Stellar acoustic radii, mean densities and ages from seismic inversions

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Abstract

The determination of stellar characteristics such as the mass, the age or the radius, is crucial when studying both stellar evolution and exoplanetary systems. In this context, asteroseismology is now a precious tool for quantifying such characteristics, especially the age. However, the main problem with current methods are their model dependence, especially when trying to determine the age. In this study, we will present a new approach based on the SOLA inversion method (F. Pijpers and M. J. Thompson 1994), used previously in linear helioseismic inversions. This approach can be used to determine stellar global properties for stars on the main sequence such as the acoustic radius, the mean density and a proxy for the stellar age based on the derivative of the sound speed. These properties were previously estimated through the large and small frequency separations to whom they are asymptotically related. We extend the study of D. R. Reese et al. (2012) on the mean density to the acoustic radius and a proxy for age, and provide a new framework in which to extract these properties from observed stars with the most accuracy. We will show that our method provides accurate results (within 0.5%) for these properties, even when the reference models are based on simpler physical ingredients than the target or use an improper characterization of convection and metallicity, or when the effects of non-adiabaticity and turbulent pressure are neglected in the oscillation modes. Thanks to our results, we propose a new version of the asteroseismic HR diagram based on the direct values of the stellar global properties instead of their asymptotic estimators. The main purpose of this work is to define a new approach based on inversion techniques to characterize stellar global properties with high accuracy and little model-dependence. Since it is solely based on structural considerations, the method can be extended to other structural characteristics one wishes to determine.

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