Comm. in Asteroseismology
Vol. 150, 2007

Asteroseismology of the β Cephei star KP Per

S. Saesen,[1] M. Briquet,[1] J. Cuypers,[2] P. De Cat,[2] K. Goossens[1]

[1] Instituut voor Sterrenkunde, Katholieke Universiteit Leuven, Celestijnenlaan 200D, Leuven, Belgium
[2] Koninklijke Sterrenwacht van België, Ringlaan 3, 1180 Brussel, Belgium

Abstract

We investigated the oscillations of the β Cephei star KP Per (HD 21803, B2IV, $V = 6.41$) using Geneva photometry. We performed a detailed frequency analysis and a mode identification by means of photometric amplitude ratios. Then we confronted our deduced observational oscillation spectrum with that predicted by theory in order to determine a range for some stellar parameters, such as the mass and radius of KP Per.

The observational oscillation spectrum

The data were taken with the P7 photometer mounted on the 1.2 m Mercator telescope located in the Roque de los Muchachos Observatory at La Palma (Spain). KP Per was monitored between December 2001 and September 2004. We gathered 338 high-quality photometric measurements in the seven colours of the Geneva system.

We carried out a frequency analysis by means of Phase Dispersion Minimization (Stellingwerf 1978), the Lomb-Scargle Fourier method (Lomb 1976, Scargle 1982) and by multi-frequency least-squares fitting. We solved alias problems (especially for f_3) by combining photometric data from the literature with each other and with our data set. We disentangled three frequencies: $f_1 = 4.95575$ cd^{-1}, $f_2 = 5.04846$ cd^{-1} and $f_3 = 4.40346$ cd^{-1}, which were already reported by Jarzebowski et al. (1981). After prewhitening the remaining standard deviation is 10 to 12 mmag in the different Geneva filters, so probably more frequencies are present.

For the mode identification we deduced the degree ℓ by comparing the theoretical amplitude ratios with the observed ones (Dupret et al. 2003). This comparison is shown in Figs. 1 and 2. f_1 and f_2 unambiguously correspond to dipole modes ($\ell = 1$). The larger error bars hampered a unique identification for f_3: both a dipole and a quadrupole ($\ell = 2$) mode are possible.

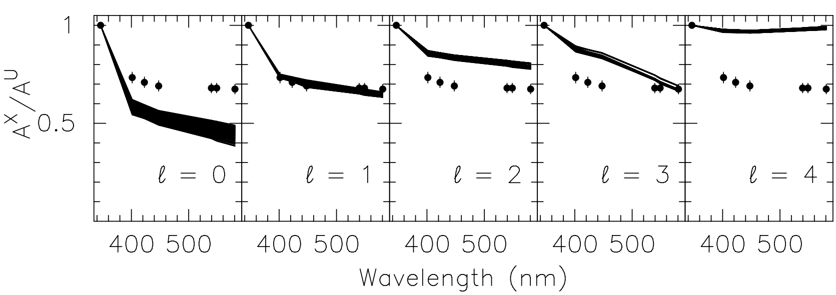

Figure 1: The amplitude ratios scaled to the Geneva U-filter for f_1. The filled circles with error bars denote the observed amplitude ratios and their uncertainties, the black bands indicate the theoretical predictions for these. The outcome for f_2 is similar.

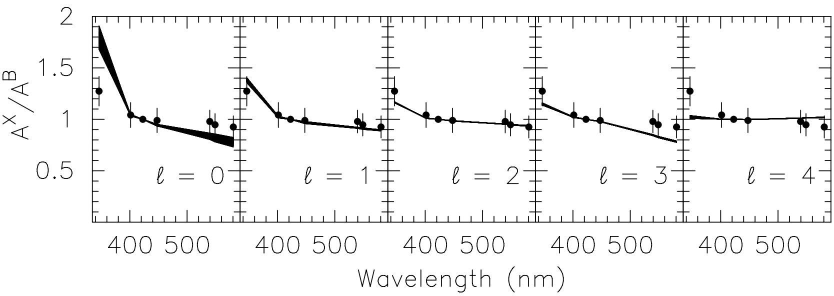

Figure 2: Same as Fig. 1 but for f_3. The amplitude ratios are scaled to the Geneva B-filter.

The theoretical oscillation spectrum

We used a grid of equilibrium models calculated by Clés (Code Liégeois d'Évolution Stellaire, written by R. Scuflaire). The models were characterized by their mass, age, initial hydrogen abundance, initial metallicity and overshoot parameter. Information on the used input physics can be found on `http://astrotheor3.astro.ulg.ac.be/files/scuflaire/`. The frequencies for these models were computed by a standard adiabatic pulsation code (Boury et al. 1975). We also checked the excitation of the modes by means of the non-adiabatic pulsation code MAD (Dupret et al. 2003).

The modelling

We compared the observational oscillation spectrum with the theoretical one. We wanted to find out which models can explain the observations in order to reveal the radial order n of the frequencies and in order to constrain some physical parameters, such as the mass, radius, age and angular rotational frequency of KP Per. As a first result of seismic modelling, we deduced that f_1 and f_2 belong to the same triplet. We then required the reproduction and excitation of f_1 as zonal dipole mode and of f_3 as dipole or quadrupole mode and we found stellar models that qualify and fall into the 3σ-error box of KP Per in the HR diagram. For more details on these models, we refer to Saesen et al. (in preparation). The choice of the zonal mode of the triplet is unimportant: modelling with f_1, f_2 or $(f_1 + f_2)/2$ gives consistent results.

Acknowledgments. This work was based on observations obtained with the P7 photometer attached to the 1.2 m Mercator telescope (La Palma, Spain). These data will be published with our forthcoming article on KP Per. MB is a Postdoctoral Fellow and SS is an Aspirant Fellow of the Fund for Scientific Research, Flanders (FWO).

References

Boury A., Gabriel M., Noels A., Scuflaire R., Ledoux P., 1975, A&A, 41, 279

Dupret M.-A., De Ridder J., De Cat P., et al., 2003, A&A, 398, 677

Jarzebowski T., Jerzykiewicz M., Ríos Herrera M., Ríos Berumen M., 1981, Rev. Mex. A&A, 5, 61

Lomb N. R., 1976, Ap&SS, 39, 447

Scargle J. D., 1982, ApJ, 263, 835

Stellingwerf R. F., 1978, ApJ, 224, 953