The HELAS Workpackage

Asteroseismology

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COROT-HELAS Workshop, Porto, 22.11.2006
What is the Workpackage Asteroseismology?

Outline: A collection of tools for the analysis of photometric and spectroscopic data of pulsating stars packed into a userfriendly interface (objective of NA5, head: Conny Aerts)

Focus on: Frequency analysis & Mode identification (according to input from COROT community at CW9)

Target stars: all Main Sequence pulsators from Gamma Dor to Beta Cep stars
What is the Workpackage Asteroseismology?

Figure by J. Christensen-Dalsgaard
What is the Workpackage
Asteroseismology?

Outline: A collection of tools for the analysis of photometric and spectroscopic data of pulsating stars packed into a userfriendly interface.

Focus on: Frequency analysis & Mode identification

Target stars: All Main Sequence pulsators from Gamma Dor to Beta Cep stars

Objective: Spread knowledge and tools to the whole asteroseismic community

Planned first release: End, 2007

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**Concept of the WPA (1)**

**Spectroscopy:**
- Analyze sets of time-resolved high-resolution spectroscopy
- Prepare data for analysis (select lines, statistics)
- Compute moments & equivalent width variations
- Fourier analysis (DFT) & least-squares fitting of moments and pixels across profile
- Mode identification methods: moment method (Briquet & Aerts 2003), Fourier parameter fit method (Zima 2006) and direct line profile fitting
  - $l, m$, intrinsic amplitude, inclination
- MIMs supported by genetic optimization (parallelization possible on multi-processor computers)
Concept of the WPA (3)

Photometry:

- analyze light curves from different photometric passbands & systems
- Fourier analysis (FFT) and least-squares fitting (similar to Period04)
- import amplitude and phase values
- mode identification with the method of amplitude ratios and phase differences between different filters

require non-adiabatic photometric observables
Photometric Mode Identification

OBSERVATIONS (from calibrations)
- Teff, log g,
- Metallicity,
- Luminosity

SEISMIC STELLAR MODELS
- Teff, log g, Mass, log L, Radius,
- age, (X,Z), overshooting, convection

Frequency
- select all models in error box
- select mode with closest frequency

Excited pulsation modes:
- Frequency (l, m)
- (f_T, ψ_T), (f_g, ψ_g)

COMPUTE PHOTOMETRIC LIGHTVARIATIONS

\[ \Delta m(\lambda) = 2.5 \log \frac{e a N_l^m P^l_m(\cos i) b_{l,m}}{|(2 + \ell')(1 - \ell')(2 + \ell)(1 - \ell) + (\alpha_r + \beta_r) f_T e^{i\psi_T} + (\alpha_g + \beta_g) f_g e^{i\psi_g}|} \]

OBSERVED
- Amplitude ratio
- Phase difference

COMPARISON
- degree l

THEORETICAL
- Amplitude ratio
- Phase difference

Static atmosphere models
Definition of the non-adiabatic observables

\[ \frac{\delta T_{\text{eff}}}{T_{\text{eff}}} = f_T e^{i\psi_T} \frac{\xi_r}{R} \]

\[ \frac{\delta g}{g} = f_g e^{i\psi_g} \frac{\xi_r}{R} \]

\( f \) describes the relation between the radial displacement and temperature/log \( g \) variations.

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Photometric Mode Identification

OBSERVATIONS (from calibrations)
- Teff, log g, Metallicity, Luminosity
- Frequency

SEISMIC STELLAR MODELS
- Teff, log g, Mass, log L, Radius, age, (X,Z), overshooting, convection
- excited pulsation modes:
  - Frequency
    - (l, m)
    - \( f_T, \psi_T \), \( f_g, \psi_g \)

COMPUTE PHOTOMETRIC LIGHTVARIATIONS
\[
\Delta m(\lambda) = 2.5 \log a N_T^{m l} \lambda^{m l} (\cos \theta) b_{l, m} \left( 2 + \ell' \right) (1 - \ell') + (\alpha_T + \beta_T) f_T e^{i\psi_T} + (\alpha_g + \beta_g) f_g e^{i\psi_g} \]

OBSERVED
- Amplitude ratio
- Phase difference

COMPARISON
- degree l

THEORETICAL
- Amplitude ratio
- Phase difference

OBSERVED Amplitude ratio
- Phase difference

Static atmosphere models

1
0.0
1
1
1
1
1
0.5
0.5
0.5
0.5
0.5
0.5
0.5
What we already have ...

- SPB and Beta Cep stars: grid of stellar models & non-adiabatic observables computed with CLES & MAD (Dupret 2003)
- \( (f_T, \psi_T), (f_g, \psi_g) \)
- calculation of amplitude ratios and phase diff. by using static Kurucz atmospheres
What we require ...

- Gamma Dor, Delta Sct & massive pulsators on MS
- Models from different research teams would be benefit
- Precomputed grid of $f_T$ & $\psi_T$ (if available $f_g$ & $\psi_g$):
  - only Main Sequence models
  - abundances X, Y, Z: new solar values (?)
  - Overshooting: different values!
  - Convection, mixing length: different values

- Summer 2007
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