, such as white dwarfs, introduced by the discovery of 40 Eri B and Sirius B; he discusses how Chandrasekhar was able to explain in the 1930s how those hot dense objects could exist, although he doesn't mention Chandrasekhar's struggles to get his model accepted in the face of Eddington's scornful disbelief, expressed trenchantly at a meeting of the RAS. However, he does give a full discussion of the physics of white dwarfs, including their observed atmospheric properties and the cooling mechanism explained by Leon Mestel in the 1950s.

The evolution of more-massive stars ($> 8\ M_{\odot}$) leads not only to supernovae but their remnants, both expanding shells and a remnant imploded core. Van Horn describes succinctly the successive nuclear fuels that are burned, leading to an 'onion skin' structure of the layers of burned material of successively higher atomic mass until an iron core has formed. He describes the explosion mechanism, in which neutrinos appear to play a vital role in ejecting the shell that becomes a gaseous nebula, and why the iron core collapses. The resultant super-dense remnant is either a neutron star or, if too massive for that, a black hole. He also discusses SN 1987A and the detection of its neutrinos, as well as reviewing other types of supernova and how Type I supernovae explode, laying out the uncertainties. Three further chapters cover the origin of the chemical elements (Big Bang and in stars) and the physics of neutron stars (with a nod to the discovery of pulsars by Jocelyn Bell). The binary pulsar is mentioned as a test of General Relativity, and X-ray bursters also get a mention. The third chapter discusses stellar-mass black holes and gravitational radiation. Van Horn was present at the historic event where the positive *LIGO* results were announced and gives a graphic account of the excitement. The final three chapters cover stars with special characteristics — pulsating stars, cataclysmic variables, and the first stars.

There are six appendices expanding on some topics, such as electron degeneracy and *LIGO,* plus an extensive bibliography as well as relevant references at the end of each chapter. I had a few gripes. Firstly, I dislike page numbering by chapter (1-1, 1-2 *etc.*), so that it is laborious to find out how many pages the book contains (I have not checked the number claimed by the *Magazine*'s Editor [who crudely adds the numbers given in the list of chapters — Ed.]). More seriously, there is no general index, so one has to rely on the List of Contents to see whether any particular topic is covered. If you wanted to find out whether a particular astronomer gets a mention, you would have to guess which chapter he or she might be in. A list of illustrations would help with that, but there isn't one. I hope that if there is a second edition the publisher might deal with those points.

In summary, then, a very comprehensive and attractively written account of stellar structure and evolution, let down slightly by editorial deficiencies. I would still recommend it warmly for those wanting to know the details of what goes on inside stars. It covers advanced material at a level that would be useful for final-year physics undergraduates and beginning graduate students in astronomy, but it is written in a style suitable for less-advanced students. Members of many astronomical societies would appreciate it. But beware: it weighs 872 g! — Robert Connon Smith.

Physics of Binary Star Evolution. From Stars to X-ray Binaries and Gravitational Wave Sources, by Thomas M. Tauris & Edward P. J. van den Heuvel (Princeton University Press), 2023. Pp. 852, 23·5 × 15·5 cm. Price £80/$95 (paperback; ISBN 978 0 691 17908 7).

The evolution of binary-star systems sounds like one of those dull but worthy fields worked arduously by the older and more-bearded members of a typical university astrophysics department. This is wrong to the point of mendacity. The evolution of binary systems depends on juicy physics and leads to some of the weirdest and most wonderful objects within astrophysics, including cataclysmic variables, X-ray binaries, multiple types of supernova, millisecond pulsars, gamma-ray bursts, and the progenitors of gravitational-wave events.

Due to the variety and complex interrelations between many of these objects, the research in this area can be a bit compartmentalized and difficult to develop an intuitive feel for. This is perfect territory for a hefty textbook where the many threads can be pulled together into a coherent overview of the subject. Such a textbook requires extensive knowledge and understanding from the authors, the space to cover all relevant points, clear writing that engages the reader, and careful organization to aid their understanding. Tauris & van den Heuvel have produced exactly this textbook; it is a masterpiece.

The book begins with a brief but informative review of history of the many types of binary star (astrometric, spectroscopic, eclipsing, cataclysmic variables, X-ray binaries, supernovae, and others). Celestial mechanics gets the same treatment, followed by the Roche model, mass transfer, tides, accretion discs, common envelopes, white-dwarf binaries (both wide and close), and more. The bulk of the book is dedicated to the ménage of X-ray binaries, as might