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Spectroscopy and Near-Infrared Photometry of the Helium Nova V445 Puppis

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Abstract. Nova Puppis 2000 (V445 Pup) has been proposed as the first example of a helium nova. Recent optical spectroscopy of V445 Pup at V = 19.91 mag obtained with IMACS on the 6.5-m Magellan telescope, shows that the spectrum consists of He I, [O I], [O II] and [O III] emission lines and no hydrogen is present. The spectroscopy shows an expanding nova shell with blue- and redshifted velocity components around ± 850 km s^{-1} and ± 1600 km s^{-1}. Images taken with Magellan under very good seeing conditions (FWHM $\sim 0.6''$) shows V445 Pup to be extended (full width at zero intensity $\sim 1.9''$) and elongated (position angle $\sim 150°$). We have followed the secular evolution of V445 Pup since the decline from (optical) maximum, at near-infrared wavelengths (J, H and K_s) using the Infrared Survey Facility (IRSF) at the Sutherland site of the South African Astronomical Observatory. We find that V445 Pup is still covered by a dense dust shell more than three years after its outburst.

V445 Pup, the very first example of a helium nova (Ashok & Banerjee 2003; Kato & Hachisu 2003), is unique in many respects; it is hydrogen-deficient (Wagner, Foltz & Starrfield 2001; Ashok & Banerjee 2003), enriched in helium and carbon, and the initially formed optically thin dust shell has developed into an optically thick dust shell (Henden, Wagner & Starrfield 2001; Woudt 2002) which still obscured the nova in 2004 August.

Kato & Hachisu (2003; these proceedings) modelled the optical light curve of V445 Pup and deduced various (model-dependent) parameters for the system: a mass of the primary (M_1) ≥ 1.33 M$_\odot$, a mass-transfer rate ($\dot{M}$) of several times 10^{-7} M$_\odot$ yr^{-1}, and an estimated recurrence time of ~ 70 yr (based on the ignition mass of several times 10^{-5} M$_\odot$). The short recurrence time between nova outbursts and the weak photospheric wind, results in the white dwarf continuously growing in mass. This makes the high-mass white dwarf of V445 Pup a prime candidate progrenitor of a type Ia supernova. Alternatively, it could end up via accretion-induced collapse as a neutron star (Kato & Hachisu 2003). Whatever the outcome in the evolution of V445 Pup, this nova provides an important opportunity to study the secular behaviour of a helium nova.

Determining the distance to V445 Pup is of importance to distinguish between the three likely possibilities for the parent population of these helium novae: 1. ultracompact binaries of the AM CVn-class of cataclysmic variables (CVs) (see Warner (1995) and Nelemans et al. (2004)), 2. CVs with helium donors (Iben & Tutukov 1991), or, 3. a high $\dot{M}$ hydrogen accretor.

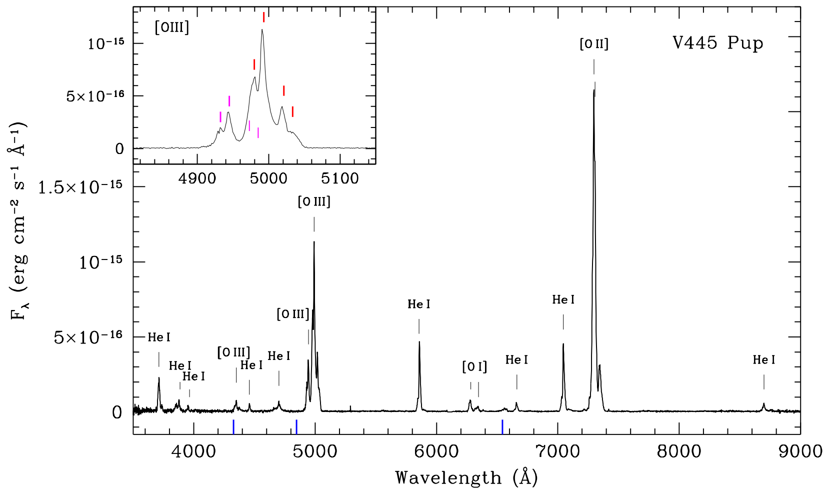

Figure 1. An optical spectrum of V445 Pup, taken on 2003 December 17 (three years after the helium nova outburst) with the 6.5-m Magellan telescope and the imaging spectrograph IMACS. The spectrum consists of emission lines of He I, [O I], [O II] and [O III], blueshifted either around -850 km s^{-1}, or around -1600 km s^{-1}. The [O II] and [O III] lines also have redshifted components at $+850$ km s^{-1} and $+1600$ km s^{-1}, as illustrated in the zoomed view of the [O III] lines. Note the very weak continuum. The small vertical lines below the continuum indicate where hydrogen lines ought to have been if present.

Our detection of an expanding nova shell (see Figure 1) offers the opportunity to determine the expansion parallax of V445 Pup through high angular-resolution imaging in combination with long-slit spectroscopy. No hydrogen features could be detected, suggesting extreme He/H abundances. For example, we find $EW(5876\text{Å})/EW(H\beta) > 50$.

The near-infrared light curve of V445 Pup (Woudt & Steeghs, in prep.) shows that 3.5 years after the outburst V445 Pup remained covered by a dense dust shell (2004 May: J, H, $K_s = 18.5$, 15.8 and 12.9 mag, respectively). A very large colour excess was still present at that time: $E(J - K_s) \approx 4.8 \pm 0.1$ mag (1999 February (2MASS): J, H, $K_s = 12.3$, 11.9 and 11.5 mag, respectively).

References

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