Theoretical γ-Dor instability domains and the quest for recurrent period spacings

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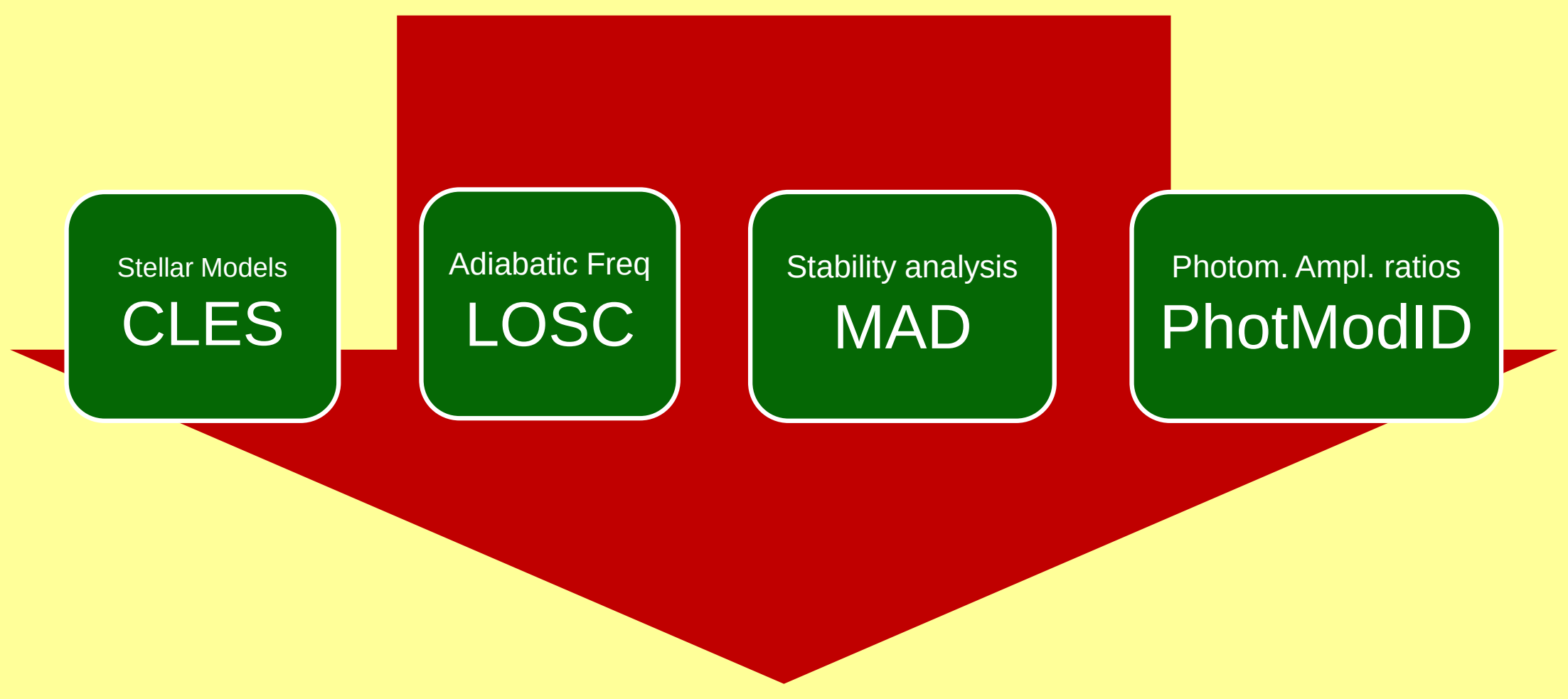
Theoretical Instability domains of γ Dor stars: the Liège Grid of γ Dor models

The depth and thickness of the convective envelope plays a major role in the driving of gravity modes in γ Dor stars (Guzik et al. 2000, Dupret et al. 2005). However, convection in stellar modelling is described in a parametric way (mixing length theory, MLT) and the depth of the convective envelope depends on the choice of the parameter α_{MLT}. Moreover, the characteristics of stellar convective envelope depend on the physics adopted in stellar modelling, for instance: opacity tables (OP, OPAL), stellar chemical mixture (GN93, AGS05), transport processes such as overshooting, macroscopic and turbulent diffusion...

