Development of stellar modelling techniques

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Overview

- Goal I: provide basic stellar parameters to the Kepler project
- Goal II: understand stellar structure and evolution

Tasks

- Verify codes to calculate stellar evolution
- Verify codes to calculate stellar oscillation frequencies
- Develop techniques for pipeline analysis of observed frequencies
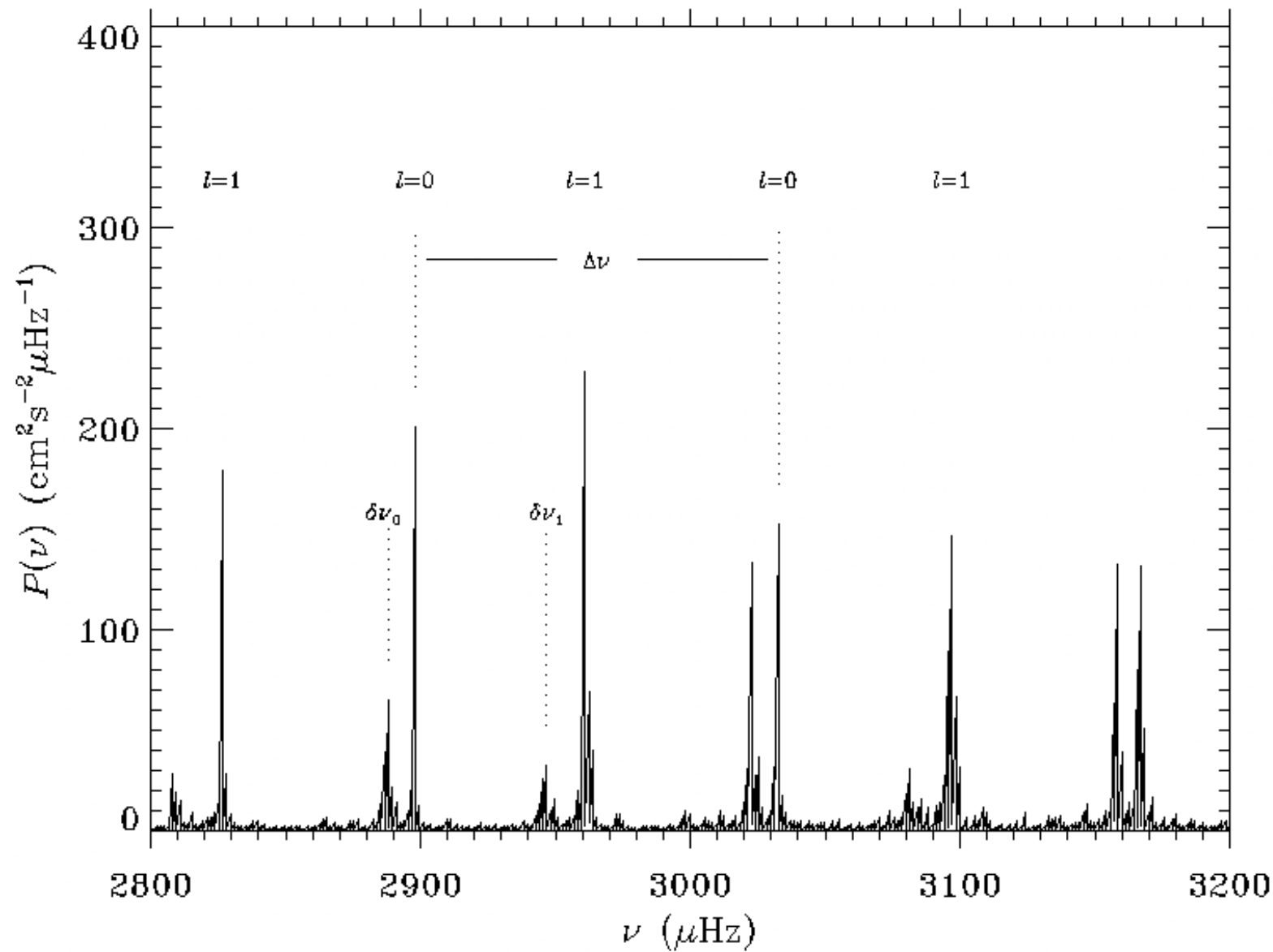- Improve understanding and treatment of stellar interior physics
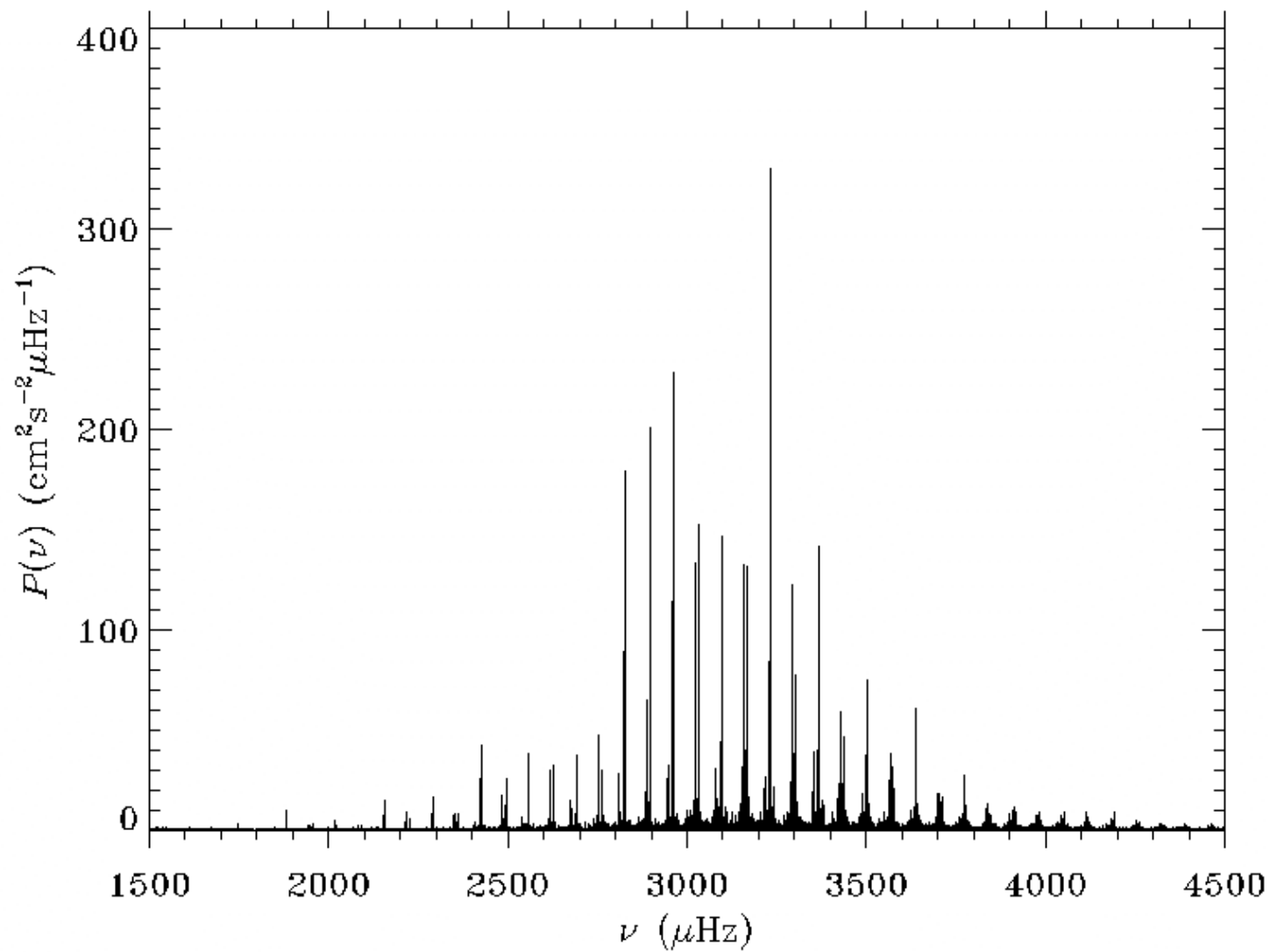
Large frequency separation:

