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New Galactic Candidate Luminous Blue Variables and Wolf-Rayet Stars

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Abstract. We have undertaken a near-infrared spectral survey of stars associated with compact mid-IR shells recently revealed by the MIPSGAL (24 μm) and GLIMPSE (8 μm) *Spitzer* surveys, whose morphologies are typical of circumstellar shells produced by massive evolved stars. Through spectral similarity with known Luminous Blue Variable (LBV) and Wolf-Rayet (WR) stars, a large population of candidate LBVs (cLBVs) and a smaller number of new WR stars are being discovered. This significantly increases the Galactic cLBV population and confirms that nebulae are inherent to most (if not all) objects of this class.

Keywords. stars: emission-line, Be, stars: mass loss, stars: winds, outflows, stars: Wolf-Rayet

1. Introduction

Despite intensive search efforts over the last several decades the Galactic Luminous Blue Variable (LBV) population has remained sparse. This paucity is difficult to reconcile with our understanding of stellar evolution of the most massive stars. Until the last year or two there were only 12 confirmed Galactic LBVs known, and 23 candidate-LBVs (Clark *et al.* 2005). LBVs display rather unique rich infrared emission line spectra, including contributions from H, He, Mg II, Na I, and Fe II. Visual inspection of the *Spitzer* GLIMPSE (Benjamin *et al.* 2003) and MIPSGAL (Carey *et al.* 2009) Galactic plane surveys have produced catalogues of previously unknown 8 μm and 24 μm nebulae with concentric point sources that can be traced back to 2MASS K-band or even optical sources as possible progenitors of the associated nebulae (Gvaramadze *et al.* 2010a, Wachter *et al.* 2010), especially with new imaging (Stringfellow *et al.* 2012). We are conducting a near-IR spectral survey to identify new cLBVs and WRs that produced these shells.

2. Observations and Results

We have obtained spectra of ∼50 stars associated with newly discovered mid-IR nebulae using SpeX on the NASA IRTF 3m, Triplespec on APO 3.5m and Palomar Hale 5m, and ISAAC on the ESO-VLT. A few of the K-band spectra are shown in Figure 1. The

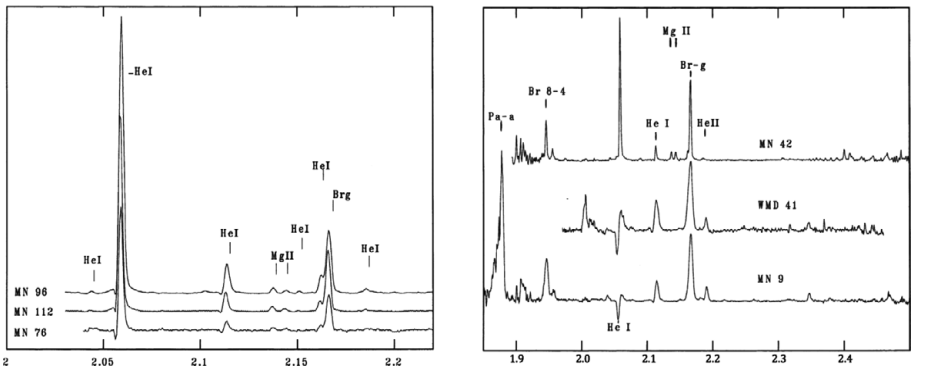

Figure 1. Normalized K-band spectra of newly identified cLBVs and WRs. See Figure 1 of Stringfellow *et al.* 2012 for images identifying MN 96, including optical recovery in the I-band.

left panel shows three newly identified cLBVs that have Fe II emission absent in their IR spectra. Prominent line emission arise from He I, Br γ, and Mg II. A spectrum of MN 96 (WMD 54, Wachter *et al.* 2010), is discussed in Wachter *et al.* (2011), who notes the similarity between both LBV and WR late-type WN spectra for this particular star. Our spectrum clearly indicates the absence of any He II 2.189 μm line emission. Comparison of an optical spectrum of MN 112 with that of P Cyg rendered classification as a cLBV (Gvaramadze *et al.* 2010b); both spectra display numerous optical Fe III lines, but no Fe II line emission. The absence of the 2.089 μm Fe II line in the MN 112 K-band spectrum is consistent with a higher temperature in this line emitting region. MN 76 (WMD 38) was classified as a Be star (Wachter *et al.* 2011), though no spectrum was shown. Clearly the K-band spectra for these three stars - MN 96, MN 112, and MN 76 - are nearly identical (barring small differences in line widths and strengths), and should render the same IR spectral classification. These stars could be transitional between the LBV and late-WN stars, or have spectral types varying between minimum contraction to maximum expansion, corresponding to hot and cool temperature phases, respectively. VLT spectra for two WRs, WMD 41 (WN8-9h) and MN 9 (WN7-9h), are displayed in the right panel of Figure 1 along with the VLT spectrum for the cLBV MN 42 (WMD 15). The WR spectra lack Mg II emission and display broader H and He lines than the cLBVs. MN 42 was classified as B[e]/LBV by Wachter *et al.* (2011) though no spectrum was shown. MN 42 resembles those cLBVs shown in the left panel, lacking Fe II emission, strengthening the case that the FeII-deficient cLBVs may be transitioning to late-WN stars. We designate MN 42, MN 76, MN 96, and MN 112 as currently FeII-deficient cLBVs.

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