A Journey to the Stars

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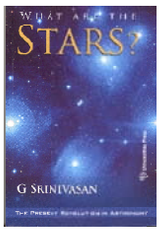
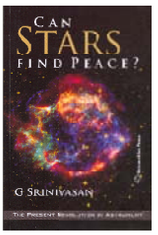


The Present Revolution in Astronomy

What Are The Stars
G Srinivasan
University Press, Hyderabad
pp.246, 2011. Price: ₹270/-



Can Stars Find Peace
G Srinivasan
University Press, Hyderabad
pp.254, 2011. Price: ₹270/-

There exists a small number of rigorous textbooks which deal with the detailed mathematical and physical nature of stars, stellar structure, and evolution. On the other hand, there are many popular websites with plenty of up-to-date 'information-based' background in this area, which many amateur astronomers and students with a beginning interest in astronomy can use.

A good understanding of the phenomenon of stars requires considerable mathematical and numerical analytical rigour. At the same time, the subject of astronomy beckons with an enchantment, almost every student of science. A middle path between the two extremes – of information-based knowledge of stars and of physics-based introduction to stars – is sorely felt. One wants to get a physical understanding of stars without losing the enchantment of the menagerie.

The books *What are the stars* (Book I) and *Can stars find peace* (Book II) in the series *The Present Revolution in Astronomy* by G Srinivasan, exactly cradle this middle path. They have the right balance of mathematical arguments laced with plenty of interesting physical insights. The ease with which the books allow simple arguments with a minimum of mathematical complexity – to arrive at very physical results in understanding stellar structure and evolution, should make this area of astrophysics (which is otherwise so very complex-mathematical-analysis oriented) very palatable to students.

In the curtain-raiser to the series, in Book I, the author defines an era of scientific revolution as a time when questions which were hitherto considered frivolous or meaningless, start becoming very meaningful. The revolution in its present decade, is more geared towards answering long-standing relevant questions, which presumably would also be ingredients of this revolution. The author also considers a deduction by the 18th and 19th century positivist philosophers that "it was in the nature of things that we shall never know what the stars are". The positivist philosophy focused on deducing conclusions from sensory or physical perception as the basis for knowledge. The scientific world had to wait until celestial photography and spectroscopy extended the role of sensory tools in order to study the stars, to determine what they were made of.

The chapters on stellar structure and energy generation in stars and the chapters leading

upto the Chandrasekhar limit, are deliciously self-contained – going through the many required conceptual corners of quantum mechanics, statistical physics, atomic, nuclear and particle physics – just enough to briefly hop, skip and jump all the necessary and sufficient steps needed before arriving at a satisfying understanding of the concept aimed at. Sometimes, though, those hops, skips and jumps can be a little uphill. The chapters following the one on the Chandrasekhar limit, in Book II, are however no longer self-contained, and may require extra reading. This, in part, stems from the fact that these stated results have all been arrived at through rigorous numerical simulations and may not be amenable to explanations through simplified analytical arguments or physical analogies.

The chapter dealing with energy generation in stars, exemplifies one aspect of the beauty of this series. On the one hand, many students interested in astronomy have this information on their fingertips that four hydrogen nuclei combine, producing a helium nucleus and the resulting mass excess is the source of Sun's energy, which students sometimes accept at face value without finding a need to question the nitty-gritty involved. On the other hand, undergraduate students meticulously plodding through various sections of quantum mechanics, atomic or nuclear physics, may sometimes be overwhelmed as to where all the complexities of these areas of physics lead up to. Here in this chapter, there is a revelation on the one hand, that four nuclei of hydrogen turning into one nucleus of helium and powering up the Sun is not as simple as all that, and on the other hand, the chapter reveals how many of the concepts being learnt in physics courses – special theory of relativity, electrostatic forces, thermodynamics and statistical distributions, quantum tunneling, nuclear and elementary particle physics combine, finally making that energy generation in the Sun a possibility.

The books, in addition, allow the astronomy enthusiasts to arrive on their own at a deeper understanding of specific aspects of stellar structure and evolution through explorations of available data and some analysis of their own. Also when graphs such as the Hertzsprung– Russel diagrams, mass–luminosity relations and so on are mentioned or reproduced from the literature, an alert to the reader that they could obtain the latest data on these aspects from many online databases and make their own explorations of these graphs, look at the current status of these results and/or any possible deviations from the broad accepted wisdom of these graphs would have been a useful nudge.