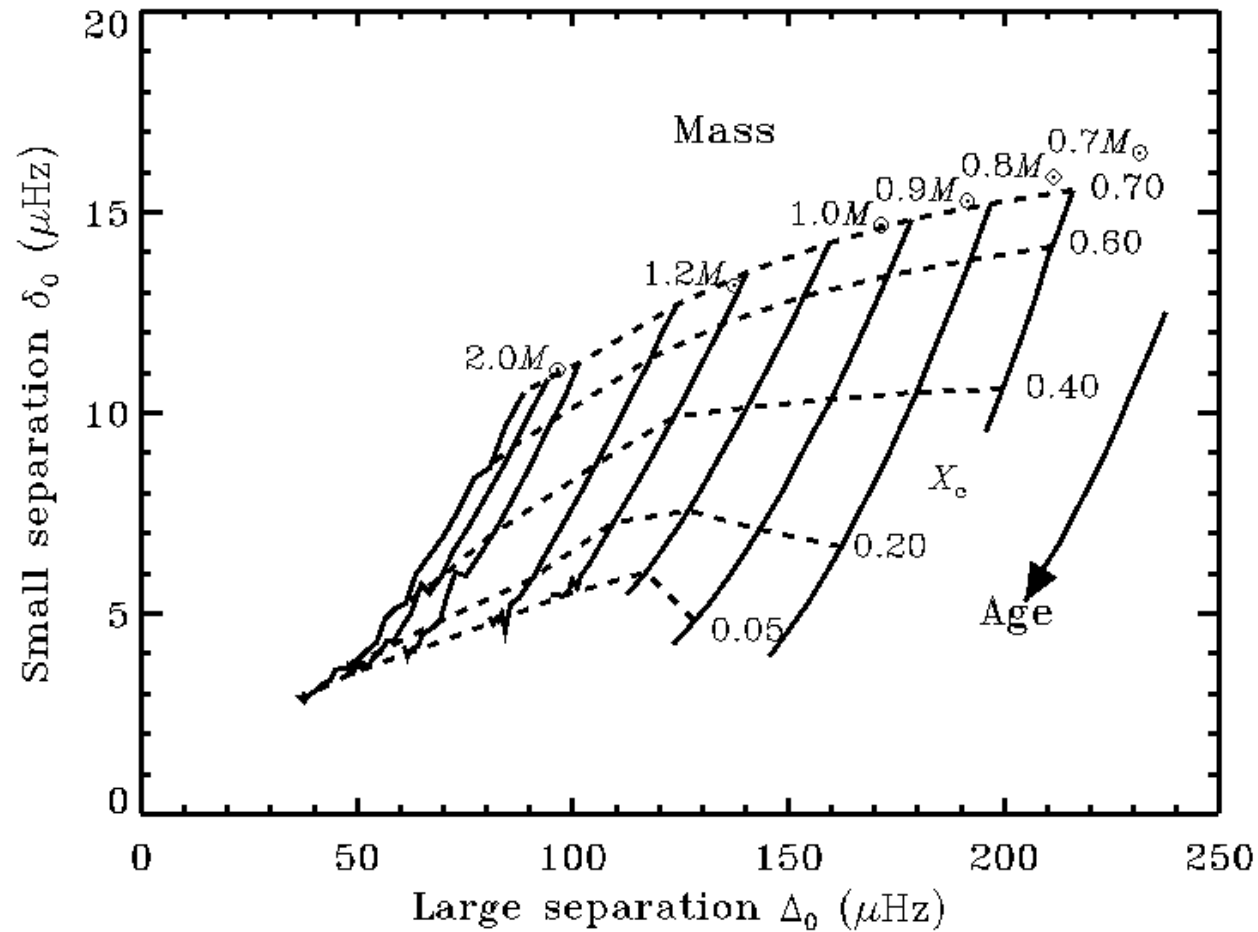$$\Delta\nu_{nl} = \nu_{nl} - \nu_{n-1\,l} \simeq \Delta\nu$$

