SpaceInn hare-and-hounds exercise

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December 5, 2014

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determining accurate stellar parameters through asteroseismology is fundamental for the PLATO 2.0 mission

- characterising exoplanets
- studying galactic populations and history
- understanding stellar evolution
According to Gough (1985) there are 3 ways of inverting helioseismic data:

- “repeated execution of the forward problem” (i.e. search in parameter space, or “forward modelling”)
- analytical methods (asymptotic methods, glitch fitting)
- formal inversion techniques

this also applies to asteroseismology. However:

- greater uncertainties on “classical parameters” (\(T_{\text{eff}}, [\text{Fe/H}], L, v \sin i\) …)
- fewer number of available frequencies
it becomes important to compare these methods
  - accuracy (precise results and realistic error bars)
  - computational cost
- hare-and-hounds exercises is a good way of carrying out such a comparison
First Spacelinn hare-and-hounds exercise

Motivations

- test how accurately fundamental stellar parameters can be retrieved from individual frequencies
- compare grid-based techniques to glitch-fitting methods for characterising the convection zone
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Group 1
- uses grid modelling to obtain best fitting models and associated parameters
  - global parameters: $M$, $R$, $\rho$, $\tau = \int_0^R \frac{dr}{c}$, age etc.
  - convection zone: $R_{CZ}$, $\tau_{CZ}$

Group 2
- applies glitch fitting strategy to find $R_{CZ}$, $\tau_{CZ}$
The hounds

**Group 1**
- W. Ball
- S. Basu
- I. Brandão
- J. Christensen-Dalsgaard
- S. Deheuvels
- S. Hekker
- Y. Lebreton
- A. Mazumdar et al.
- T. S. Metcalfe
- I. W. Roxburgh
- A. Serenelli
- V. Silva Aguirre
- D. Stello

**Group 2**
- H. M. Antia and K. Verma
- S. Basu
- H. R. Coelho
- G. Houdek
- A. Mazumdar et al.
- M. J. P. F. G. Monteiro
- I. W. Roxburgh
The hares

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The hares

Team work

- A. Miglio: produce models
- D. R. Reese: adjust models and calculate frequencies
- W. J. Chaplin & G. R. Davies: prepare “observed” data
The data

- various classic parameters ($T_{\text{eff}}$, $L$, [Fe/H])
  - we assume Gaia-quality parallax for the luminosity
- seismic indices: $\Delta \nu$, $\nu_{\text{max}}$ (these are purely indicative)
- individual frequencies
  - bypass mode parameter extraction and assume frequencies are unbiased
The hares

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Surface effects

- offset at high frequencies, caused by near-surface layers
- ways this can be implemented
  - truncate model
  - apply different boundary conditions
  - modify near-surface structure
  - use different atmosphere
  - apply non-adiabatic calculations
Surface effects

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Surface effects

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  - **Truncate model**
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Surface effects

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![Echelle Diagram](image-url)
Other factors

- the stellar mixture
  - possibilities: GN93, GS98, AGS05, AGSS09
- diffusion
  - is it present?
  - does it apply to all elements?
- overshoot
Other factors

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Preliminary results

![Graph showing the ratio of \( \rho / \rho_{\text{exact}} \) for different targets. The x-axis represents the target numbers in random order, and the y-axis shows the ratio values.

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Preliminary results

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Preliminary results

- The hounds
- The hares

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Preliminary results

![Graph showing normalized difference against target in random order.](image-url)
Preliminary results

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Preliminary results

\[ R/R_{\text{exact}} \]

Target (in random order)
Preliminary results

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Glitch fitting
Glitch fitting

\[ \delta \nu (\mu \text{Hz}) \]
\[ \nu (\mu \text{Hz}) \]
\[ l = 0 \]
\[ l = 1 \]
\[ l = 2 \]

\[ t_{0,\text{ind}} \]

Percentage of Realisations

Acoustic depth \( \tau \) (s)

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Glitch fitting

![Graph showing glitch fitting results](image)

\[ \frac{T_{cz}}{T_{cz}} (\text{exact}) \]

Target (in random order)
Glitch fitting

![Graph showing glitch fitting results](image-url)

- **Context**: The hounds
- **The hares**: Preliminary results
- **Next steps**: SpaceInn hare-and-hounds exercise

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Glitch fitting

![Graph showing normalised difference vs target in random order](image_url)
Next steps

- still waiting for final results before doing full processing
- carry out future rounds to test other quantities (He content, He ionisation etc.)