We present instability strips computed using the Time-dependent Convection treatment of Grigahcène et al. (2005) for several grids of main-sequence models computed with CLES (Scuflaire et al. 2008 Ap&SS).



grid of models + oscillation frequencies + stability analysis + photom. amplitude ratios & phases

Grid of models:

Z=0.01, 0.02 α_{MLT}=1.4, 1.7, 2.0
M=1.2-2.2 M_{sun}, step 0.1 M_{sun}
Overshooting: 0, 0.2 Hp
Opacity tables: OPAL96 , OP07
Metal mixture: GN93, AGS05
X=0.70, 0.73

Examples:

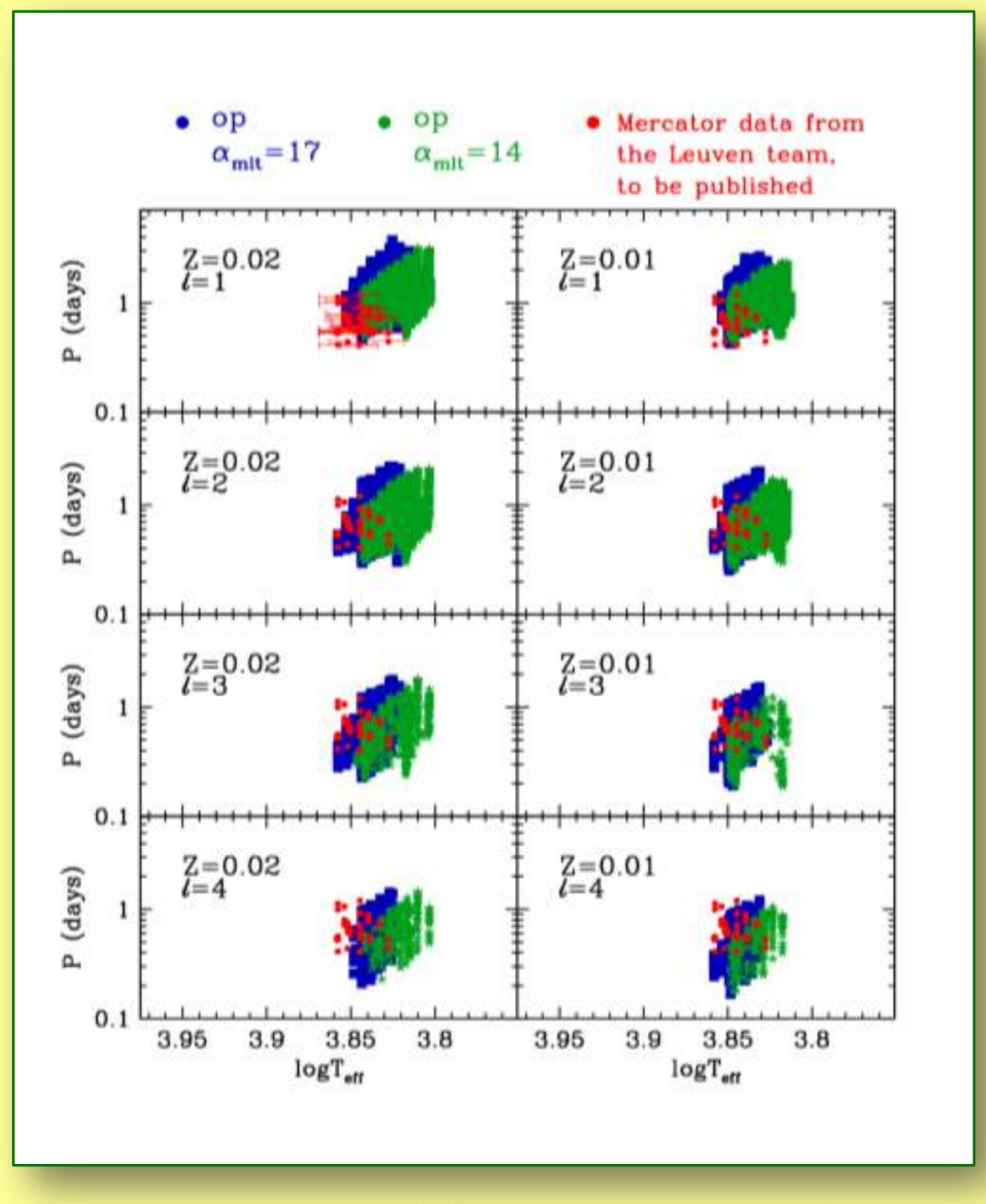


Fig. 1: γ Dor Instabiliy domains in a logT$_{eff}$-Period diagram obtained with models of different metallicity (Z=0.01 and Z=0.02) and mixing-lenght parameter: α_{MLT}=1.4 (green points) and 1.7 (blue points). Red points represent observational data from Cuypers et al 2009 A&A, submitted

