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EXPLORATION OF PARAMETER SPACE FOR MODELING COROT AND KEPLER TARGETS WITH CESAM CODE

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Abstract. In order to extract the basic stellar parameters we use the asteroseismic inversion method where the observed oscillation frequencies are used to estimate the stellar parameters. The inversion is a process where the best estimated parameters for a given star correspond to the input parameters for the model that shows frequencies most similar to the observed ones. We have computed a wide grid of stellar models and their associated oscillation frequencies and we have designed a tool to evaluate the value of χ^2 on that grid for different possible sets of observational data. Stellar models have been calculated with the CESAM stellar evolution code for values of mass in the range $0.8 - 4.0$ solar masses, initial metalicity Z in mass fraction in the range $0.006 - 0.04$ and initial helium abundance in the range $0.26 - 0.28$, and we considered different values or options for the input physics of the models (microscopic diffusion, mixing - length parameter of convection, overshooting). The oscillation frequencies have been computed with the LNAWENR non-adiabatic code for modes of degree $l = 0, 1, 2, 3$.

1. STELLAR MODELS CALCULATION INPUT PHYSICS

Stellar models have been calculated with the CESAM (Morel and Lebreton, 2008) evolution code. This code have been validated and thoroughly compared during the ESTA stellar model comparison activity (Lebreton et al., 2008a). We adopted the ESTA input physics described in Lebreton et al., (2008b)

- Opacity tables: OPAL96 tables (Iglesias and Rogers, 1996)
- Equation of state: OPAL 01 tables (Rogers and Nyfonov, 2002)
- Nuclear reaction rates: NACRE rartes (Angulo et al., 1999)
- MLT theory of convection (Bohm-Vitense 1958; Henyey et al. 1965)
- Convective core overshooting: temperature gradient equal to adiabatic gradient in the overshooting region (Zahn 1991)
- Microscopic diffusion (Burgers 1969, Thoul et al. 1994)
- Atmosphere: Eddington grey law

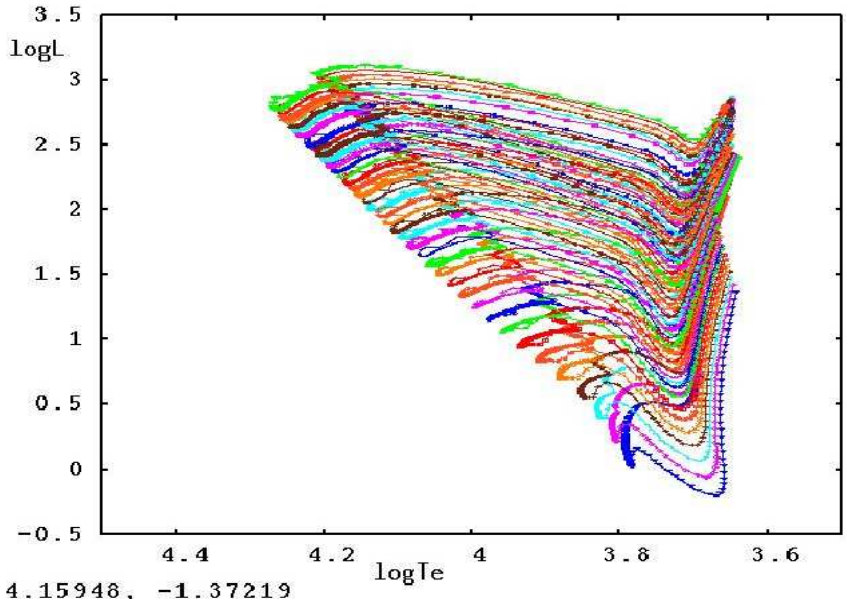

Figure 1: Subsample of evolutionary tracks with stellar masses between $0.8M_\odot$ and $4.0M_\odot$ initial metallicity $Z = 0.02$.

2. GRID SPECIFICATIONS INPUT PARAMETERS

- Mass $M/M_\odot = [0.8, 4.0]$ by steps of $0.05M_\odot$
- Initial metallicity $Z = [0.006, 0.04]$ by steps of 0.01
- Initial helium content $Y = 0.26, 0.27, 0.28$
- Mixing length parameter: $\alpha_{MLT} = l_{MLT}/H_P = 1.65, 1.80$
- Core overshooting parameter: $\alpha_{OV} = l_{OV}/H_P = 0.0, 0.1, 0.2$

3. OSCILLATIONS CALCULATION

We calculated the oscillation frequencies of p and g modes of degree $l = 0, 1, 2$ and 3 of a large number of models along the evolutionary tracks using LNAWENR/ROMOSC linear, non-radial, non-adiabatic oscillation code (Montalban et al. 2008; Suran 2008).

4. ILLUSTRATION CALIBRATION OF THE G9.5 GIANT ϵ OPH

OBSERVATIONAL CONSTRAINTS: frequencies and global stellar parameters from Kallinger et al. (2008).