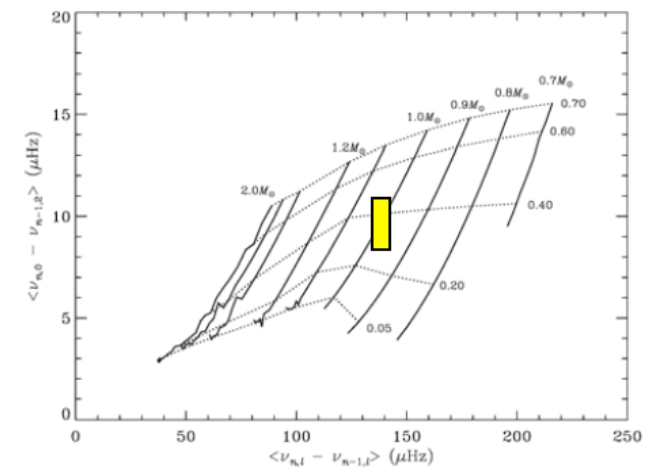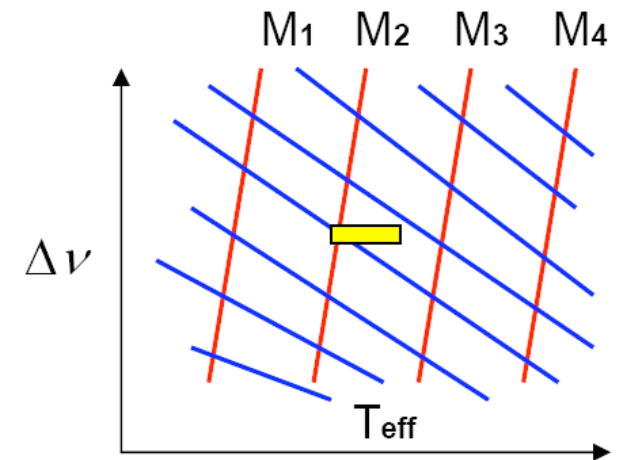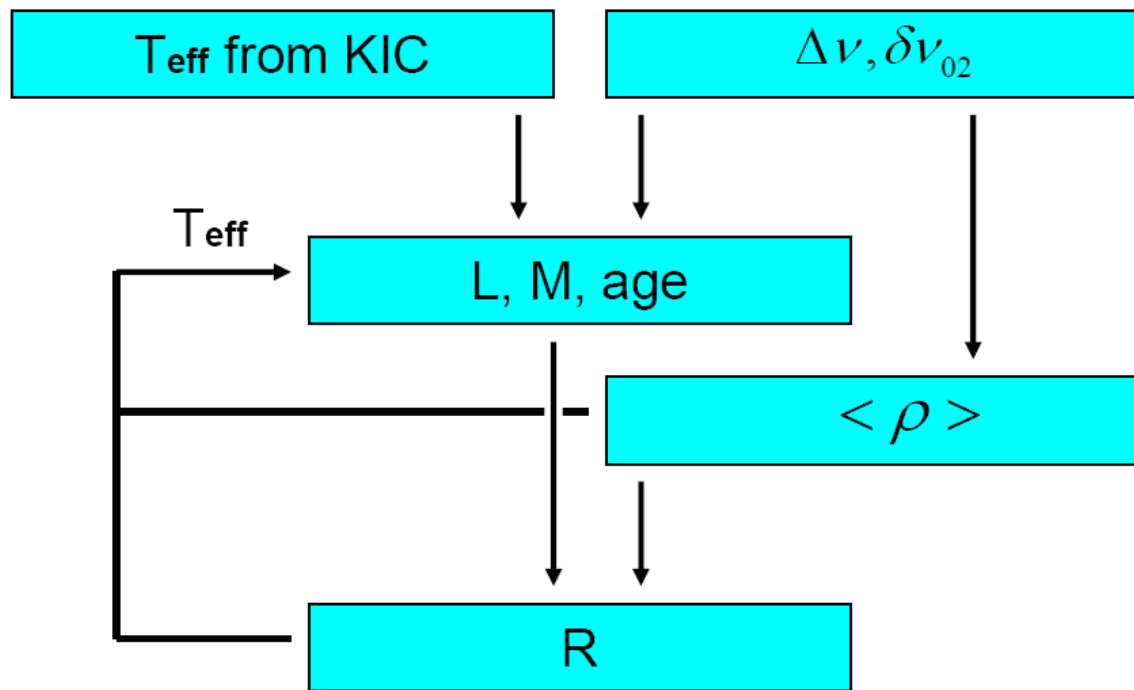Frequency separations:

$$\delta\nu_{nl} = \nu_{nl} - \nu_{n-1\,l+2} \simeq -(4l+6)\frac{\Delta\nu}{4\pi^2\nu_{nl}}\int_0^R \frac{\mathrm{d}c}{\mathrm{d}r}\frac{\mathrm{d}r}{r}$$

Asteroseismic HR diagram

Analysis pipeline

Near-surface frequency effects

Stellar structure and oscillation modelling deal inadequately with

• Treatment of convection in modelling (thermal structure, turbulent pressure)

• Mode damping excitation

• Dynamical effects of convection on oscillations

• Atmospheric structure

• …………………..