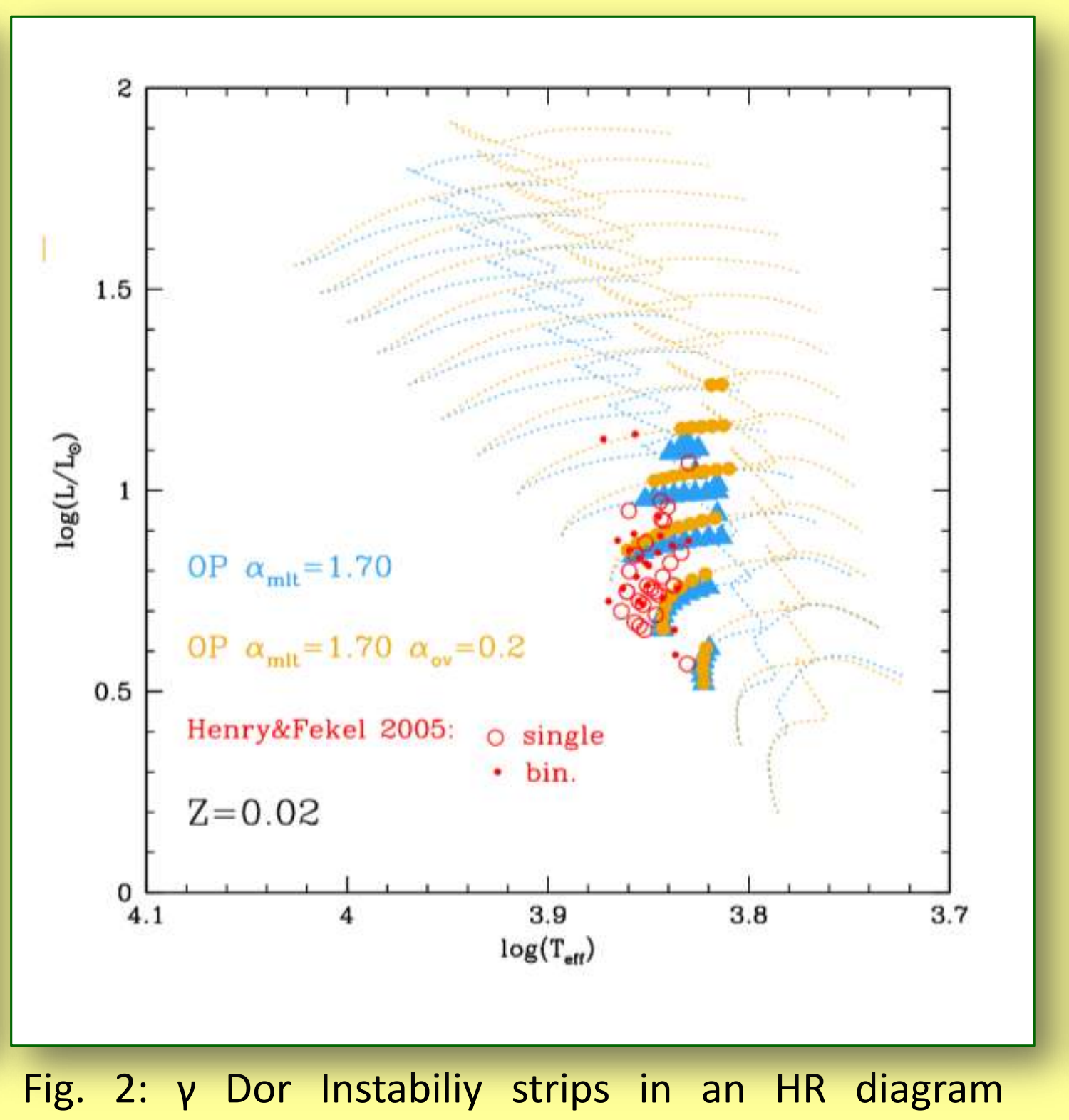


Fig. 2: γ Dor Instabiliy strips in an HR diagram obtained with Z=0.02 models computed without (cyan points) and with overshooting (α_{OV}=0.2 Hp, orange points). Red points represent known γ Dor pulsators (from Henry&Fekel 2005)

