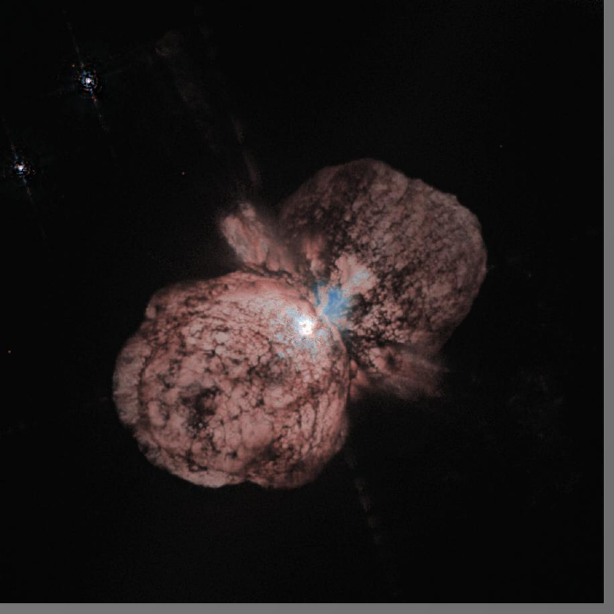
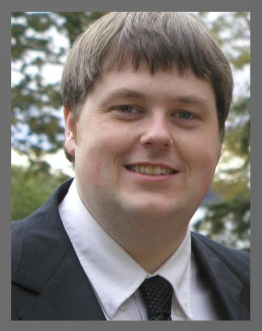


THE LINE PROFILE VARIATIONS OF ETA CARINAE THROUGH THE 2009.0 SPECTROSCOPIC EVENT



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Abstract: We report on high resolution echelle spectroscopy of the 2009.0 spectroscopic event of η Carinae that we collected via SMARTS observations using the CTIO 1.5m telescope and echelle spectrograph. Our observations were made almost every night over a two month interval around the predicted minimum of η Car. We observed a dramatic fading of the Hα line emission that reached a minimum six days after the X-ray minimum. About 15 days prior to the Hα flux minimum, the Hα profile exhibited the emergence of a broad, P Cygni type, absorption component (near a Doppler shift of -500 km/s) and a narrow absorption component (near -144 km/s and probably associated with the intervening gas from the Little Homunculus Nebula). We also observed the He I 6678 line. The line profiles are similar to those observed during previous events, and the temporal variations are consistent with qualitative expectations about changes in the primary star's stellar wind that result from the wind-wind collision with a massive binary companion. Future work will include analysis of many more transitions.

