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V620 Oph = CoRoT 104190253 – A MISCLASSIFIED RR LYRAE STAR

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While I was reading the recently appeared CoRoT Legacy Book (CoRoT Team, 2016) I noticed the figures A.1 and A.2 in the paper of Ollivier et al. (2016). The authors call the attention to a rare but possible failure of the jump detection algorithm of the CoRoT data pipeline. If a large amplitude variable star has similar period than the CoRoT satellite South Atlantic Anomaly passing through rate (0.499 d), this could lead to a false jump detection and the algorithm heavily distorts the light curve. The effect is illustrated with the case of the RR Lyrae star CoRoT 104190253. Since the CoRoT Variable star Classifier (CVC, Debosscher et al. 2009) uses the processed light curves, this star was not classified as an RR Lyrae star. So it has not been reported by any of the specific CoRoT RR Lyrae studies nor by the two review papers (Szabó et al. 2014, Benkő et al. 2016).

1 History and classification

The SIMBAD database contains a Mira variable star V620 Oph at the position of CoRoT 104190253 (α_{2000}=18$^{\rm h}$33$^{\rm m}$47$^{\rm s}$.35, δ_{2000}=+9°06′58″.608). The literature of V620 Oph is rather poor. Its variable nature was discovered by Hoffmeister (1936) who later gave the finding chart as well (Hoffmeister, 1957). The only additional paper which mentioned the star is the work of Kinnunen & Skiff (2000), which provides proper positions for many variable stars. No specific study of V620 Oph has been found.

The star was observed by the CoRoT satellite (Baglin 2006, 2016) in its fourth long run towards the Galactic centre direction (LRc04) between 07 July and 29 September 2009 (84 days). After the first two days the observation was taken in oversampled mode which means 32 sec sampling rate. This resulted in more than 19 000 individual data points[1]. Considering the data it is immediately visible that the Mira classification is wrong. The period, the amplitude, and the light curve shape are all typical of a fundamentally pulsating RR Lyrae (RRab) star (Fig. 1).

[1]The CoRoT N2 reduced data used this work can be downloaded from the IAS CoRoT Public Archive site at http://idoc-corot.ias.u-psud.fr/sitools/client-user/COROT_N2_PUBLIC_DATA/project-index.html

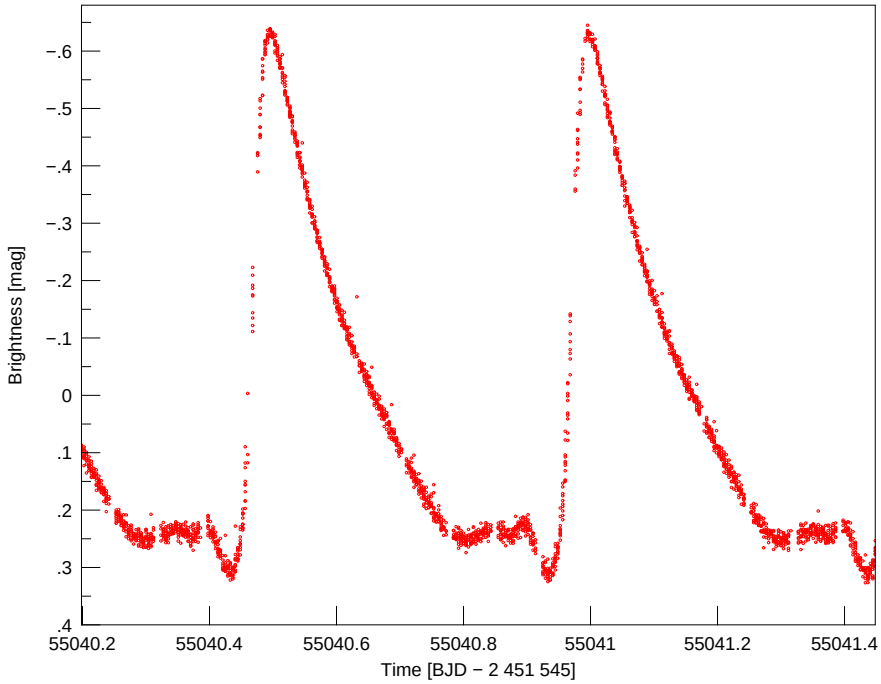

Figure 1. A light curve part of the CoRoT observation of V620 Oph.

2 Data analysis and results

The data was selected, processed, and analyzed in the same way as it was described in Benkő et al. (2016). The main pulsation period P_0 is 0.501743±0.000003 d and the Fourier amplitude of the main frequency in CoRoT instrumental magnitude scale is $A(f_0) = 0.3284 \pm 0.0005$ mag. All the errors given in this paper are estimated with the Monte Carlo Simulation tool of Period04 program package (Lenz & Breger 2005).

The light curve does not show any serious modulation effects but the Fourier analysis shows some. If I pre-whiten the data with the main pulsation frequency and its harmonics the residual spectrum is dominated by side peaks around the harmonics and a highly significant (S/N=12.2) peak in the low frequency regime at $f' = 0.016 \pm 0.013$ d^{-1}. The side peak distances from the harmonics and f' frequency itself determine a possible ∼60 d-long modulation.