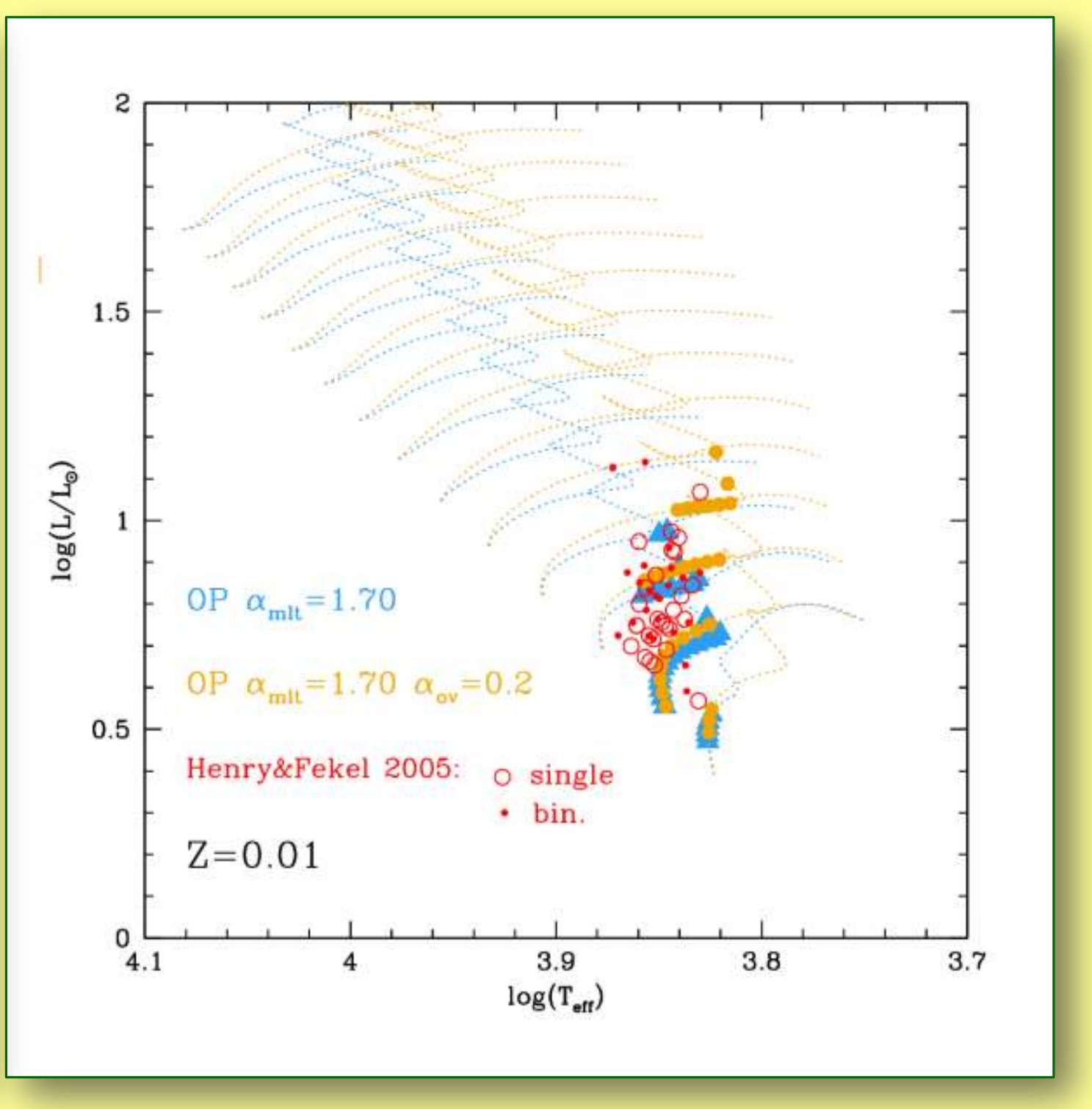


Fig. 3: γ Dor Instabiliy strips in an HR diagram obtained with Z=0.01 models computed without (cyan points) and with overshooting (α_{OV}=0.2 Hp, orange points).

The results of our computations are available within the γ Dor thematic team to allow a first comparison with CoRoT observations.
The detection of numerous candidate Dor pulsators in the exofield (see poster by Mathias et al.) promises to significantly increase the number of class members. This will allow a reliable definition of the instability domains if coupled with photometric/spectroscopic determinations of T$_{eff}$&logg.

Searching for recurrent period spacings: numerical simulations and first results on CoRoT targets

The sound detection of a recurrent period spacing would allow detailed inferences on the properties of the near-core region of intermediate-mass stars. Whereas the average period spacing (see Fig. 4) is related to the integral of the buoyancy frequency in the central region of main-sequence stars (Tassoul 1980 ApJS 43), deviations from a uniform ΔP contain detailed information on μ–gradients near the core (Miglio et al. 2008 MNRAS 386).

