THE SYMBIOSIS BETWEEN ASTEROSEISMOLOGY AND EXOPLANET STUDIES: IMPROVING THE PRECISION AND ACCURACY OF THE ESTIMATED STELLAR PROPERTIES



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Asteroseismology can provide the accurate and precise estimates of the stellar properties (i.e., density, surface gravity, mass, radius and age) that are needed to make robust inference on the properties of the planets. Building on the experience with CoRoT and *Kepler*, and in preparation for TESS and PLATO, we are developing and testing procedures that will enable us to:

1 determine efficiently and robustly global properties of main-sequence and evolved stars

2 systematically explore the impact of uncertainties on the micro and macro physics on the inferred stellar properties

3 stress test stellar models, and feed back improved models to grids used to infer global stellar properties

Asteroseismic Inference on a Massive Scale (AIMS)

Our code (Reese et al. 2016, http://bison.ph.bham.ac.uk/spaceinn/aims/) relies on a Monte-Carlo-Markov-Chain approach to find a representative set of models which reproduce a given set of classical and asteroseismic constraints. These models are obtained by interpolation from a pre-calculated grid thereby increasing computational efficiency.

Grids of models
- n-dimensional
- stellar models computed with the Code Liegeois d'Evolution Stellaire (Scuflaire et al. 2008, Gabriel et al. 2015)
- oscillation frequencies computed with LOSC (Scuflaire et al. 2008)

Analytical priors & Observational constraints
- seismic: ν, r_{01}, r_{02}, $\Delta\nu$, …
- classical: T_{eff}, L, [Fe/H], …
- uncertainties and correlations

AIMS
- unstructured linear interpolation
- MCMC approach with parallel tempering (via the EMCEE python package, Foreman-Mackey et al. 2013)

Estimated properties
- probability distribution functions for different parameters

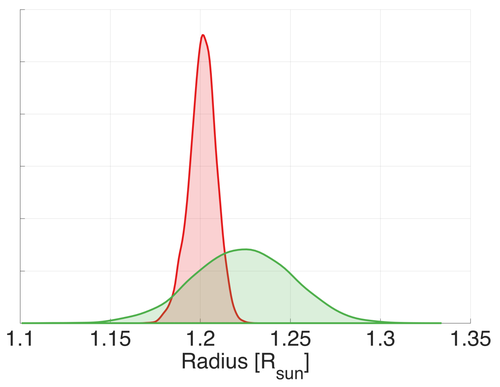
Representative models
- acoustic structure interpolations from grid of models
- allows inversions for stellar structure

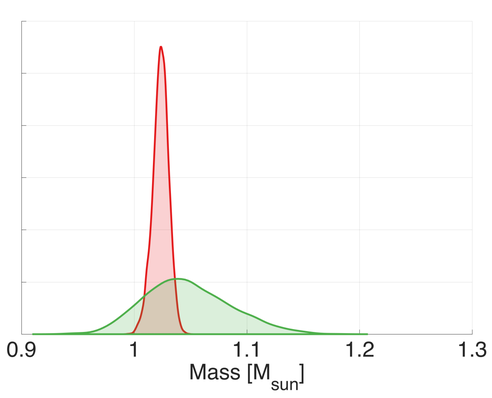
A first example: 16 Cyg A

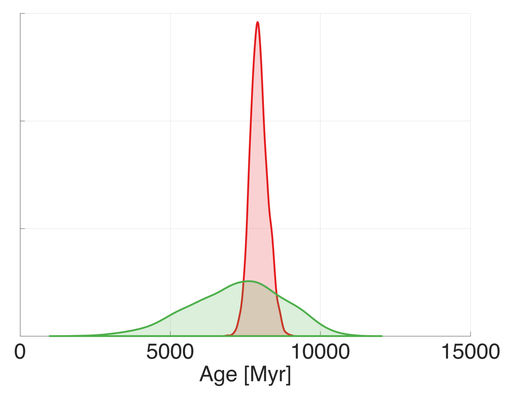
Posterior probability density of global stellar properties (R, M, Age) obtained considering the following observational constraints:

