Photometric and spectroscopic variability of 53 Per

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A new investigation of the variability of the SPB-type star 53 Per is presented. The analysis of the BRITE photometry allowed us to determine eight independent frequencies and the combination one. Five of these frequencies and the combination frequency were not known before. In addition, we gathered more than 1800 new moderate and high-resolution spectra of 53 Per spread over approximately six months. Their frequency analysis revealed four independent frequencies and the combination frequency, all consistent with the BRITE results.

53 Per (HD 27396, B4 IV, $V = 4.85$ mag) is one of the first studied variable mid-B stars of the northern hemisphere. Its photometric and spectroscopic data have been gathered and investigated since the mid-seventies (see Chapellier et al., 1998; De Ridder et al., 1999, and references therein). Nonetheless, our understanding of the pulsational behaviour of 53 Per is still far from complete. The star was a prototype of a group of mid-B type stars showing variability due to non-radial pulsations in line profiles, later incorporated into the SPB class of variable stars. Before the BRITE observations three modes were known in this star (De Ridder et al., 1999).

53 Per was one of the stars observed by the BRITE satellites in the Perseus field. The observations spanned 170 days between September 2, 2014, and February 18, 2015, and come from a single BRITE satellite, UniBRITE (UBr). Details of the instrumentation and observing procedure are given by Weiss et al. (2014). The combined red-filter light curve consists of 165 274 data points. Prior to time-series analysis BRITE photometry was corrected for instrumental effects. The corrections included outlier rejection and decorrelations with centroid positions and CCD temperature. Final correction accounted for offsets between four individual setups of the UBr observations. The obtained light curve was used for time-series analysis, which consisted of the calculation of the Fourier frequency spectrum, identification of the highest maximum in the spectrum, and pre-whitening the original light curve with all previously detected frequencies. In total, eight significant independent frequencies were identified in BRITE photometry. The highest amplitudes were obtained for the three previously identified modes ($f_1 = 0.46112$, $f_2 = 0.59388$, $f_3 = 0.47116\,\mathrm{d}^{-1}$), with amplitudes ranging from about 7 to over 20 mmag. For the other modes, the amplitudes are lower than 5 mmag. In addition, one combination frequency, $f_1 + f_2$ was found.

The spectroscopic observations of 53 Per lasted from October 2015 to March 2016. The moderate and high-resolution spectra were obtained with four different échelle spectrographs, working at the 2-m telescope of the Thüringer Landessternwarte Tautenburg (TLS, 1428 spectra), the 0.5-m Poznań Spectroscopic Telescope (PST1, 322), the 91-cm telescope of the Osservatorio Astrofisico di Catania (OAC, 16), and the 2-m telescope of the Bulgarian National Astronomical Observatory (BNAO, 24). The spectra have an average S/N ratio of about 100. After the standard reduction and calibration procedures all spectra were normalised to the local continuum. To compute radial velocities (RV), we extracted useful neutral helium lines (4713.15, 4921.93, 5875.62, and 6678.16 Å). RVs were calculated using the cross-correlation method. In total, four significant independent frequencies and the combination one ($f_1 + f_2$), were identified. Two frequencies with the highest amplitudes were known before (f_1 and f_2). All spectroscopically obtained frequencies are consistent with the BRITE photometry analysis.

The investigation of BRITE photometry has enabled us to identify more frequencies than were previously known, including the combination frequency. Thanks to this, the next step of our analysis will be mode identification and seismic analysis of the star (Niemczura et al., in preparation).

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