

BOOK REVIEW

Asteroseismic data analysis: foundations and techniques

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Asteroseismic data analysis: foundations and techniques, by Sarbani Basu and William J. Chaplin, Princeton University Press, 2017, pp. x + 337. £58.00, ISBN 978-0-691-16292-8 (Hardback). Scope: textbook. Level: postgraduate students and professional astrophysicists.

Stars pulsate and their nature of their pulsations can provide a great deal of information about them including, for example, their masses, radii and ages. Oscillations in stellar brightness were first observed long ago, at the end of the sixteenth century. Since then, it has been established the phenomenon is seemingly a ubiquitous feature of stars and its study has been named *asteroseismology*.

The early observations of stars with oscillating brightness referred, for obvious reasons, to cases where the oscillation amplitude was relatively large, enabling them to be identified reliably despite the noise and fluctuations in the atmosphere. These oscillations are now known to be self-excited with some layers in the star acting effectively as heat engines. More recently, it has come to be appreciated that there is also a multitude of much smaller-amplitude oscillations that arise in a stochastic manner, i.e. due to equilibria being disturbed by fluctuations and then relaxing again in an underdamped fashion on characteristic timescales. The focus of Basu and Chaplin's book is strongly on the latter kind of oscillation, which may be only a few parts per million in amplitude as in the case of our Sun. Of course, it is largely the relatively recent advent of space-based observations that has provided the precision and quality of data needed to investigate such tiny effects.

Stellar oscillations occur in three dimensions, and they involve a wide range of different periods, typically between minutes and days. In the last few years there has been a veritable explosion of data, coming from enormous numbers of stars, so that a general text on how to analyse and interpret all this material is greatly to be welcomed. It is aimed mainly at students and researchers entering the field, and at other astrophysicists who are interested in finding out something about asteroseismology and how the data are analysed.

The authors start with a context-setting introductory chapter. Although their book is mainly about data analysis, the introduction is followed by chapters on stellar structure and on the equations that govern the oscillations, which are helpful in making the exposition more coherent and self-contained. The remaining seven chapters discuss in considerable detail the different techniques that have been developed and applied for analysing the data and modelling the processes giving rise to them. There are exercises at the end of each chapter together with quite extensive bibliographies of suggestions for further reading.

The analysis of time series data is, of course, an activity that occurs universally throughout science, and workers in seemingly very different areas can often learn from each other. There are a number of potentially useful data analysis methods that the authors leave unmentioned, perhaps because they have been tried and found not to be useful, or maybe because they have not yet

been applied. For example, given the wide range of frequencies involved, and fact that some of the oscillations are time-variable due e.g. to Doppler shifts, it is natural to wonder whether wavelet and other time-frequency approaches might sometimes be useful to complement the Fourier methods described. Nonlinear mode decomposition could be applied for distinguishing non-sinusoidal oscillations that overlap in frequency. Also, a natural question to ask is whether there may be mutual interactions between some of the oscillations? If so, synchronisation and coherence analyses might be particularly revealing of the underlying physics. Maybe such approaches have already been tried without useful outcome. Alternatively, however, they could be questions for the future.

As an account of how asteroseismic data are currently analysed and interpreted, it seems to me that that Basu and Chaplin's book could hardly be bettered. It is scholarly, wide-ranging but also detailed and quantitative, thoughtfully put together, and extremely well written.

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