These effects are concentrated very near the surface

Solar frequency differences
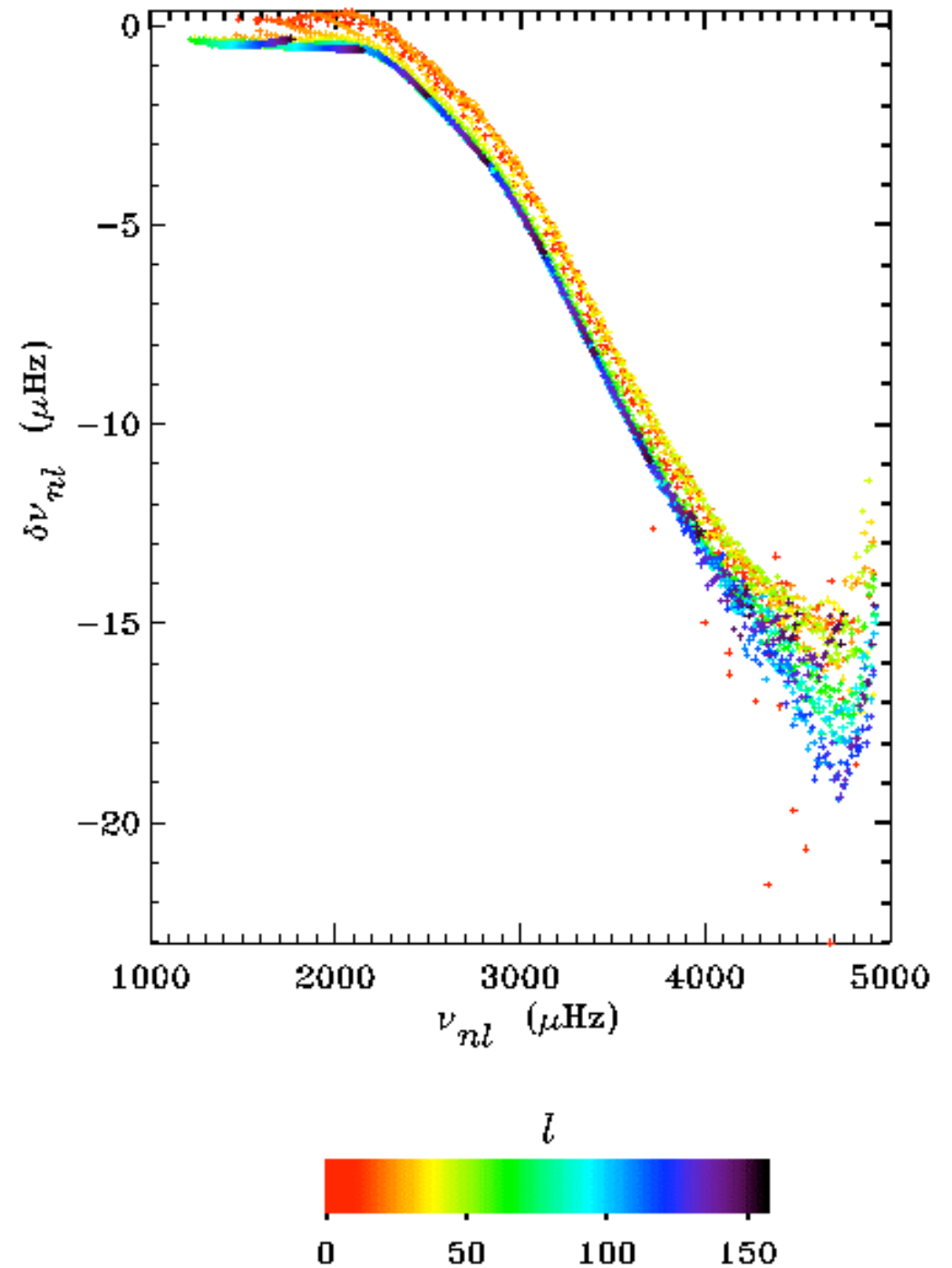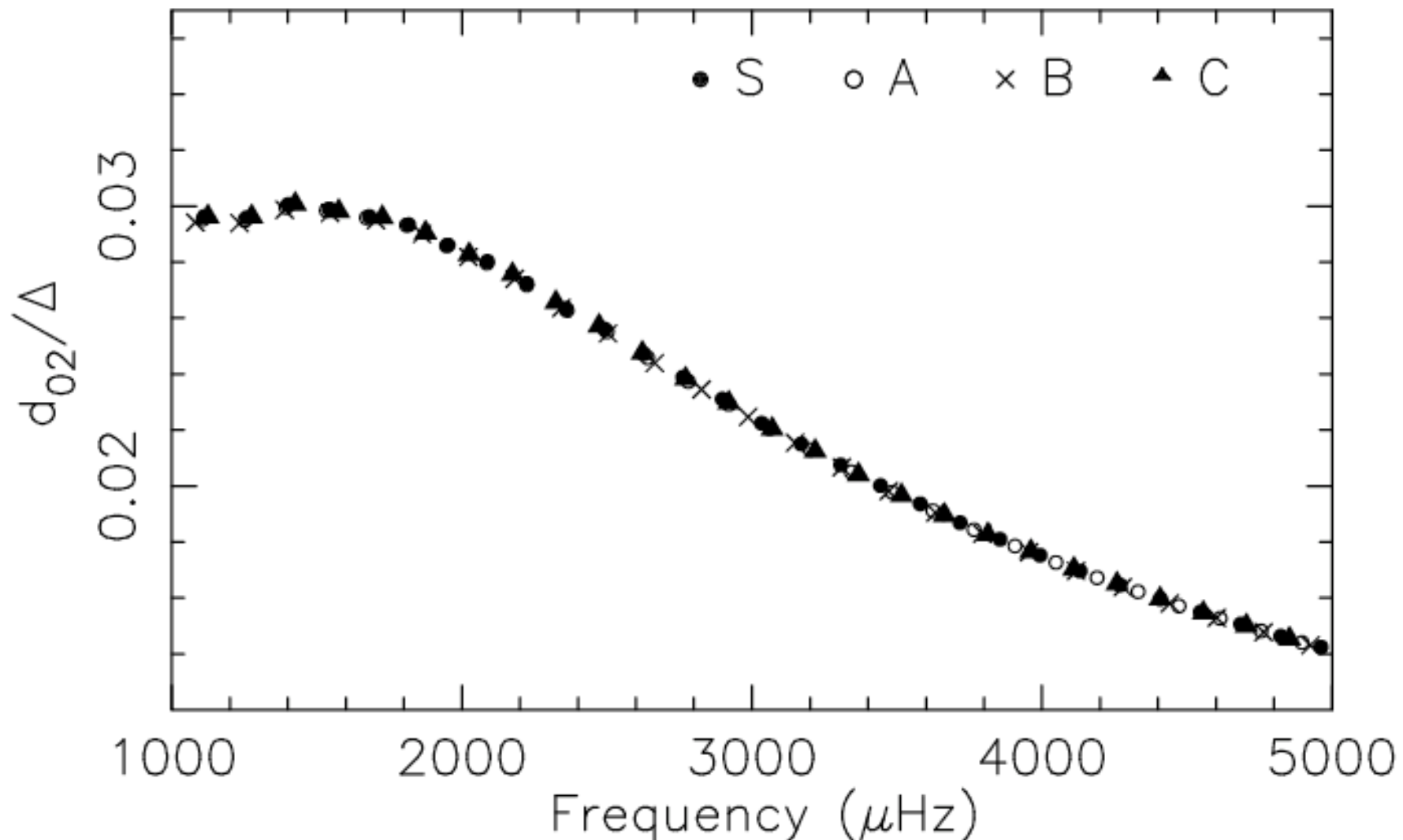
