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Time-Resolved Low Resolution Spectra of BLAP-009 and BLAP-014

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ABSTRACT

We present time resolved low resolution spectra of BLAP-009 and BLAP-014 collected with SPRAT on the Liverpool Telescope. The spectra were median-stacked in four ranges of phase (see Fig. 1). It was intended to note the variation in the shape of the helium absorption lines as a function of phase, but they do not appear to vary with time in low resolution spectra. The lack of clear offsets in the absorption lines suggest that there can only be small radial velocity due to either unseen companion or rapid expansion/contraction of the envelope.

Keywords: stars: peculiar (except chemically peculiar) — stars: oscillations (including pulsations): individual (OGLE BLAP-009, OGLE BLAP-014) — stars: variables: general

INTRODUCTION

Blue Large Amplitude Pulsators (BLAPs) are a new type of variable star reported by Pietrukowicz et al. (2017, hereafter P17) that has a high effective temperature ($\sim 30,000$ K) and exhibits large variability ($0.2 - 0.4$ mag) over a short timescale (20-40 min). They discovered 14 BLAPs from the Optical Gravitational Lensing Experiment (Udalski et al. 2015, OGLE). They proposed that the large amplitude can arise from the oscillations within a thick hydrogen-helium atmosphere of low-mass stars. Stellar evolution models have shown three potential evolutionary scenarios: (1) progenitors of extremely low mass white dwarfs (Romero et al. 2018) (2) post-common envelope stars (Byrne & Jeffery 2018, 2020); (3) mid/late stage of core helium burning stars (Wu & Li 2018). Ramsay (2018) applied interstellar reddening correction using data available from Gaia DR2 (Gaia Collaboration et al. 2018) showing BLAPs occupying space near where hot subdwarfs and hot white dwarfs lie in the HR diagram.

METHODS

On the nights of the 7$^{\text{th}}$ and 9$^{\text{th}}$ of May 2018 and the 4$^{\text{th}}$ of July 2018 we collected 12 spectra of BLAP-009 using SPRAT on the Liverpool Telescope with a resolution of $R = 300$. The first 3 spectra are 120 s exposures with the subsequent 9 spectra being 300 s exposures. We also collected 6 spectra of BLAP-014 on the 4$^{\text{th}}$ of July 2018 with the instrument and configuration above with exposure times of 450 s. All were taken during photometric condition and reduced with ASPIRED (Lam et al. 2020; Lam 2020). We use the periods determined from McWhirter et al. (2020). The observation times of our spectra were converted from Modified Julian Date (MJD) to HJDs. These phases are binned into four distinct phase ranges: around maximum, slow-fall, around minimum and the fast-rise. The spectra are median-stacked for each phase range as shown in Fig. 1.

RESULTS

The 12 spectra of BLAP-009 fully covered the phase space. The sampling is not as complete for BLAP-014 with the fast-rise being unobserved. The binned spectra do not exhibit the expected helium absorption line variation as a function of pulsation phase. Higher resolution and signal-to-noise binned spectra are needed to reveal these underlying

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changes. The spectra are further median stacked into a single spectrum for line identification. The stacked spectrum of OGLE-009 exhibits many of the expected hydrogen and helium absorption lines seen in P17. The spectrum of OGLE-014 has a lower signal-to-noise yet shows the helium absorption lines, especially a strong line at 5876 Å. The main surprise is the apparent absence of the H-α absorption line. The presence of the H-β, H-γ and H-δ lines are inconclusive given the noise.

Cross-matching with catalogues available on Vizier[1], near infrared photometry from the VISTA Variable in the Via Lactea Survey DR2 (Minniti et al. 2017) does not indicate infrared excess in both BLAPs, which rules out low mass star companion or accretion disc. Based on Gaia DR2, the distances (Bailer-Jones et al. 2018) suggest they are foreground objects lying between the Sun and the Galactic bulge. Assuming no radial velocity, BLAP-009 has Galactic velocity $(U, V, W) = (14, 169, 10)\,\mathrm{km\,s^{-1}}$, while BLAP-014 has $(U, V, W) = (11, 167, -7)\,\mathrm{km\,s^{-1}}$ calculated with Astropy. Due to the close proximity to the Galactic Centre (GC), the radial velocity is mostly contributed to the U component. Thus, from inspecting at the V velocities only, they are likely members of the thick disc.

DISCUSSION

There is an interesting feature with OGLE BLAP-014: the helium absorption lines appear to be stronger than those in OGLE BLAP-009. This suggests that may have a higher effective temperature than that computed in P17. Alternatively, this may be evidence of an atmosphere mixing process bringing interior helium to the surface in a short period of time. Given the disputed nature of these stars due to evolutionary disagreements between the positive and negative rates of period change and the high-amplitude pulsation modes, further investigations of BLAP-014 are definitely warranted to determine the evolutionary changes in this source.

