Radial and Nonradial Pulsations as Probes of Stellar Physics
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The Blazhko Effect Unravelled ?[1]

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Abstract. A detailed frequency analysis on ELODIE observations of the Blazhko star RR Lyrae (Chadid et al., 1999) clearly revealed the importance of non-linear effects upon the radial fundamental mode (with frequency f_P), and a multiplet structure with a separation equal to the Blazhko frequency (f_B) around the main frequency and its harmonics. These results provided strong evidence for the presence of non-radial modes in the star. The identification of these non-radial modes is the following step in our work.

1. Introduction

We modelled as completely as possible the effect of the radial pulsation mode upon the spectra and the moments, taking into account the importance of non-linearity, and the variations of the intrinsic profiles, due to the pulsations of RR Lyrae.

Our theoretical model for the radial mode contains the following ingredients:

- Variable intrinsic profiles from Kurucz models for a grid of observed values for $\log g$ and $T_{\rm eff}$ over the pulsation cycle, taken from the literature.

- A non-linear velocity expression up to the third order derived from the paper by Van Hoolst (1996). The radial pulsation frequency f_P and its two first harmonics are the most prominent peaks in the periodogram resulting from the frequency analysis. One may therefore hope that the third-order expression is sufficient to model the line-profile variations.

[1] The RR Lyrae spectra were gathered with the 1.93m telescope of the Haute-Provence Observatory in France in 1996 and 1997.

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- A polytropic model with index $n_e = 4.98$, as a first approximation for the RR Lyrae structure. This model is used to calculate the non-linear coefficients appearing in the velocity expression.

2. Results

With these ingredients we generate theoretical line profiles, and confront them with the observations. Our idea is to look for frequencies $f_P \pm f_B$ which can be identified with non-radial modes in the residuals of observations and theory.

The non-linear theory up to the third order appears to be insufficient, however, to model the radial mode in such a way that it can be filtered out of the data. The effect of the higher-order non-linearities on the line profile shape turns out to be larger than those due to the Blazhko effect.

The present lacking of theoretically sufficient ingredients leads us to the conclusion that a model for theoretical line profile generation will not reveal the non-radial modes directly from the spectra.

3. Conclusions and future work

We turn to the moments derived from the line profiles to continue our identification attemps with an adapted version of the moment method (Aerts, 1996). On the one hand we use a generalized theoretical expression for the moments in case of a multiperiodic pulsator. On the other hand we construct a harmonic fit to the first and second moment, considering the frequencies appearing in the theoretical expression.

The amplitudes of the moment terms containing the Blazhko frequency f_B will be used in an adapted discriminant function for a multimode pulsator, to obtain the most probable (ℓ, m)-values for the non-radial modes in RR Lyrae. The identification of the degree will put constraints upon the validity of the models proposed to explain the Blazhko effect (Kovács, 1995), since the magnetic models (Shibahashi & Takata, 1995) and the resonance models (Van Hoolst, 1998) make different predictions about the degree of the present non-radial modes.

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