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tomso: TOols for Models of Stars and their Oscillations

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Software

- Review
- Repository
- Archive

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Summary

Many branches of astronomy interpret observations through approximate, one-dimensional models of stars. Furthermore, many stars are observed to undergo resonant pulsations, and the frequencies at which they do so are similarly interpreted through the predicted pulsations of the one-dimensional models. Since the problem was defined in its modern form around the mid-20th century, many programs have been written to produce models and predict their frequencies and correspondingly many custom data formats have been defined, with varying levels of ease-of-use and interoperability. `tomso`'s main purpose is to provide a high-level interface for parsing data in these formats and simplify research that uses them.

Statement of need

Data formats for stellar models and their oscillations vary widely. Some are fixed-width plain text files with several blocks; some are Fortran binaries; and few can easily be read with standard routines for loading data. Some programs require data to be prepared in a specific format and provide tools to do so but these tools are incomplete and difficult to extend.

`tomso` is a set of Python modules that provides a high-level interface to several formats and enables or simplifies several common tasks in analysing the stellar models and oscillations. First, it allows the user to load the data for inspection, which can be cumbersome, given the complicated specifications of some formats. The high-level interface also allows straightforward access to complicated properties that can be derived from the data. Second, it can be convenient—and, as mentioned above, is sometimes necessary—to convert files between different formats. Finally, some computational experiments involve modifying the stellar models directly, which requires reading the file in the correct format, manipulating the data, then ensuring that the data is correctly re-written in the same format.

For example, two derived properties are the speed of sound c_s and acoustic depth τ, which is how long a sound wave would take to travel from a star's surface to some depth inside. The sound speed gradient $dc_\mathrm{s}/d\tau$ is useful for identifying regions where sudden changes in the star's structure might discernibly affect the frequencies at which it vibrates. Such a figure is shown for a standard solar model, Model S (Christensen-Dalsgaard et al., 1996), in the textbook by Aerts et al. (2010; their Fig. 7.30, which is in essence the same as Fig. 1 in Monteiro et al., 2000) but requires some manipulation of the source data because neither c_s nor τ are part of the data format. Fig. Figure 1 shows the same data but with `tomso` this is naturally expressed in two functional lines of Python code: one to read the data file and one to plot the relevant data using the high-level properties `cs` and `tau`.

`tomso`'s interfaces also aim to be easily extensible, so that in the future it can not only support more current codes and file formats, but also those that have yet to be developed.

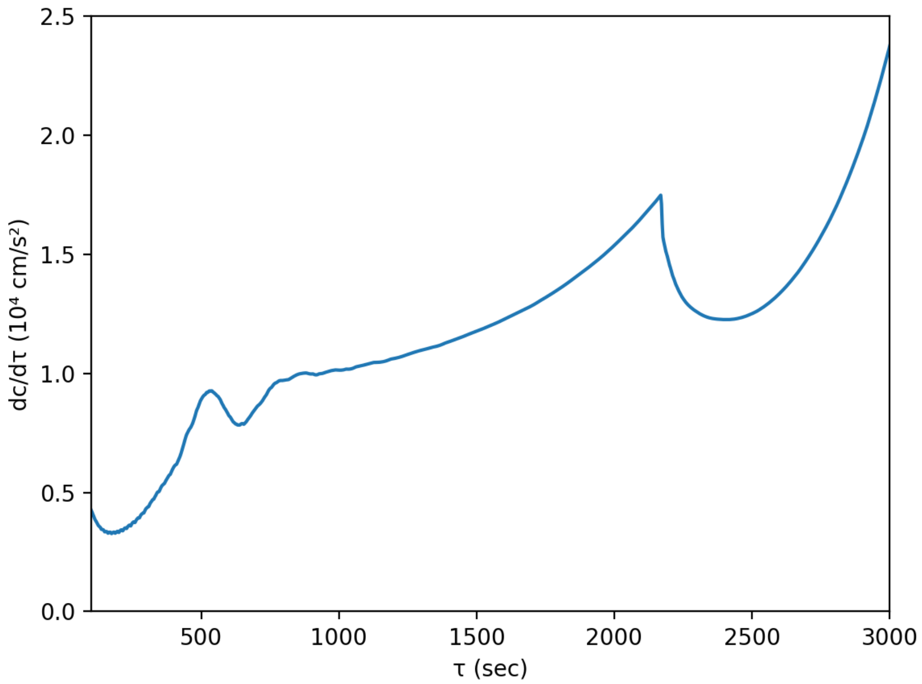

Figure 1: Plot of the sound speed gradient as a function of the acoustic depth in a standard solar model (Model S, Christensen-Dalsgaard et al., 1996), as in Fig. 7.30 of Aerts et al. (2010).

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