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[1] https://vizier.u-strasbg.fr/

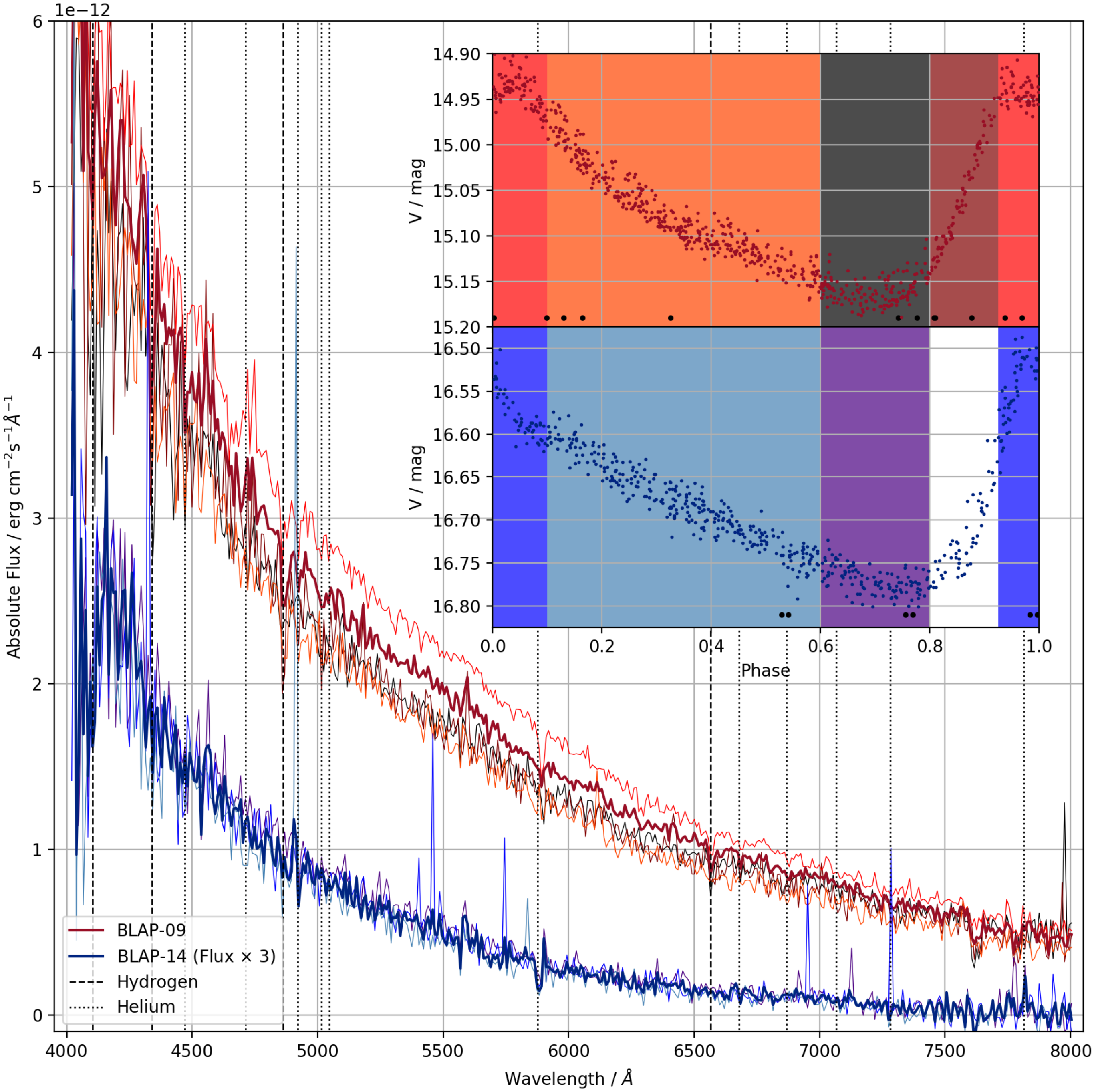

Figure 1. Spectra with red-hue represent BLAP-009: Black - minimum; brown - fast-rise; red - maximum; orange - slow-fall. The thick dark red spectrum is the median stack of all spectra. Spectra with blue-hue represent BLAP-014: Indigo - minimum; white - no data; blue - maximum; light blue - slow-fall. The thick navy blue spectrum is the median stack of all spectra. In the inset, dark red and navy blue dots are the phased OGLE data from P17. Black dots show the phases during which individual exposure began. Data can be found at https://telescope.livjm.ac.uk/cgi-bin/lt_search under the Proposal ID `JL18A12`.

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