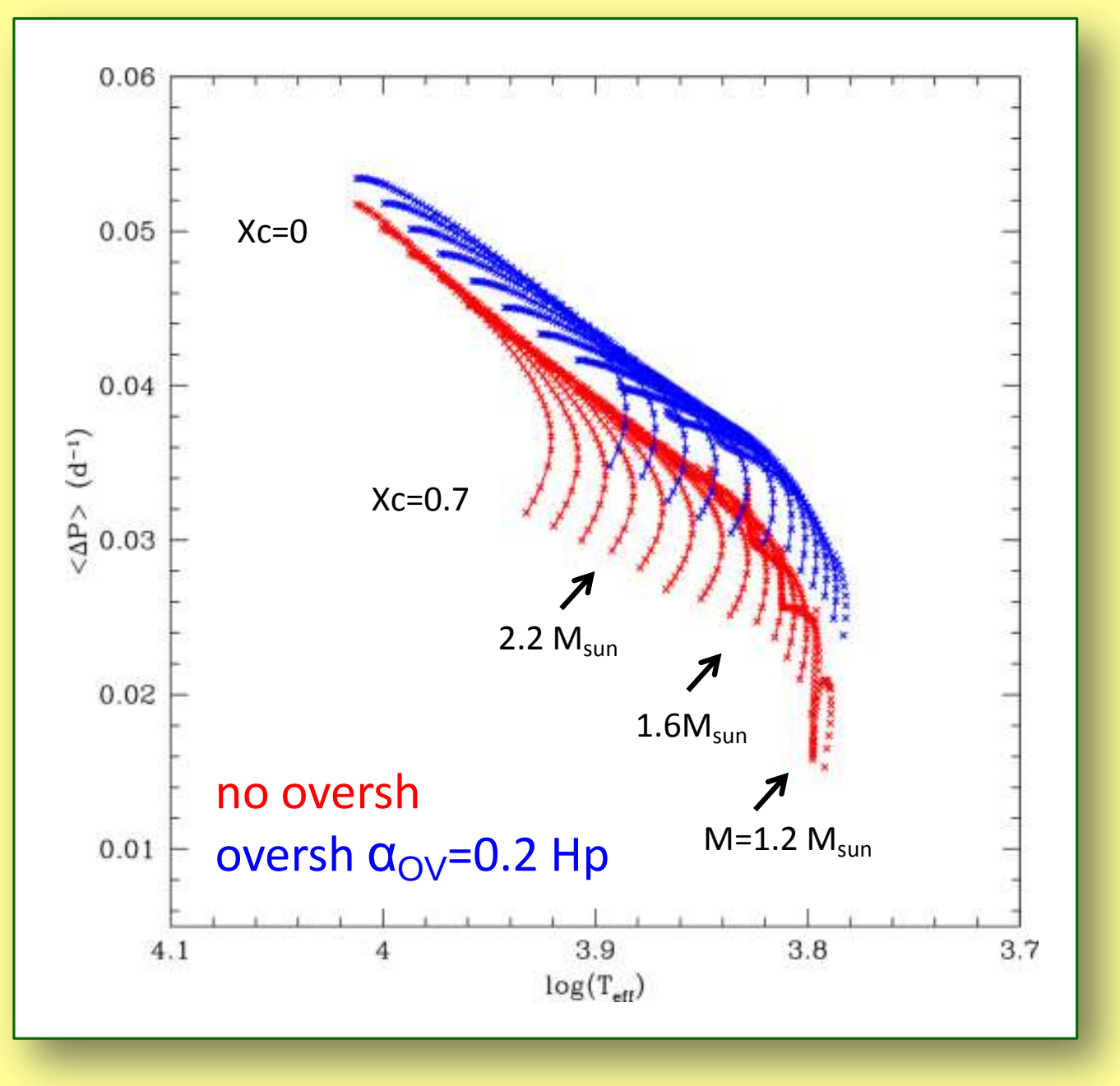


Fig. 4: Average period spacing of l=1 high-order g modes in main-sequnce models as a function of T$_{eff}$. Each line connects models of the same mass.

1. Since the frequency resolution does not permit an explicit analysis of period spacings even for the COROT Long-Run data, we calculate a significance spectrum (Reegen 2007 A&A, 467, 1353) over period rather than frequency. The second step is to evaluate serial correlation coefficients over period spacing. The result is a preferred period spacing, or a set of such preferences.

2. For comparison, we performed numerical simulations using the same sampling as for the COROT LRc01 data and modelled a light curve using unstable l=1 and l=2 model eigenfrequencies (1.6 M_{sun}, Z=0.02, α_{MLT}=2), amplitudes distributed according to a Gaussian, plus white noise. A mode selection mechanism was simulated by a binomial distribution with an elementary probability of 0.5. Different noise levels were examined to achieve different signal-to-noise ratios (see **Fig. 5**).