Parametrized fit (with a solar bias)
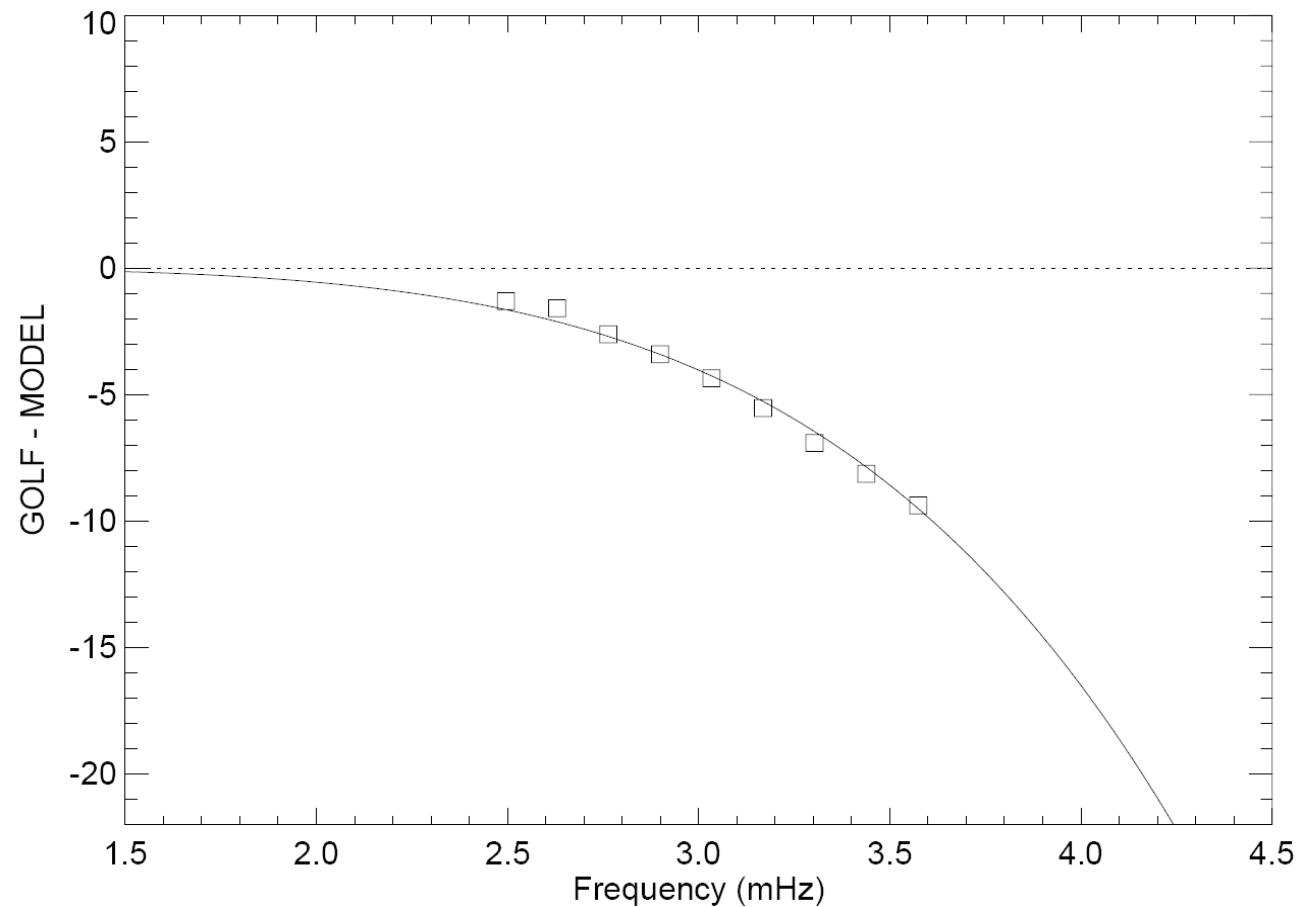
Need better theoretical understanding of the surface effects