As usual, we quantify the difference between observed and calculated spectrum by the following χ^2 definition:

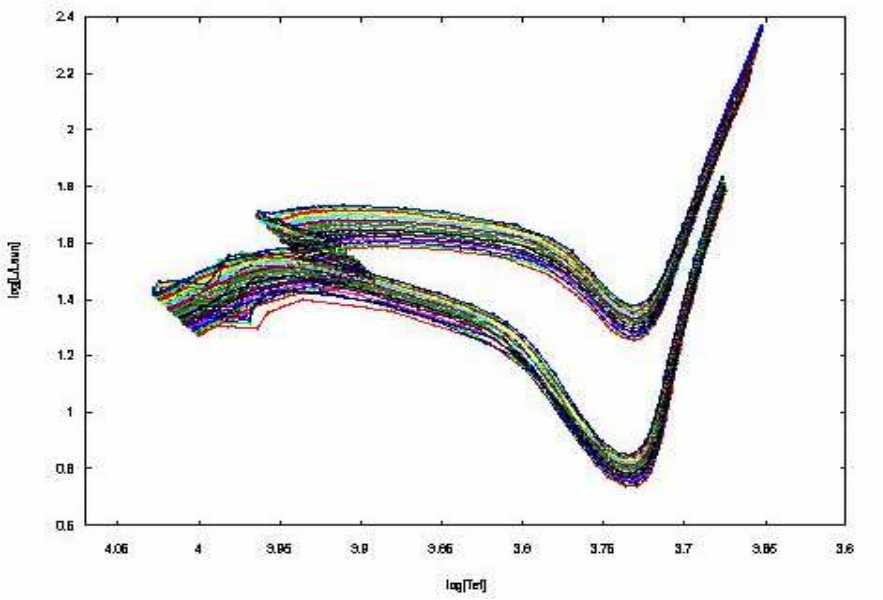

Figure 2: The grid of stellar models used to constraint basic stellar parameters of the G9.5 star ϵOph.

$$\chi^2 = \frac{1}{N}\sum_{i=1}^{N}\frac{(\nu_i^{obs} - \nu_i^{calc})^2}{\sigma_i^2}$$

where ν_i^{obs} is the observed frequency for the ith mode, ν_i^{calc} is the corresponding model frequency for the ith mode, σ_i^2 is the observational uncertainty for the ith mode and N is the total number of matched modes.

For each model on the grid the χ^2 value is calculated. We considered here masses in the range $1.93M_\odot$ and $2.10M_\odot$ with step $0.01M_\odot$, initial metallicity $Z = 0.01$. In our analysis we only considered radial modes and strongly trapped unstable (STU) non-radial modes (Dziembowski et al. 2001) with mode degree l up to 3. The fundamental stellar parameters of the best fitting model for ϵOph are: $M = 2.03M_\odot$, $T_{\rm eff} = 4892$K, $L = 59.13L_\odot$, $R = 10.76R_\odot$ and $age = 0.73Gyr$. These values are very similar to those obtained by Kallinger et al. (2008).

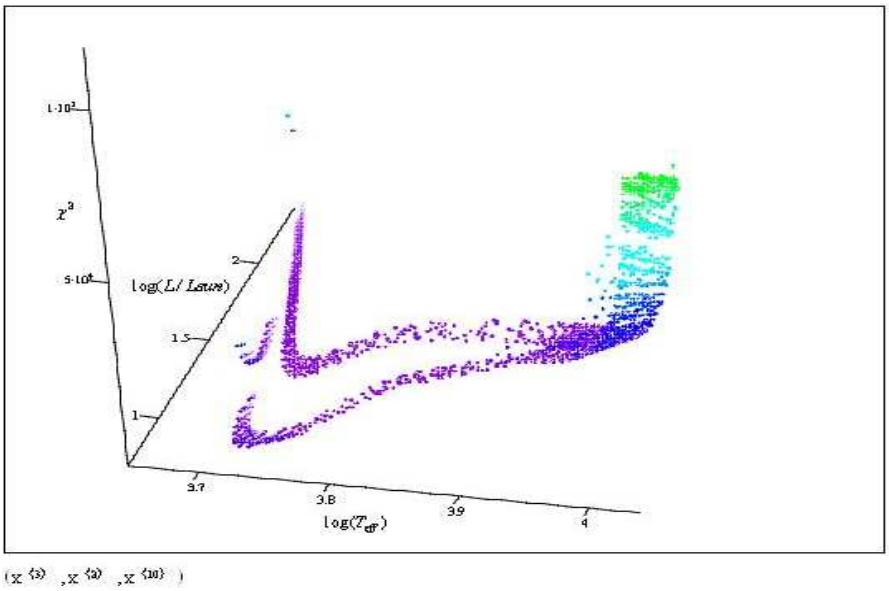

Figure 3: The values of χ^2 on the whole grid of stellar models.

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