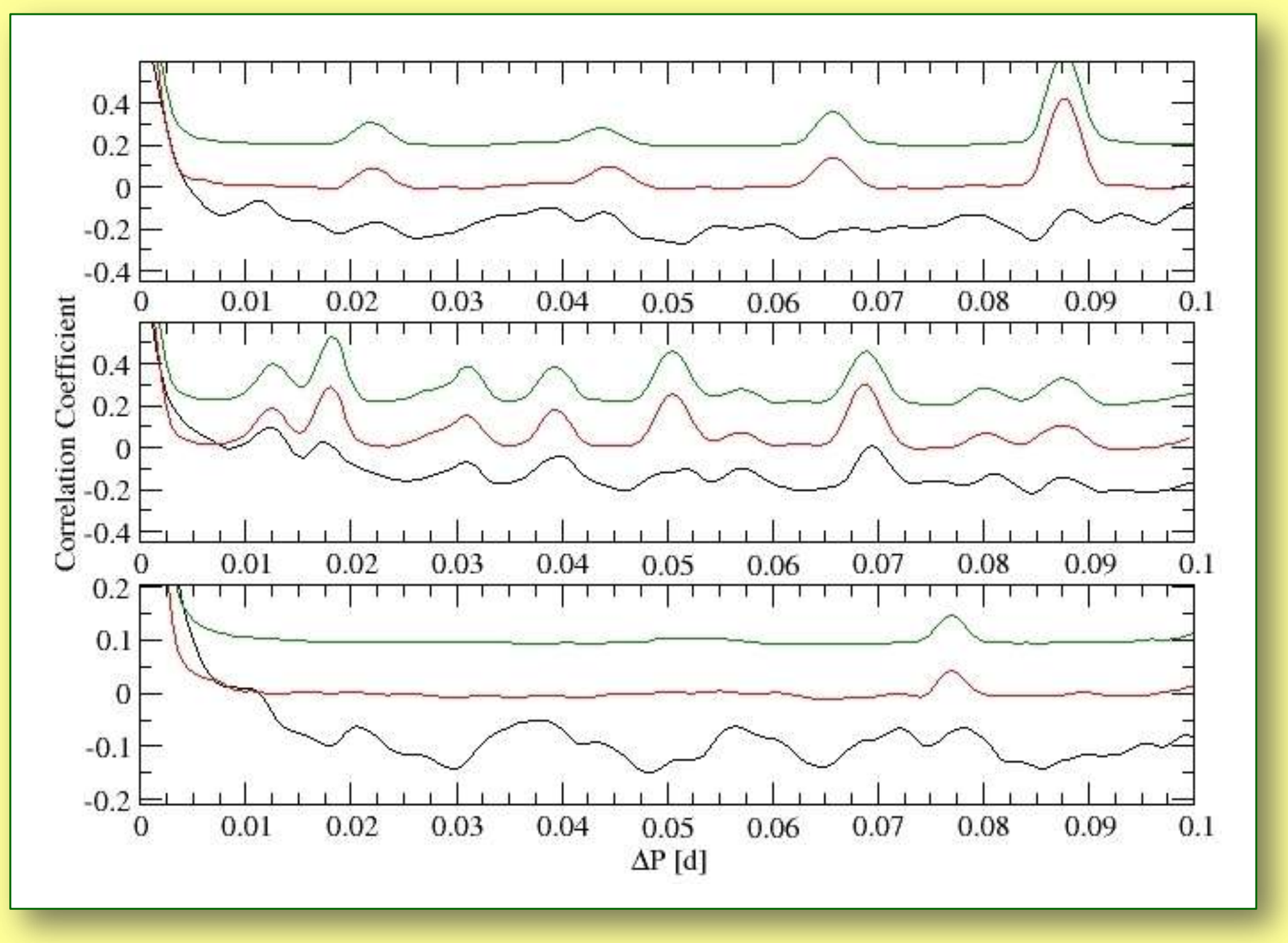


Fig. 5: Autocorrelation functions from **theoretical frequencies** for different evolutionary stages. From top to bottom: log g = 4.17, 3.87 and 3.78 respectively. Green lines correspond to a high, red lines to medium and black lines to low S/N ratios. The graphs are plotted with an offset for visibility.

3. Two data sets were chosen for a first comparison (see **Fig. 6**): in these targets prominent features in the autocorrelation function (ACF) indicate a set of preferred period spacings which are compatible with theoretical models.

The method presented provides a viable tool to search for recurrent period spacings in CoRoT targets. In the future more simulations are however needed for a systematic analysis, and a further extension of this work will be to consider in our simulations the critical role of rotation on the oscillation periods of γ Doradus stars.

