TOWARDS ASTEROSEISMOLOGY OF THE NON-RADIAL PULSATING SDB STAR PG 1605+072

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The recently discovered new class of sdB pulsators (sdBV) offers a powerful possibility for the investigation of their interior and thus their evolutionary history. The first step towards applying asteroseismologic tools is the identification of pulsation modes. The best target for such an investigation is PG 1605+072 because of its outstanding properties among the sdBVs: it is the brightest object (B = 13 mag), it has the longest periods ($\sim$ 500 s) and the largest variations (0.2 mag in the optical) as well as the richest pulsation spectrum with more than 50 modes (see Kilkenny *et al.* 1999). The rather rapid rotation ($\mathrm{v} \sin i = 39\,km/s$, Heber *et al.* 1999) complicates the interpretation of the pulsation spectrum due to non-linear mode splitting.

We want to accomplish the mode identification by measuring both the light and the radial velocity curve for PG 1605+072. The analysis of equivalent width changes of the Balmer lines and of line profile variations (as a future task in preparation) will support the aim of the project. Moreover, we want to determine light/velocity amplitude ratios and search for a wavelength dependence of photometric amplitudes which gives us information on limb darkening effects.

The interpretation of these measurements require sophisticated models. Phase dependent synthetic spectra will be calculated with a code developed by Falter (2001). As a prerequisite for these models the time dependent sur-

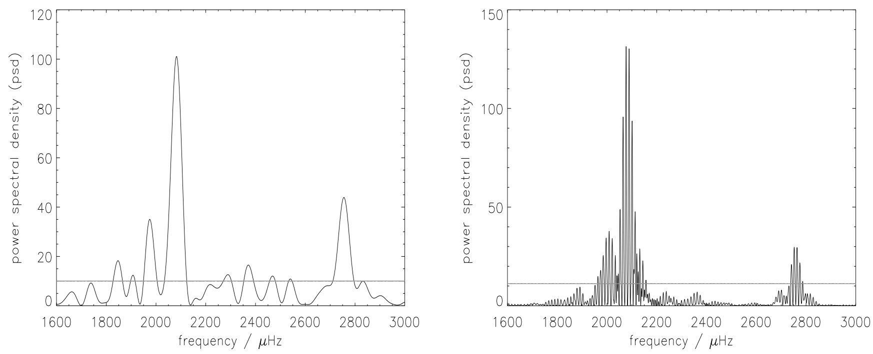

Figure 1. Periodogram of the RV curve of H_β (left panel) and of the light curve of the BUSCA 'UV' band (right panel). The power spectral density (psd) is a measure for the probability that a period is present in the RV or lightcurve. The horizontal line in both panels is the 3σ confidence level.

face distribution of $T_{\rm eff}$, $\log g$ and the velocity field are determined using Townsend's (1997) program BRUCE which also takes effects caused by rotation into consideration. Furthermore, detailed evolutionary pulsation models (Charpinet *et al.*, these proceedings) are at hand for the comparison with the observational frequency pattern.

Feasibility studies:

As a first step we carried out a feasibility study in May 2001 by monitoring simultaneously the radial velocity (RV) curve for about 5.5 h and the light curve in four spectral bands for about 48 h at Calar Alto Observatory, Spain (for details see Falter *et al.* 2003).

Time resolved optical spectra (spectral resolution: $\sim$1 Å) were obtained at the 3.5 m telescope equipped with the TWIN spectrograph. The time resolution was achieved by trailing mode observations which is the tuning of the guiding system such that the star moves slowly along the slit in N-S direction (drift velocity: $270''$, 15 s time resolution). The periodogram analysis of the RV curves measured for H_β and H_γ reveal three dominant frequencies (see Fig. 1). These frequencies are consistent with previous photometry (Kilkenny *et al.* 1999). A comparison with other feasibility studies (O'Toole *et al.* 2000, 2002, Woolf *et al.* 2002) shows that the power of the modes around 2.1 mHz and 2.75 mHz has switched in the course of the years 1999, 2000 and 2001.