The books follow a historical framework of narrative. Is historical stream of narration always pedagogically productive? While some excess of historical meanderings could be pruned here and there and the narration kept crisper for the younger generation (more so, in Book II), nowhere does the historical/chronological format of narration seem as apt as in the story of the solar neutrinos, with its compelling story-telling in Book I, and the appropriate digressions sounding out the Sun's belly,

reassuring the reader about the soundness of conclusions drawn about the interior conditions of the Sun which were accurate enough to force the community to look seriously into the missing solar neutrinos.

Sometimes though, a very good physical understanding that could come about from a historical narrative is missed, as in the case of the tale of the proper motion of Sirius. Adding two sentences describing the fact that the actual proper motion of Sirius over two millennia amounting to about one and a half times the angular diameter of the Moon as had been noticed by ancient and medieval observers, and then bringing in the wobble in this proper motion as carefully observed by Bessel, would have made the significance of these observations much clearer than the relatively hurried statement about these observations as currently in the book. Another location where one does wish for more than a quick glancing statement about observations made, is when referring to Tycho Brahe's 1572 guest star observations in Book II. Here too, a few statements mentioning the relative accuracies of Tycho Brahe's positional astronomy observations, his parallax measurements for comets versus the measurements for the supernova and attempted parallax measurements for stars, would have made a reader pause here and appreciate positional astronomy measurements. However, this would perhaps be a subjective nitpicking, considering that the build-up in both the books towards any significant steps of understanding has been always to lay the necessary and sufficient mathematical and physical foundation towards that step, and then treat the background of observations to test these foundations.

It is clearly stated in the preface to the series that emphasis throughout would be on physical understanding and not a pedagogical step-by-step build-up of concepts. This jump in narrative style allows the author to take the reader through many exciting concepts and an understanding of observed phenomena which would otherwise not fall within the scope of a single book. However, the reference to some mathematical results or technical terms stated simply and then used in context may sometimes decrease the interest of those still used to a step-by-step build-up which they can then reproduce. It may have been useful to give some specific references where these complex mathematical results have been arrived at or explained in a pedagogical manner. For instance, in the discussion on Brownian motion, a pedagogical reference which discusses physically discuss the stated result obtained by Einstein, would certainly help the interested student.

Another example is the narration related to the definition of the photosphere of the Sun and its limb darkening which proceeds in a very exciting fashion as the reader is made to travel outward, along with superman with his X-ray vision, from the center of the Sun. However, within the narrative of the series, referring to the technical term 'optical depth' and talking of the photosphere layer as that which one reaches in that outward journey wherein the random-walking photons have a

50 percent probability of escaping to infinity, leaves an unitiated reader without any justification for this at that stage. The technical definition and mathematical framework for the optical depth, is in any case dealt with, but in a later chapter, and an alert earlier might leave the reader not so clueless.

The author has generally refrained from technical jargon in a fast-flowing narrative. There are very few instances where a beginner may be pulled up short when suddenly faced with unfamiliar terminology. An example is in the reference to radial profiles of physical conditions in the stellar interior. The terminology gets clarified through later figure captions and discussions, but a first encounter of the term may be overwhelming to a beginner, particularly given that a small typographical error at this stage confuses the symbol for the radius of the Sun.

As promised in the preface, there are very many startling analogies which make one sit up and take notice of; this might pass the reader by in a more even-toned narrative. Some examples: Superman's X-ray eyes (!), a golfer's handicap style for marking the X-axis in a Hertzsprung–Russel diagram, Victorian crinoline dresses to emphasise the vast emptiness inside an atom, neutrinos as hostile witnesses fleeing the scene, personality disorders of neutrinos, tired photons knocking off the extra electron from H^- ion, and so on.

Every once in a while, the books shoot thought-provoking unanswered questions or unexplained concepts to be dealt with either by the reader on their own (e.g., the issue of gravitational redshift versus ordinary Doppler effect possibility for the observations of Sirius B) or to be dealt with in later books of the series (e.g., comparison of arrival at the Chandrasekhar limit and Oppenheimer–Volkoff limit with respect to applicability of perfect gas assumptions), where time spent by the reader thinking through the issues raised, would be rewarding.

To conclude, the books would perhaps work best for a student who will not draw back from a serious technical understanding of stars and their remnants, will pause every few sentences in each of the chapters which encompass a wealth of conceptual understanding, follow up these threads, and perhaps go on to becoming a researcher in the area, or at the very least develop an appreciation. For the garden astronomy enthusiast who may not be willing to go to such lengths, the two books could yet give a comfortable physical understanding of stars, which they may not easily obtain through other means.

And finally, the books would be found very useful by physics students, even by those whose interest in astronomy may be peripheral, as they will find here many physical concepts in their course work applied so skillfully in the context of stars.

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