Stellar evolution

R. J. Tayler

Stellar Evolution. Second edition. By A. J. Meadows. Pp. 171. (Pergamon: Oxford, 1978.) Hardback £7.50; paperback £2.50.

THE subject of stellar structure and evolution is believed to be the branch of astrophysics which is best understood. Because most parts of physics—such as nuclear physics, atomic physics, thermodynamics and statistical physics, electromagnetism and gravitation—are involved in determining the structure of a star, it is a very suitable topic in applied physics to introduce to undergraduates. It is also possible to present the subject to an audience with a slighter knowledge of physics and this is the concern of Professor Meadows.

When the first edition of this book was published in 1967, it received a warm welcome because of the manner in which it bridged the gap between very superficial discussions of stellar structure and evolution in books for the layman and complex mathematical texts for the professional astronomer. Twenty years earlier George Gamow's book *The Birth and Death of the Sun* had served a similar purpose, but by 1967 this was seriously out of date in detail. The first edition of Meadows' book gave a clear account of the observed properties of stars and the manner in which they are obtained. It then discussed the principles underlying the structure of stars, the source of the energy radiated from stellar surfaces, the manner in which this energy travels from the centre to the surface of a star, and the physical state of the matter inside stars. The remainder of the book was concerned with the evolution of stars from their birth as dense condensations in interstellar gas clouds, through the major part of their life as main sequence stars (the present state of the Sun) and subsequently as red giants, to their death as white dwarfs, possibly after a supernova explosion. It was then difficult to see how our knowledge of stellar evolution could be treated in a significantly clearer manner without the introduction of mathematical detail, which was completely absent from Meadows' book.

The first edition has now been revised to take account of developments in the subject. Most of the book has been photographically reproduced from the first edition and in most places it is possible to see where changes have been made because of a slight variation in contrast of the type. In the first half of the book there are only a small number of detailed alterations but later there are much more substantial changes, particularly in chapters 6, 7 and 8. The book is essentially unchanged in length, the addition of new material being balanced by the removal of speculative or unimportant material.

Substantial changes in the new edition include the following. A section has been added on the solar neutrino experiment, the results of which are at present the major question mark against the standard view of stellar structure. There is a completely revised discussion of the evolution of low mass stars following the helium flash, the explosive onset of the conversion of helium into carbon. The major change concerns stellar old age and death. Shortly after the first edition appeared, pulsars were discovered and it was soon realised that they are neutron stars. It now seems certain that neutron stars rather than white dwarfs are a normal end-product of a supernova explosion. In addition it has been realised that sufficiently massive stellar remnants will be neither white dwarfs nor neutron stars but will be black holes. Rather surprisingly in view of the great current interest in close binary stars and mass exchange between their components, the section on this topic has been slightly reduced in length, although there is a brief mention of the possible detection of a black hole in Cygnus X–1.

The revised edition of this book remains a very good non-mathematical introduction to stellar evolution and the paperback edition is very reasonably priced. □

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Microcosm of astrophysics

F. Graham Smith

The Crab Nebula. By Simon Mitton. Pp. 194. (Faber and Faber: London; Scribners: Totowa, New Jersey, 1979.) £6.50; $14.95.

THE 900th birthday of the Crab Nebula was celebrated by radio astronmers in July 1954. At that time it was almost the only celestial object, apart from the Sun, where a close link between optical and radio astronomy had emerged. In these days, when such links have appeared throughout astronomy, the Crab still has a unique importance, and annual celebrations of the supernova explosion would still be appropriate. Geoffrey Burbridge once said that astronomy could be divided into two parts: the astronomy of the Crab Nebula and the astronomy of everything else. There are indeed links between the Crab and almost everything else in astronomy, so that a discourse on the Crab can be used as an introduction, for example, to astronomy, stellar evolution, cosmology and interstellar matter; including the Crab Pulsar extends the list to the physics of condensed matter, high energy electrodynamics, superconductivity, and many other aspects of quantum physics.

This microcosm of astrophysics can therefore be used as a general introduction to astronomy, which should appeal to any scientist and which may persuade some that astronomy is a very useful means of education in basic physics. Popular books on astronomy often do not succeed in presenting the more serious aspects of the subject, and their readers might not realise the important part which is played by astronomy in postgraduate physics education. Mitton is a physicist, and emphasises the basic physics throughout, but his book is nevertheless a popular book. He eschews mathematics, and uses not a single equation. The reader need only be moderately numerate, so that he can appreciate the large powers of ten involved in any branch of astrophysics.

The decision to exclude mathematics reduces the astronomy of the Crab to less than half of the total of astronomy; and further choices have been made. Mitton has chosen to make the book readable, straight through, for anyone with an undergraduate level of physics or astronomy. Others, with less expert knowledge, will enjoy at least the historical accounts of the supernova explosion, gleaned from Chinese and Japanese records of the "guest star", and the more recent history of discoveries—notably of the pulsar which remains the centre of the nebula, providing the powerhouse for the energy to keep the nebular shining. For the physicist, the exposition of the basic concepts of degeneracy in white dwarfs and neutron stars, and of superconductivity, will have a strong appeal, as they show most clearly the connection between terrestrial and celestial solid-state physics.