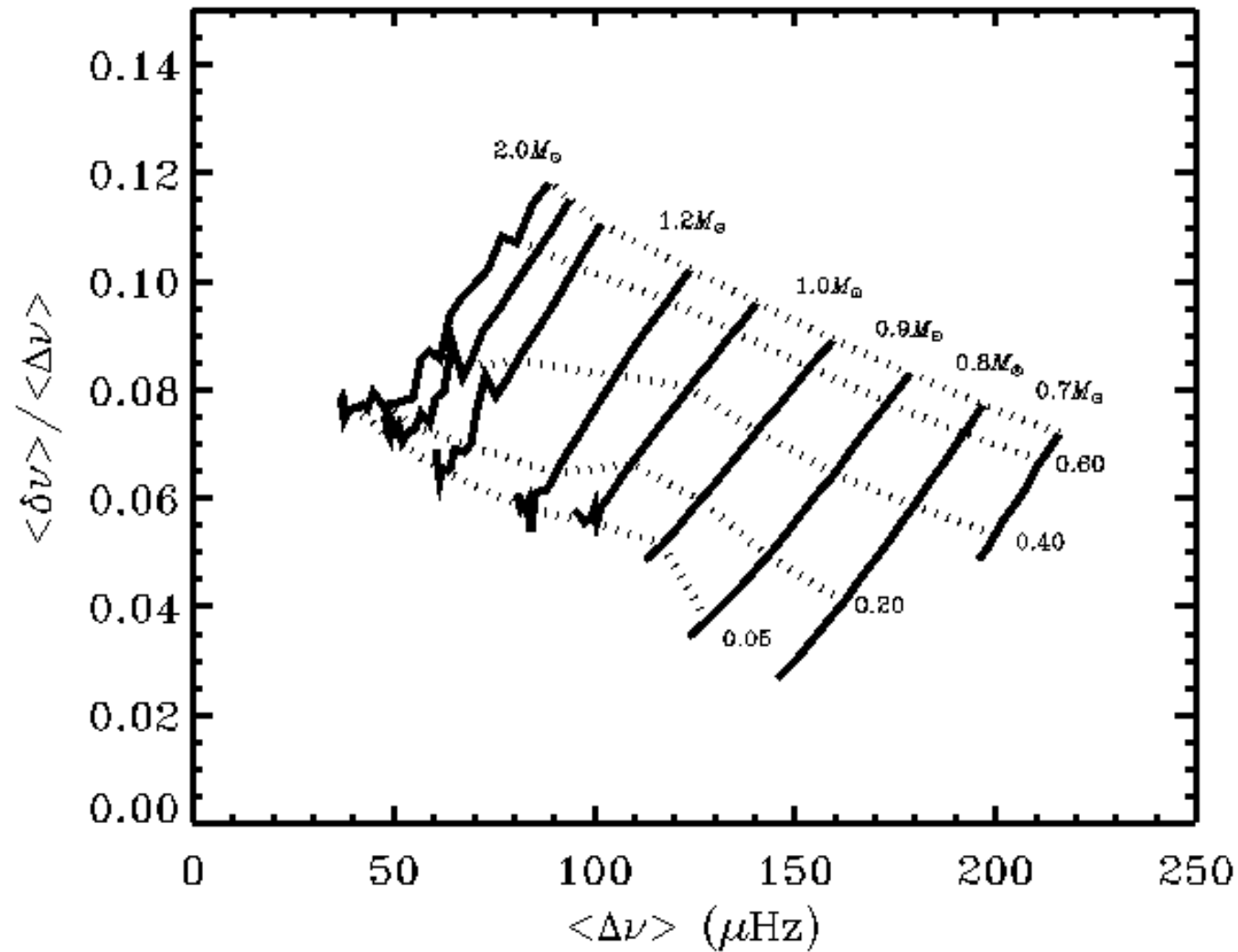
Kepler will help
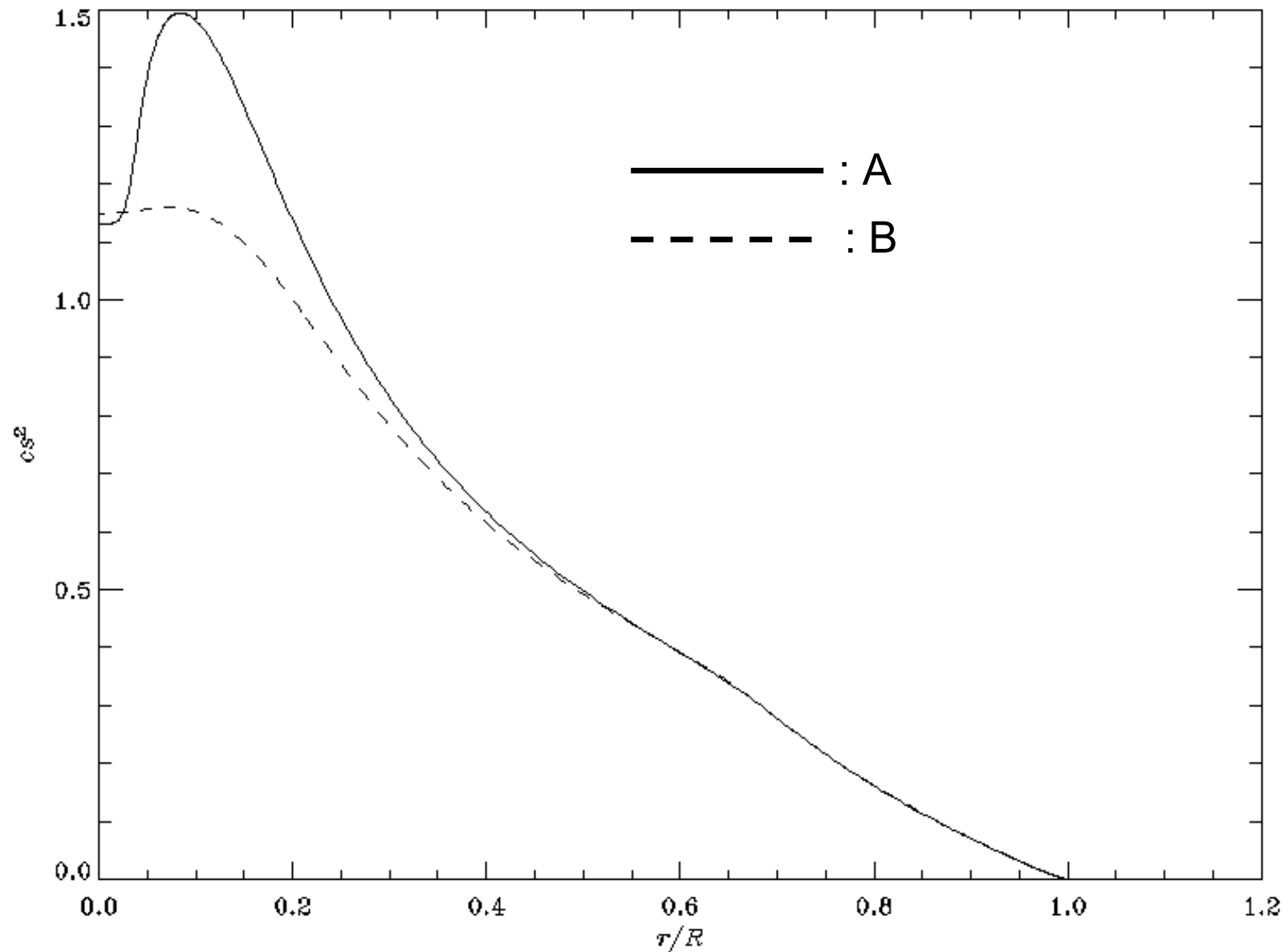
Scaling of small separation