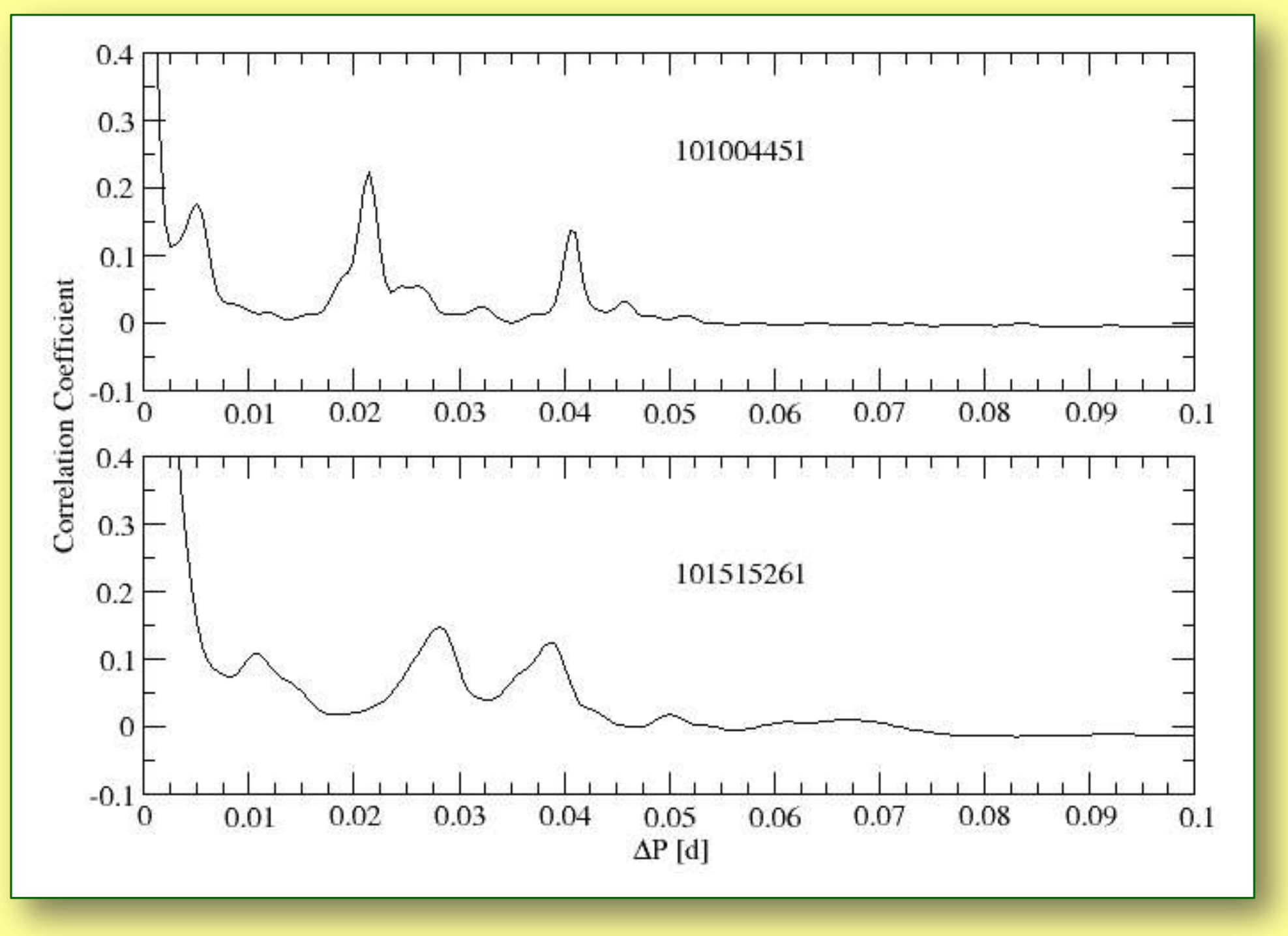


Fig. 6: Autocorrelation functions for **observed data** for two P3 γ Dor stars. The upper panel resembles the simulated ACF of a younger star (Fig. 5 upper panel), while the lower panel the structure of a more evolved star. (middle panel of Fig. 5)