- L, T_{eff}, [Fe/H]
- L, T_{eff}, [Fe/H] + acoustic oscillation frequencies (Davies et al. 2015)

a factor 3-5 higher precision in R, M, Age



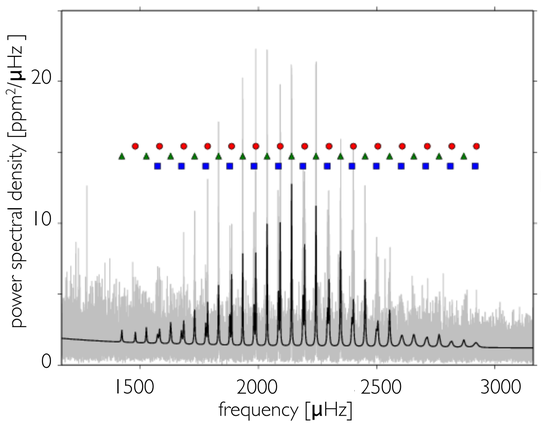




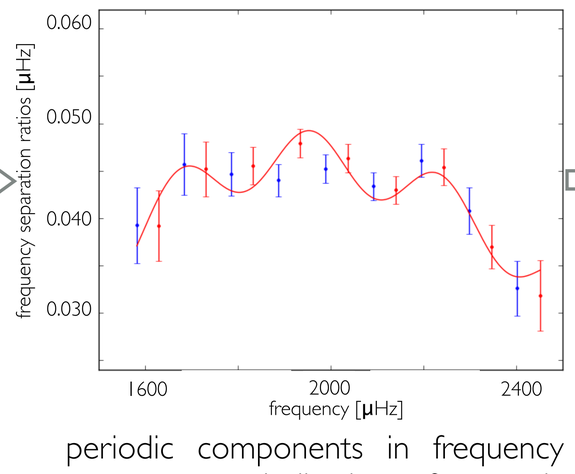
Acoustic glitches

Model independent characterisation of sharp-structure variations in stellar interiors (convective-envelope depths, signatures of helium ionisations), which can be used e.g. to set constraints on the efficiency of atomic diffusion, convective-envelope undershooting, and to infer the envelope He abundance.

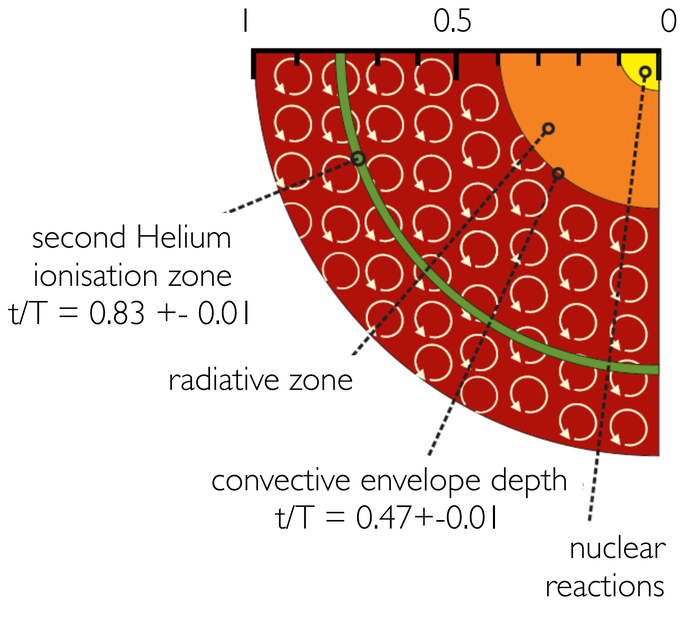
e.g. *Kepler* exoplanet host star Kepler-408



power spectral density of Kepler-408 (Davies et al. 2016)



periodic components in frequency patterns are indicative of acoustic glitches. The period of the component is proportional to the relative acoustic radius t/T of the glitch, where t is the sound travel time from the core to the glitch and T the stellar acoustic radius.



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