Mitton is an enthusiast. In conveying his enthusiasm he does sometimes overstep the mark, in such purple passages as his description of synchrotron radiation: "photon screeches from very energetic electrons as they wrap themselves round the ambient magnetic field". He refers to the giant pulses from the pulsar as "jumbo", he tells us

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that the "youngest pulsars are the jazziest". He also obtrudes a view on space research: the X-ray observations were "made at truly vast public expense". Colourful presentation, but nothing incorrect. Colour is a strong advantage in places—for example, where the energy of one mosquito is given as a million million electron volts.

The astrophysics is sufficiently complete and correct that one can regret quite small omissions, such as the optical polarisation of the pulsar, and wish to dispute the conclusions on the birthrate of neutron stars in the Galaxy. The serious reader is encouraged to consult a useful but rather short bibliography. This will certainly not be adequate for astrophysicists, and the index is also far too short. Nevertheless, the book is strongly recommended. □

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Anatomy of a stellar murder

Donald D. Clayton

Stars: Their Birth, Life and Death. By I. S. Shklovskii. Pp. 442. (Freeman: San Francisco and London, 1978.) £10.70.

ARE you a practising astrophysicist unable to keep up with the literature, too fatigued by your own specialty? Are you worried that you are becoming too narrow while an exciting flood of astrophysical discovery flows all about you? Then this book is for you. Or are you a physicist wondering what the physics of modern astronomy is all about? This book is for you too. It is also for the amateur astronomer or the student who wants to hear the real issues of astrophysics from one who wrestles with them and who can also describe them without needless complication on the one hand or sterilising simplifications on the other.

Iosif Shklovskii writes incisively about the full range of what I would call stellar astrophysics. Not addressing extragalactic astronomy or cosmology on the one extreme, nor the origin and evolution of the Solar System at the other, Shklovskii concentrates on "stars, the most interesting and important objects in nature." But what stars! Not the serenely twinkling objects we see above us, but rather the collapsing, masering, exploding, bouncing, pulsing, bursting, spinning, extincting labour of birth and violence of death in the heavens. What makes his "serious popular book" (in the author's own words) so exciting is the closeness of many thrilling discoveries to Shklovskii's own career. His brilliance as a thinker and writer is evident throughout, not at all dampened by what must be a very good translation from the Russian, in which language the book was first published in 1975. This English edition has been updated by the author to render it even more current, although currency is not the main objective.

Perhaps the book should have been called *Anatomy of a Stellar Murder*, so vividly described are the clues marking the birth, ageing, and death throes of its central character. The reader feels like a detective on the case. The book unashamedly emphasises the newer areas of astrophysics, especially the evidence of birth in molecular clouds and the phenomena associated with neutron stars. Shklovskii correctly credits radio astronomy with the leading role in these discoveries, perhaps somewhat under-representing the contemporary excitement in optical astronomy because it is older and, alas, just as taken for granted as a wife of several decades. It would have been Shklovskian to have paused to conjecture how different it would all have been had we by accident evolved within an optically opaque atmosphere.

This book is quantitative, but not mathematical, displaying only important equations. A strong point is the presence of the many clarifying figures, which seem almost as abundant as the equations. Not designed as a textbook it would nonetheless fascinate final-year astronomy undergraduates or beginning research students, and could be supplemented by physics derivations in class. I would use it for such purposes without hesitation. In fact, the publisher should for this market consider issuing a separate companion paperback of derivations and problems at this level. This is, however, a personal book with the author as its main attraction. It has no references, except a general list at the end, but Shklovskii is liberal with text credits to pioneering researchers. The fact that half of these salutes are to Russians and to himself seems, in this case, justifiable by the author's own major role and by a general lack of awareness in the US of research in Russia.

The book is in four parts, having a total of 24 chapters. Some of the chapters, especially those on Cosmic Masers, Evolution of Protostars, the Crab Nebula, Neutron Stars and Pulsars, and X-ray Stars, are so fascinatingly written as to be pinnacles of astronomical exposition. Don't tell me that when it comes to writing serious popular books there is no difference between a great thinker and merely a great writer. Shklovskii is in the former league with Fred Hoyle and Carl Sagan. Only in the chapters on normal stars does Shklovskii lose the torch. In discussing white dwarves, for example, he seems to slip from his role as excited guide to that of teacher, beginning to wax pedagogical. Stellar structure and evolution suffers also in comparison, results of calculations tending to supplant discussions of physical mechanisms. Nucleosynthesis in stars is not described at all. A few controversial positions are taken up, such as that the admixture of overlying ^{3}He excesses is the resolution of the solar neutrino problem. But maybe it is only in the eyes of this reviewer that this part of the book seems less stimulating than the mystery of the death screams of the heavenly moribund.

All in all, this is a wonderful addition to the astronomical literature, not only as an introduction to modern issues in stellar astrophysics but also as a chronicle of the way of thinking and the temperament of one of its most colourful practitioners. □

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