Hα Variability

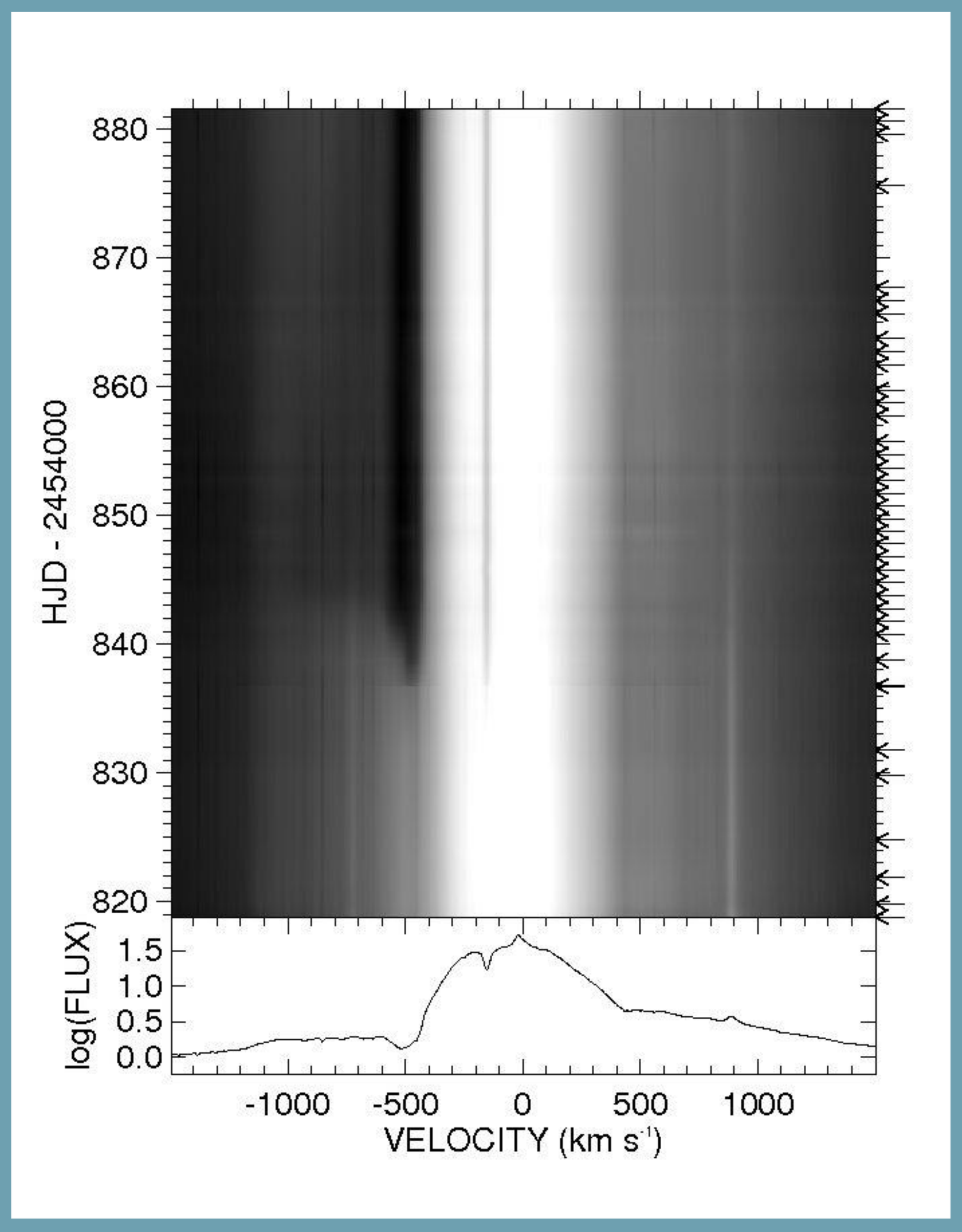


Figure 1: A gray scale representation of the Hα profiles, where the intensity is scaled to the logarithm of the normalized flux in order to display lower contrast features. The profile in the bottom panel represents the average logarithmic profile. Arrows along the right note the actual times of our observations. The narrow absorption at −144 km s−1 and the P Cygni absorption at −500 km s−1 both appear to strengthen near HJD 2454837, just prior to phase 0.0.