The reality of such a long period modulation needs a careful check which can distinguish it from the possible similar time-scale instrumental trends. For this purpose I chose the Period04 amplitude/phase variation calculation tool which is sensitive for finding small amplitude or phase modulations (Nemec et al. 2011, 2013). To test the method dependence on the bin size I run the program twice using either 3 days-long or 5 days-long bin sizes. The results concerning the amplitude and phase of the main pulsation frequency are shown in Fig. 2.

The variation is clearly seen in both panels of the figure. The different symbols (which denote the two bin sizes) show the same curve shape demonstrating that the variation is independent of the used bin sizes. The amplitude and phase variation curves are highly (anti)correlated which strengthen the reality of the effect. Fourier spectra of these curves

yield a period of $P = 41.2 \pm 11$ d which is in agreement with the result of the above light curve Fourier analysis. The huge period error of both methods is on the one hand due to the small number of covered cycles (~ 2), on the other hand because of the irregularity of the cycles. The observed two Blazhko cycles have different amplitude and phase variation curves suggesting multiperiodic and/or irregular nature of the effect. It is not a surprise because it was recently demonstrated that the multiperiodic Blazhko effects are very common (Benkő et al. 2014).

The amplitude of this amplitude variation is $\Delta A_1 = 0.042 \pm 0.001$ mag while the amplitude of the phase variation is $\Delta\phi_1 = 0.0018 \pm 0.0008$. Here I used the definition of Nemec et al. (2013) for ΔA_1 and $\Delta\phi_1$, the phases defined as in Lenz & Breger (2005) that is they should be multiplied by 2π for obtaining the phases in radian. The amplitude of the detected variations is low but not extremely: V620 Oph values are between the parameters of the two *Kepler* Blazhko stars KIC 11125706 and V838 Cyg (Nemec et al. 2013). (Here I assumed that the CoRoT white light amplitudes are similar to those that the *Kepler* unfiltered ones.) Otherwise, this star shows the smallest amplitude Blazhko effect among the non-blended CoRoT RRab stars.

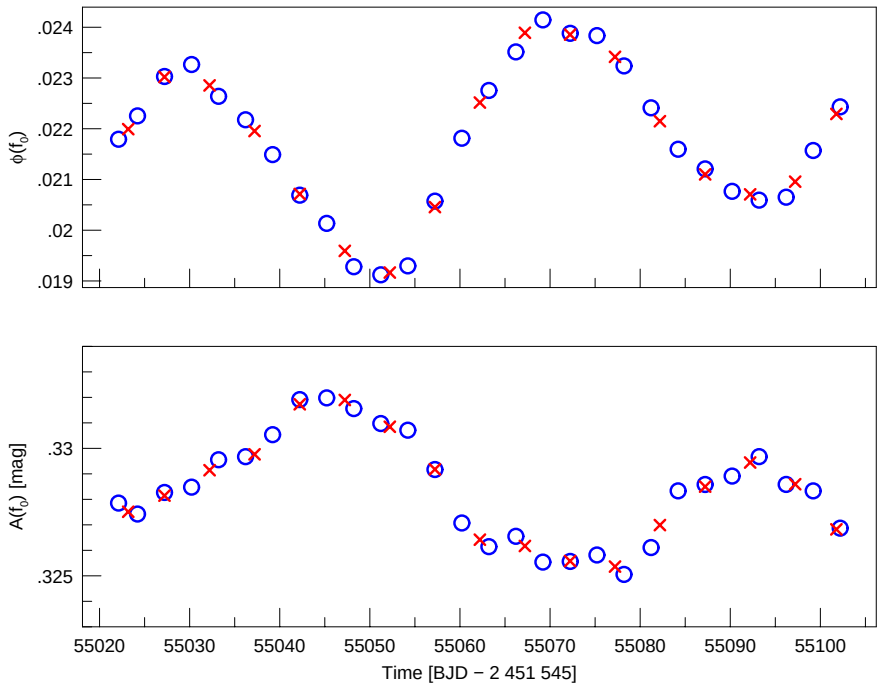

Figure 2. The amplitude (bottom) and phase variation (top) of the main pulsation frequency f_0. Phase units are rad/2π. The open circles denote the result obtained using 3 days-long bin size while x symbols show the 5 days-long bin size result. The error of the individual data points is smaller than the symbol sizes.

3 Conclusion

In this short paper I demonstrated that the formerly misclassified V620 Oph is a fundamental-mode pulsating RR Lyrae star showing a small amplitude but real Blazhko effect. The effect has possible multiperiodic or irregular character.

The lesson from the accidental finding of the star is that some RR Lyrae stars with similar period might be hidden in the CoRoT archive. This is the first and the only identified RR Lyrae star within the period range of 0.4853-0.5385 d. In turn the maximum of the period distribution function of Galactic RR Lyrae stars (0.556 d, see e.g. Soszyński et al. 2011) is near of this interval.

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