A new correction of stellar oscillations for near surface effects

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What are near-surface effects?

- little/no dependence on angular degree
- grows with frequency

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**v\_max**

**BiSON - Model S**
Why a problem?

large separation about 1 $\mu$Hz different
New parametrizations

\[ \delta \nu \propto \frac{\nu^3}{I} \]

Noted by several authors

- Gough (1990)
- Libbrecht & Woodard (1990)
- Goldreich et al. (1991)
Model S

Kjeldsen et al. (2008) correction

\[ \chi^2 \approx 5500 \]

\[ \chi^2 = 49,981 \]

BiSON - Model S

\[ \delta v = a v^b \] (Kjeldsen et al. 2008)
Model S

New correction

\[ \chi^2 \approx 5500 \]

\[ \chi^2 = 16150 \]
Sun-as-a-star

New correction

![Graph showing the difference between observed and corrected frequencies (v_{obs} - v_{mod}) in units of microhertz (μHz) against observed frequencies (v_{obs}) in microhertz (μHz). The graph compares uncorrected (filled circles) and corrected (open circles) data.]
HD 52265

New correction

![Graph showing the comparison between uncorrected and corrected data.](image-url)
HD 52265
Kjeldsen et al. (2008) correction

![Graph showing the comparison between uncropped and corrected data for HD 52265. The graph plots $(V_{\text{obs}} - V_{\text{mod}})$ in μHz against $V_{\text{obs}}$ in μHz. The data points are represented with black circles for the uncropped case and white circles for the corrected case. The graph includes error bars for each data point.](image)
### HD 52265

Parameter comparison

<table>
<thead>
<tr>
<th>Surface term</th>
<th>$M/M_\odot$</th>
<th>$t$/Gyr</th>
<th>best-fit $\chi^2_{\text{seismo}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cubic Kjeldsen et al. (2008)</td>
<td>$1.215^{+0.030}_{-0.008}$</td>
<td>$2.44^{+0.16}_{-0.15}$</td>
<td>33.0</td>
</tr>
<tr>
<td></td>
<td>$1.222^{+0.020}_{-0.005}$</td>
<td>$2.26^{+0.18}_{-0.11}$</td>
<td>123.2</td>
</tr>
</tbody>
</table>
Kepler targets
Kepler targets
Conclusions and prospects

- New function fits better than a power law, though model parameters consistent
- Needs testing against less Sun-like solar-like oscillators
- Forward modelling needed to calibrate effect in other stars

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surface_correction_scheme = 'cubic' in MESA r7184+
What causes near-surface effects?

Simulation from Beeck et al. (2013)

stellar model + 3D HD simulation: effect reduced to \( \sim 1 \mu\text{Hz} \)