The light curves were measured with the new multi-band camera BUSCA (see Cordes *et al.* 2003) at the 2.2 m telescope in four wavelength bands simultaneously. Three beamsplitters split the incoming light into four beams feeding four 4k$\times$4k CCDs. In order to reduce the achievable S/N and the

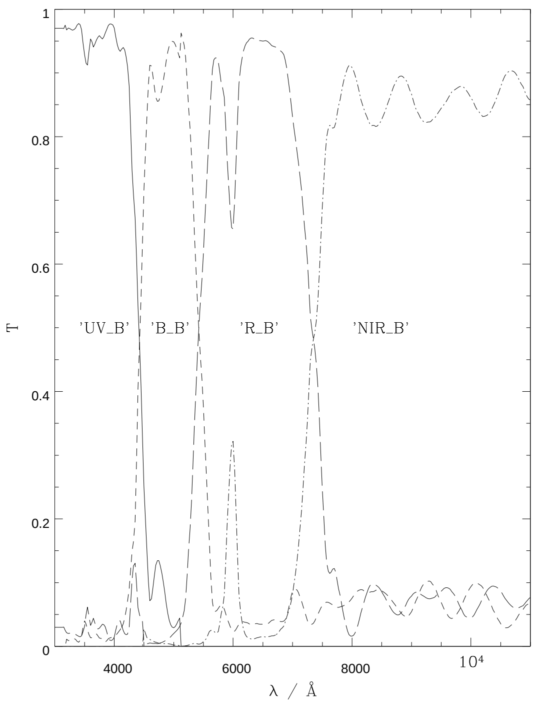

Figure 2. Transmission curves of the four BUSCA wavelength bands. The four ranges are denoted by 'UV_B' (central wavelength: 3 600 Å), 'B_B' (4 800 Å), 'R_B' (6 300 Å) and 'NIR_B' (8 000 Å) which are not comparable to the classical Johnson UBVRI system.

cycle time (51 s) no filters were inserted and, therefore, the beamsplitters served as broad wave band filters. Fig. 2 shows the transmission functions of the four bands. The photometric time series in the four wavelength bands confirm the three frequencies found in the RV curves and reveal two additional frequencies (see Fig. 1). These five detections are found in all wavebands. More frequencies are present but not consistent in the four bands. For all frequencies, we find a wavelength-dependent variation of the amplitudes. Fig. 3 shows the relative deviation of the amplitude in the passband from the mean value over all bands (for four example frequencies).

The Multi-Site Spectroscopic-Telescope project (MSST): Our feasibility study as well as the previous ones (O'Toole *et al.* 2000, 2002, Woolf *et al.* 2002) were unable to resolve the rich power spectrum of the RV and light curves. A considerably longer period of monitoring with as little gaps as possible is required to reach this goal. The next step towards the identification of pulsation modes for PG 1605+072 is the MSST project. From the beginning of May until the end of June in 2002, an international collaboration involving more than 25 colleagues measured the light and

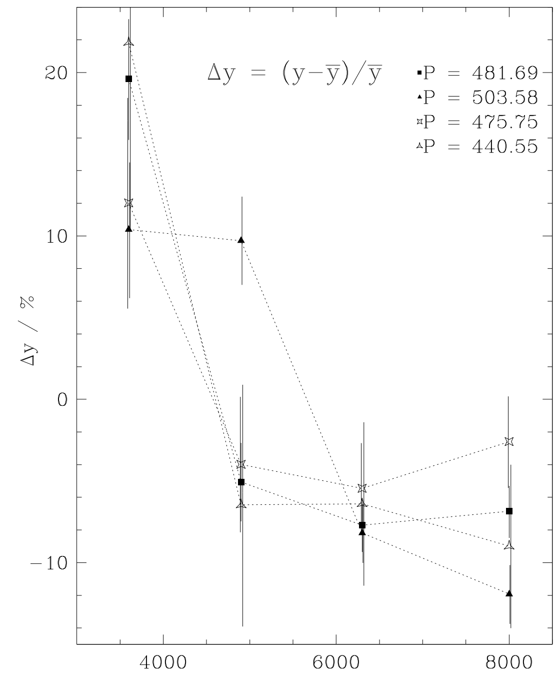

Figure 3. Relative semi amplitudes of four frequencies found with BUSCA. These are calculated by $\Delta y = (y - \bar{y})/\bar{y}$, y denotes the flux in the wavelength band y and $\bar{y}$ the mean value of all four wavelength bands.

radial velocity curves at 15 observatories around the world. More details about that project are described elsewhere (Heber *et al.*, these proceedings). In the course of this project we additionally had the benefit of a contribution by the WET collaboration which observed PG 1605+072 as an alternate target during their Xcov22 campaign (see Schuh *et al.* 2003).

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