VARIABILITY OF WOLF-RAYET STARS THROUGH MOST(LY) BRITE EYES

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Abstract. We present preliminary results from *BRITE* and *MOST* photometry of a subset of 8 Wolf-Rayet stars. After allowing for any known periodic variations in binaries, we found only stochastic light variations, for which time-frequency and wavelet analyses reveal an average life-time of around 10 days, with frequencies ranging from 0.05 to 0.5 cycles/day.

Keywords: Stars: Wolf-Rayet, winds, activity, massive, techniques: photometric

1 Introduction

Wolf-Rayet (WR) stars, the descendants of main-sequence O stars, present the densest sustained winds known among all types of massive stars. These hot and luminous stars are known for their variability, both from intrinsic processes such as pulsations (e.g. Hénault-Brunet et al. 2011), wind clumping (e.g. Robert 1992) and rotational modulations (e.g. Morel et al. 1997), as well as from binarity. Those dense winds prevent us from seeing the surface of the star where the wind driving occurs. There is little consensus as to the source of the short-term variability observed, and the lack of periodicity complicates the task of identifying it. This contribution presented preliminary results from an attempt to characterize those variations better.

2 Data Reduction and Results

This study of the short-term variability of 8 WR stars of various subtypes was conducted using *BRITE*-Constellation (Weiss et al. 2014) and *MOST* (Walker et al. 2003) data. They were de-correlated against the various satellite parameters to clean the observed fluxes from instrumental biases. Our datasets are presented in Table 1.

A period search was carried out on each light-curve using a Fourier transform time-frequency analysis with a sliding, tapered window. (The periodic eclipses in WR22 were subtracted away before this analysis). Stochastic light variations were found in all the stars in our sample, corresponding to significant features in the time-frequency diagram. The average life-time of the features measured along the time axis had a mean value of $\sim$10 days, with frequencies ranging from 0.05 to 0.5 cycles/day. As an example, the time-frequency analysis of 2017 data sets for WR22 and WR24 are presented in Figure 1.

The time-frequency analysis allows one to characterize temporal changes of the frequencies in a variable signal, but does not allows one to detect abrupt changes in a signal due to the constant size of the sliding window (Mallat 2000). On the other hand, a wavelet analysis, which relies on a mother function localized in timescale parameter space, is more efficient at finding sudden changes by providing information on the powers and periods of the wavelets used to analyze the signal. Therefore, we performed multiple wavelet analysis of our sample light-curves. As presented in Figure 2, a much better resolution was reached for longer periods/shorter frequencies. The results of that analysis support our previous ones, namely, that stochastic variations with time-scales of 2–20 days were detected, with some signals surviving as long as 40 days before disappearing.

3 Conclusions

The physical processes causing these variations and the time-scales driving their temporal evolution have not yet been identified. Being stochastic in nature, however, does narrow down the choices, with wind clumping currently popular. We are presently carrying out a more thorough analysis of these data using Gaussian processes with different Kernels, and also a Bayesian analysis. Stochastic clumping models are being explored too, as are the *TESS* light-curves of WR stars.

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Table 1. Our WR datasets analyzed so far. B-Hz stands for BRITE-Heweliusz and B-Tr stands for BRITE-Toronto.

Star (year if available)	Spectral Type	Observing Interval (days)	Satellite
WR22 (2017, 2018)	WN7h+O9III-V	153	B-Hz
WR24 (2016, 2017, 2018)	WN6ha	163, 153, 62	B-Tr, B-Hz, B-Tr
WR71	WN6o	27	MOST
WR92	WC9	26	MOST
WR115	WN6o	38	MOST
WR119	WC9d	48	MOST
WR120	WN7o	38	MOST
WR121	WC9d	47	MOST

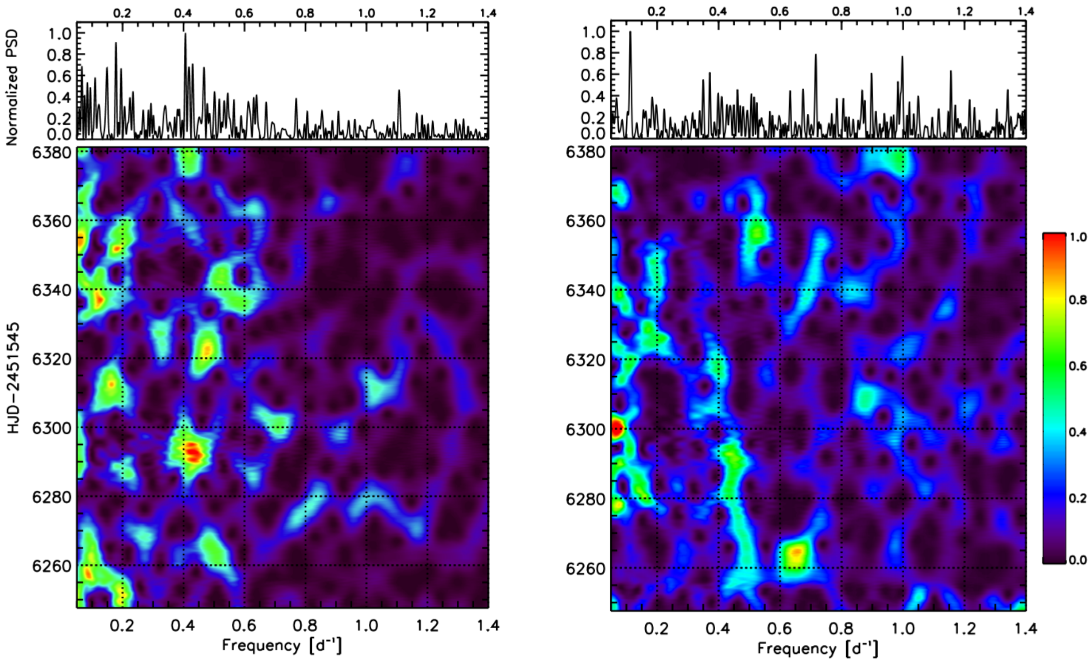

Fig. 1. Left: Time-frequency analysis of the 2017 data set of WR22. **Right:** Time-frequency analysis of the 2017 data set of WR24.

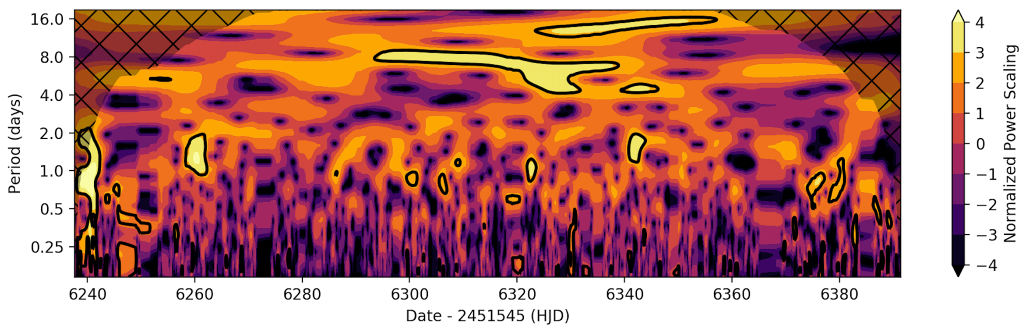

Fig. 2. Wavelet analysis of the 2017 data set of WR24.

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