Unraveling the mysteries of the massive and BRITE stars in Cygnus

Massive stars are rare in the universe, but are important to our understanding of galaxies and the distant universe. Their large luminosities make them appear bright from large distances, which is why 40% of naked-eye stars are massive stars. The recently launched BRIght Target Explorer – Constellation (BRITE-Constellation) is a network of 6 nanosatellites that will revolutionize our understanding of massive star physics by obtaining millimag-precision photometry of the brightest stars in the sky.

During the summer of 2014 (starting near the beginning of June), the BRITE satellites will be observing the constellation Cygnus. Among the ~15 stars for which we will obtain data in the field, two of these stars are extremely important to also obtain high signal-to-noise optical spectroscopy concurrently: Deneb and P Cygni. Here, we outline some things already known, some mysteries, and how professional-amateur collaboration can truly help in examining the problems.

Deneb, the brightest star in Cygnus, is an anchoring star in the Summer Triangle. It is a prototype of A-type supergiants, which are amongst the visually most luminous stars in the Universe. Recent work has even suggested that these stars could be used as extragalactic distance indicators, making these stars of cosmological importance. While there is a whole class of alpha-Cygni variable stars, the actual variability of alpha Cygni (Deneb) is very poorly documented, with only 3 studies into the photometric behavior, and only 5-6 studies of the radial velocity changes caused by pulsations. The H-alpha profile shows a weak P Cygni profile, and is extremely variable during the timescales of weeks-months (see review in Richardson et al.~2011, AJ, 141, 17).

Figure 1: Radial pulsations seen in Deneb, documented by photometry (top) and radial velocities from the Si II 6347,6371 A absorption lines.

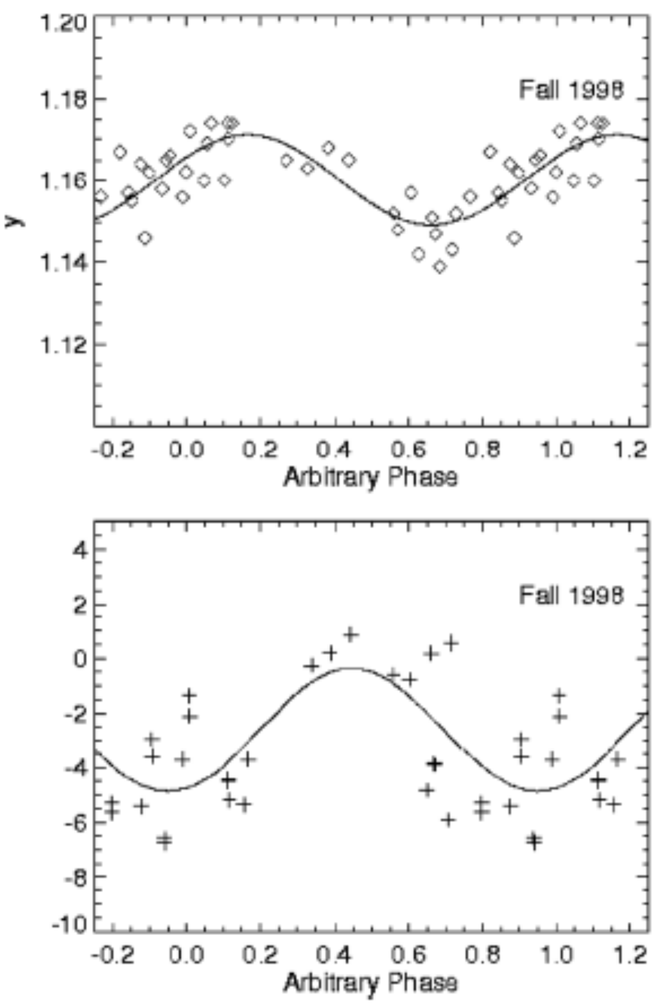

Figure 2: The variable H-alpha line of Deneb (from Richardson et al. 2011)