Note that $\Delta \nu_{nl}$ and $\delta \nu_{nl}$ share the frequency scaling:
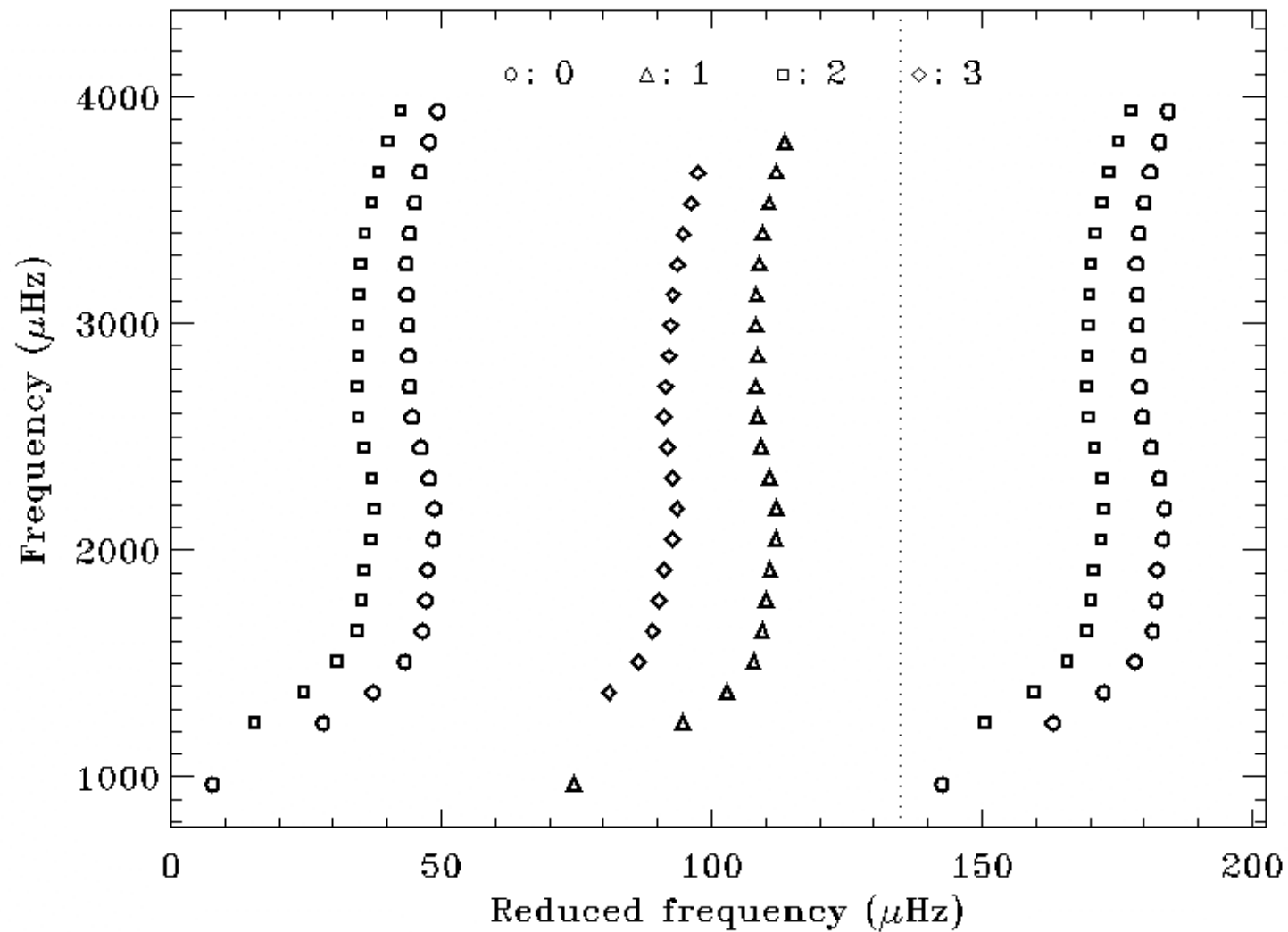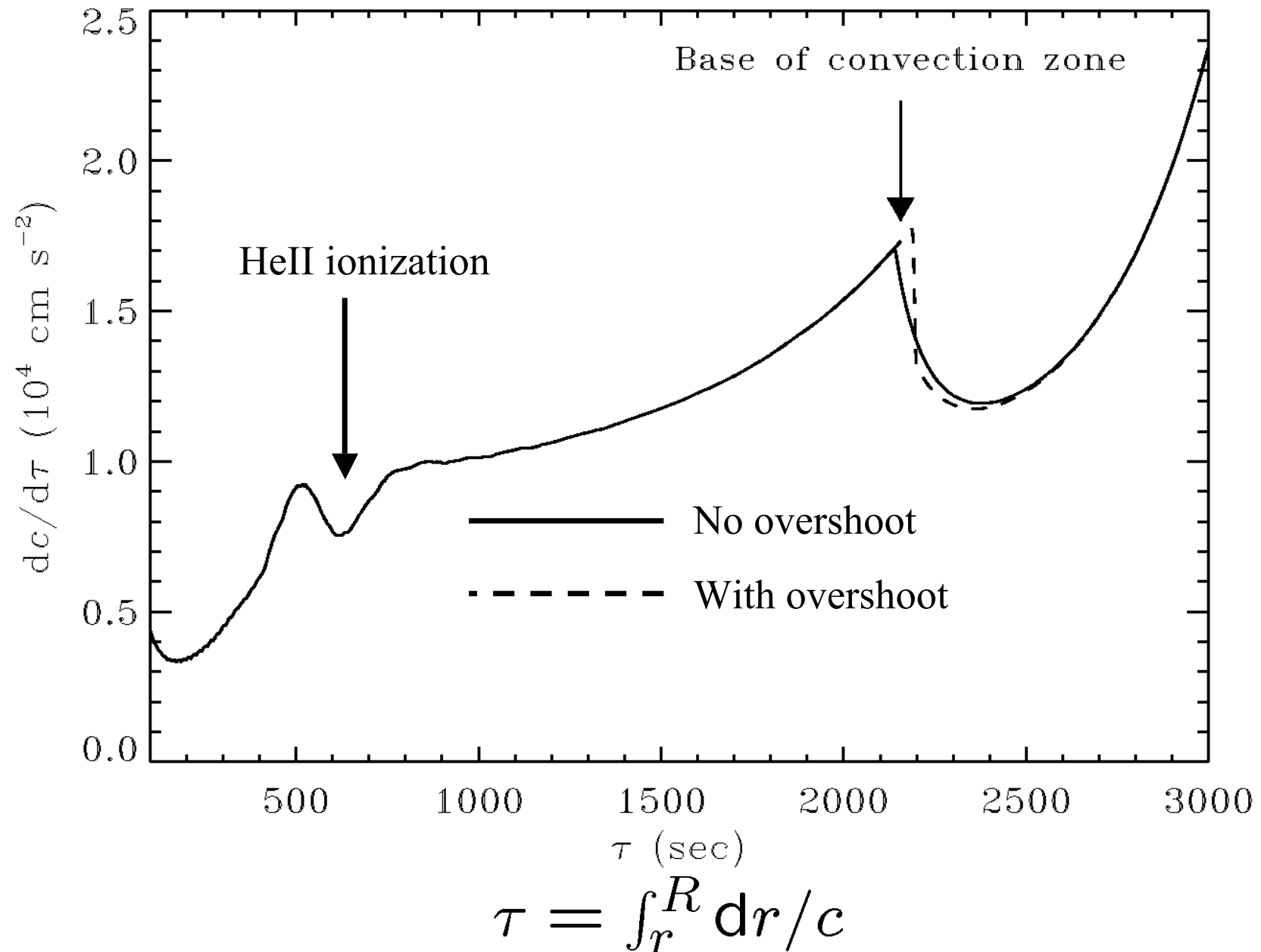
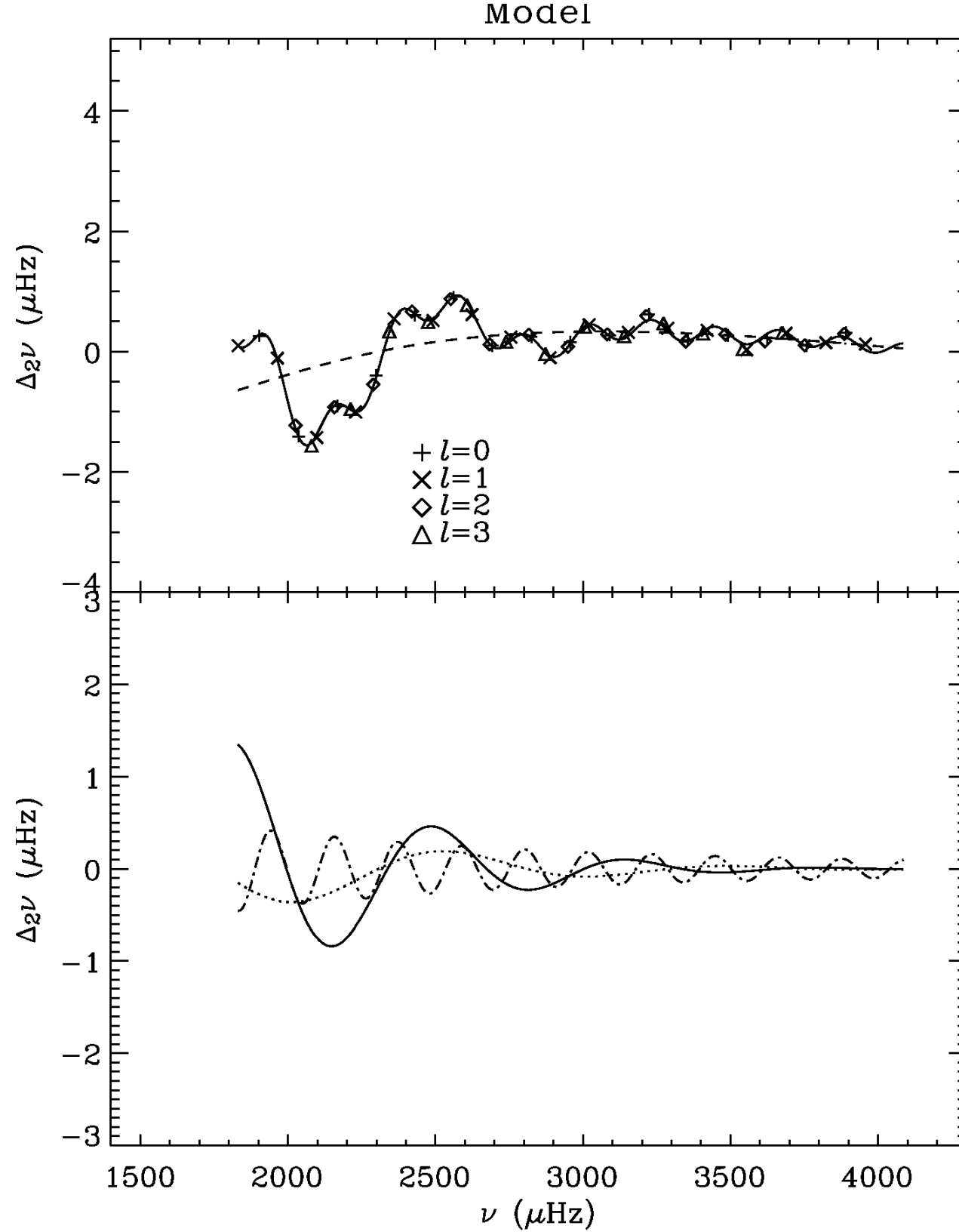# Scaled asteroseismic HR diagram

Small frequency separations

Echelle diagram

Sharp features in stellar models

$$\tau = \int_r^R \mathrm{d}r/c$$

Oscillatory signals, original model

Houdek & Gough (2007; MNRAS 375, 861)

Required development

- Mode physics (damping and excitation)
- Near-surface effects
- Effects of rotation on frequencies
- Effects of rotation on stellar structure
  - Transport processes
  - Dynamical effects