No detection of Strange Mode Pulsations in massive prime candidate

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1. INTRODUCTION

Theoretical work suggests that strange mode pulsations (SMPs) are present in hot and luminous stars with a high luminosity-to-mass ratio, where the thermal timescale is short compared to the dynamical timescale and radiation pressure dominates (Glatzel & Kiriakidis 1993). The most violent SMPs are expected in classical WR stars, the bare, compact helium-burning cores of evolved massive stars (Glatzel et al. 1999), where SMPs are predicted to manifest themselves in cyclic photometric variability with periods ranging from minutes to hours and amplitudes in the several to tens of mmag range. Since WR 2 is one of the hottest WR stars known, it should make it an excellent candidate for SMPs.

2. OBSERVATIONS AND REDUCTION

We monitored WR 2 using the NIR panoramic camera CPAPIR (Artigau et al. 2004) at the 1.6m telescope of the Observatoire du Mont Mégantic (QC, Canada) from 2009 January 11 to 16, securing 3 useful 3-6 hour continuous sequences (Fig. 1a). Each exposure was 10.8 s long, with 5 s overhead. The data were obtained in “staring mode”, i.e. the telescope pointing was kept fixed on the sky through the entire sequence (Girardin, Artigau & Doyon 2013), which renders our results fairly independent of flat-field errors. In order to isolate the light from the deepest layers of the WR wind, we selected a narrow-band filter (Δλ = 0.025 µm) centered on a region of the spectrum where no strong emission lines are present (λc = 2.033 µm).

All images were uniformly reduced using standard procedures carried out with routines written in Interactive Data Language (IDL). We performed aperture photometry using the aper Astrolib routine (Landsman 1993) on all stars present in the WR 2 field. We adopted an aperture size equal to twice the FWHM of the point spread function (PSF) and an annulus of sky was selected with inner and outer radii of respectively 4 and 8 times the FWHM of the PSF. The light curves were obtained by correcting the zero-point of all frames, using the best frame obtained during the first 30 mins of observation of each night. Since no flux standards are known in the band we used, we retain instrumental magnitudes (roughly calibrated to the K-band 2MASS photometry).

3. LIGHT CURVE ANALYSIS

In Fig. 1b, WR 2 is much closer to the 1- than to the 3-σ rms limit, and can be confidently labeled as non variable at that limit. Also, WR 2’s σ gives a Rσ value of 1.7 (for complete definition, see Dekany et al. 2011), which confirms that WR 2 does not vary significantly on timescales up to ~6 hours with an upper limit on the amplitude variation of 4 mmag. This result is also confirmed during the two other observing nights.

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Figure 1. a) CPAPIR light curves of WR 2 for 2009 January 11, 15 and 16. The data are arbitrarily shifted from one night to the next. b) Standard deviations of the light curves of all detected stars (including WR 2) during the night of 2009 January 15, as a function of the average instrumental magnitude using two different definitions ($\sigma_{\text{rms}}$ and $\sigma_i$, as defined in Dekany et al. 2011). The $\sigma_{\text{rms}}$ value of WR 2 is marked with a red X. c) Periodogram of the light curve obtained in 2009 January 15.

Visual inspection of the WR 2 light curve does not show any significant intrinsic change in time. Atmospheric variations cause a larger scatter at the end of 2 nights. We used a phase-dispersion minimization (PDM) algorithm (Stellingwerf 1978) as well as a Scargle algorithm (Scargle 1982; Roberts 1987) to search for periodicity in the photometric observations between periods of 1 minute and 0.5 day, using a step in frequency of 0.003 d$^{-1}$. This analysis failed to reveal any stable period, and only led to a noisy periodogram with no significant peak (see Fig. 1c). The highest peak in the periodogram has an amplitude of 1.2 mmag, which can be considered the smallest amplitude of a coherent periodic variation that we could have detected.

4. CONCLUSIONS

Taking the predictions from Glatzel et al. (1999) for a star with $M = 14M_\odot$, $log L/L_\odot = 5.41$ and $log T_{\text{eff}} = 5.089$, i.e. within 10% of the values obtained by Hamann, Gräfener & Liermann (2006) for WR 2, we see that the expected SMPs should have an amplitude of 80 mmag over a period of $\sim 15$ mins. This is more than one order of magnitude greater than our detection limit. Only the model for a low-mass WR star from Glatzel et al. (1999) predicts an amplitude of 4 mmag over a period of $\sim 200$ secs for SMPs or in other words, $1-\sigma_{\text{rms}}$ for our dataset. However, the stellar parameters (such as the temperature and luminosity) used for that model are both 50% lower than those of WR 2. Also, if we use $\sigma_i (=2.5$ mmag) as the formal error on each point and if we consider that during the night of
2009 January 15 we covered the predicted period $\sim 100$ times with $\sim 15$ data points per phase interval, we should expect some significant signal in the periodogram, or at least some coherent signal once the curve is folded into the predicted period. This is not what we observe.

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**Facilities:** OMM

**Software:** Astrolib ([Landsman 1993](#))

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