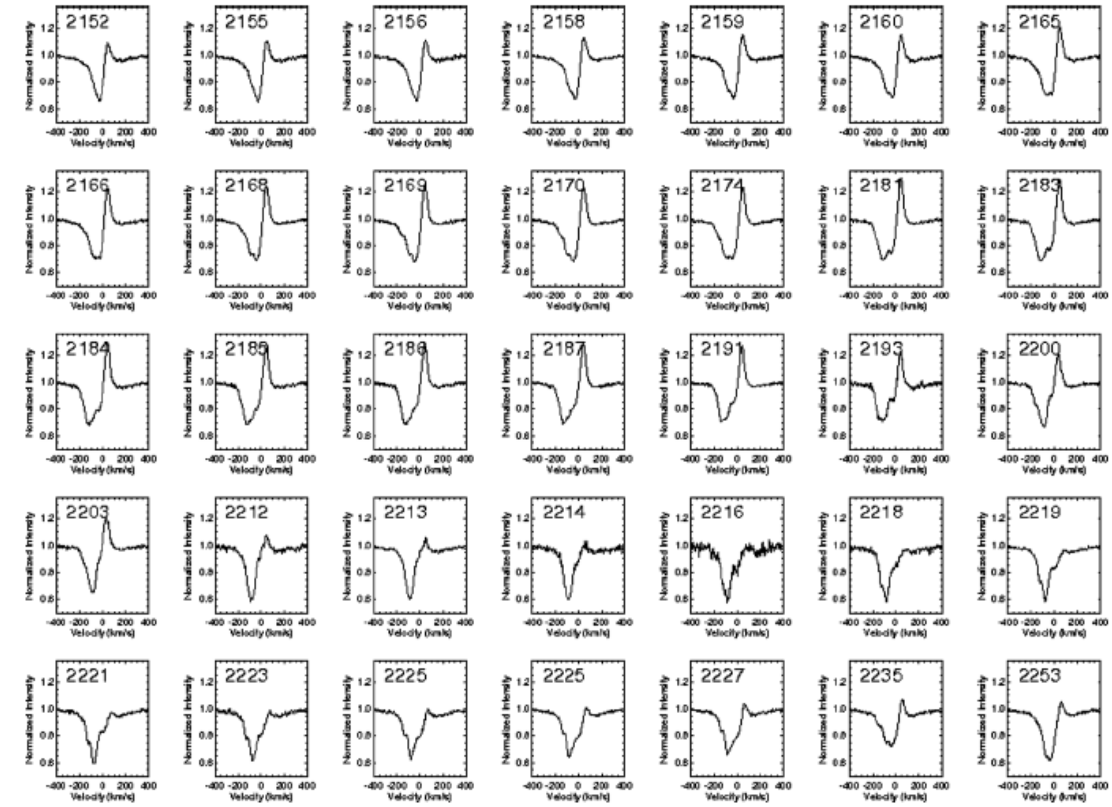

Figure 6. Line profiles of Hα observed during the major 2001 absorption and emission event. Features to note are the development of deep secondary and tertiary absorption components, the increase in the Hα emission, and the near disappearance of the emission component beginning at HJD 2452214.5. All spectra are normalized to unity in the continuum and are plotted in the rest frame of Hα. The HJD − 2450000 is shown to the nearest integral day in each plot.

Our goal for the supporting spectroscopy is two-fold. First, we wish to document the changes in the atmosphere from radial velocity shifts and line profile variations, especially photospheric absorption lines such as Si II 6347, 6371. The variability of H-alpha and H-beta will allow us to look for a connection between the wind variability and the photosphere, which is highly unknown and would have implications on if the star has a magnetic source of variability.

P Cygni, a prototype for the luminous blue variables (LBVs), is one of the most interesting stars in the northern sky. It experienced great eruptions in 1600 and 1654, where it lost about a tenth of a solar mass over the short time scale of a few weeks. The cause of that is still unknown. The variability has been studied through several studies, and the star is a known favorite of many amateur spectroscopists. The P Cygni profile is named after this star because its optical spectrum has this type of profile for almost every spectral line. The wind of the star is very strong, and it loses somewhere around 10^28 kg of matter into space every year. The LBVs are vastly misunderstood, and the long-time-series of precision photometry and spectroscopy could yield new insights into the structure that were previously unknown.

Figure 2: The H-alpha profile of P Cygni (based on data from Richardson et al. 2011, AJ, 141, 120)

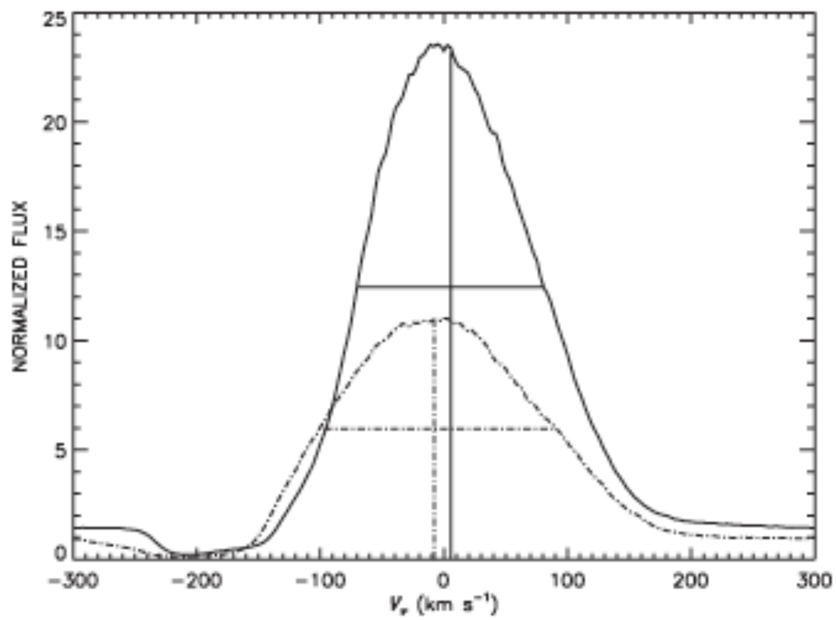

Figure 4. Comparison of two observed Hα profiles corresponding to extremes of the emission variability (maximum and minimum in corrected equivalent width). The spectrum plotted as a solid line is from HJD 2,452,070, while that shown as a dash-dotted line is from HJD 2,450,004. Vertical and horizontal line segments show the velocity offset ΔV_r and the FWHM range, respectively.

The primary goal will be to connect different wind lines to the photometric variations. Therefore, we need high S/N spectroscopy of H-alpha, and H-beta, He I lines (6678, 5876, 7065, …), Fe II lines (such as 5169) and any other wind lines. The changing characteristics of these lines (probed at high temporal resolution) along with the continuum variations (from BRITE) could lead to either the discovery of pulsations or a detailed model of the size of the wind and determination of where different emission lines form.

The campaign and data

Please send reduced spectra to Noel Richardson (richardson@astro.umontreal.ca). We hope for at least one spectrum of Deneb each day starting as soon as possible, and continuing through the end of 2014. For P Cygni, we hope to have 3-4 spectra per day to sample many different time-scales in the star.

For observers with an LHIRES spectrograph, we ask that you concentrate on H-alpha for both targets, and then obtain a spectrum of the Si II 6347-6371 lines for Deneb. Observers with an eshel spectrograph are especially encouraged, as they can record the entire optical spectrum with one exposure.

Note that the H-alpha emission line of P Cygni is very strong. Observers are cautioned that they may need short exposures for H-alpha and longer exposures for the remaining part of the spectrum. We also ask observers to try to obtain a spectrum of zeta Aql for telluric line correction on the same nights of observing the targets.

Star	**RA**	**DEC**	**V mag**
Deneb	20 41 25.9	+45 16 49.2	1.3
P Cyg	20 17 47.2	+38 01 58.6	4.7
Zeta Aql (standard)	19 05 24.6	+13 51 48.5	3.0