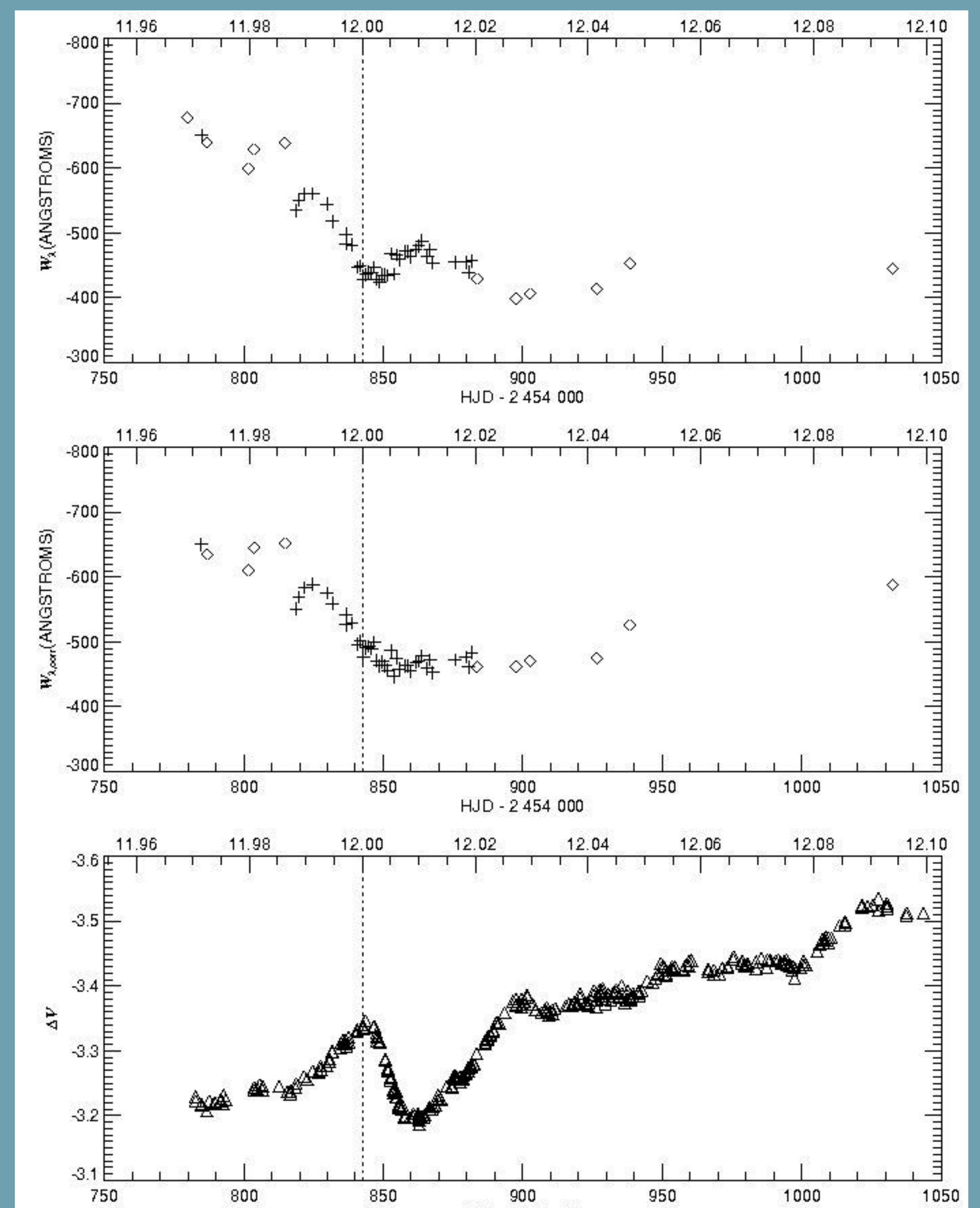
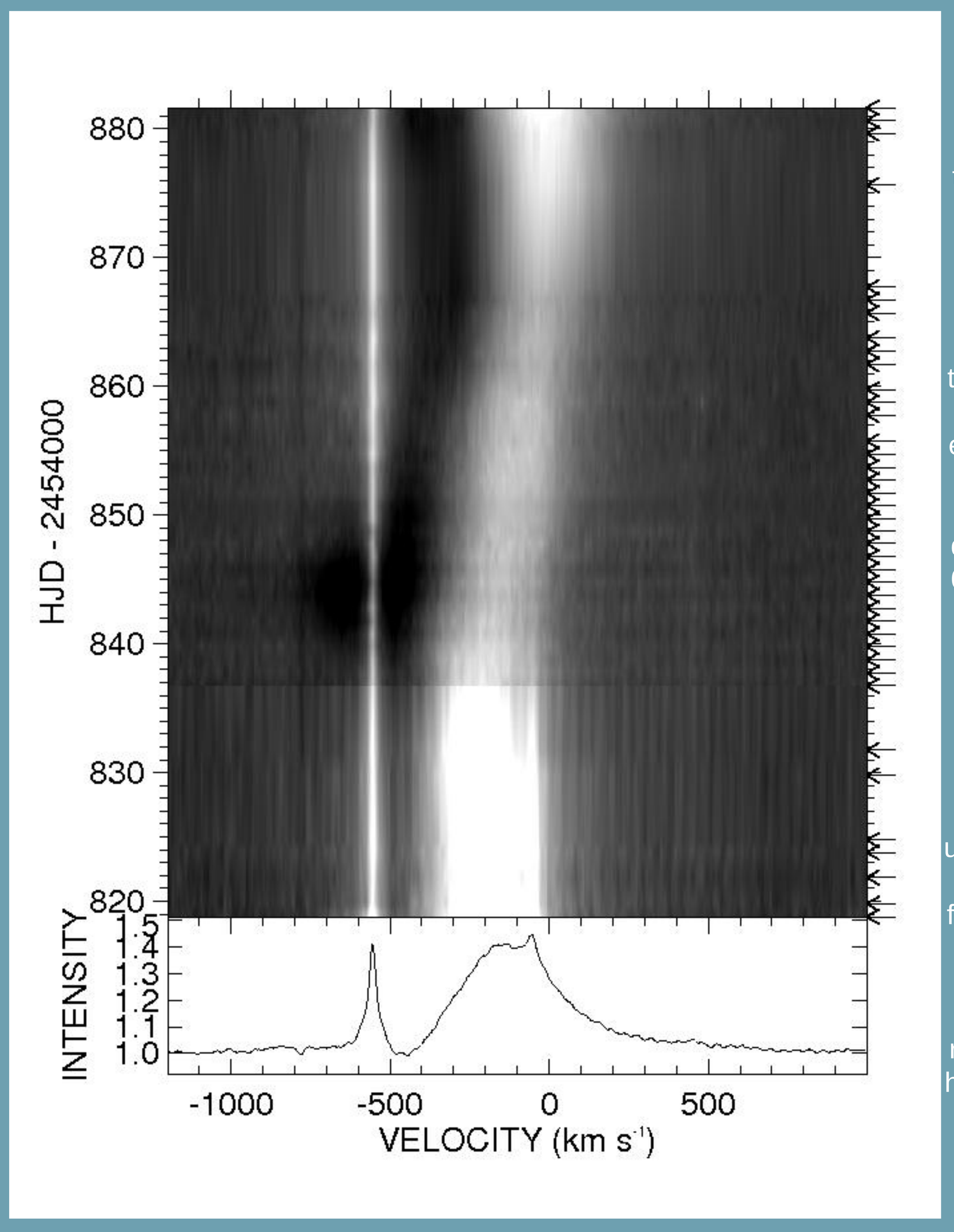


Fig. 2.— The temporal variations of Hα strength and V -band magnitude. In each plot the abscissa represents the date (bottom) or phase (top). Phase 0.0 from Damineli et al. (2008) is marked in each plot with a vertical dotted line. The top plot shows the equivalent width derived from spectra obtained with the RC spectrograph (◊) and with the echelle spectrograph (+). The middle plot shows the equivalent width corrected for the changing continuum flux that is documented by the differential V -band photometry in the lower plot (Fernandez-Lajus et al. 2009). The V -band photometry shows that an eclipse-like event began shortly after phase zero and was followed by a general increase in brightness.

An initial paper describing the Hα variations in much more detail has been accepted in AJ. Copies available by emailing richardson@chara.gsu.edu

He I Variability



Figures 3 displays grey scale plots of the HeI 6678 line as η Car progressed through the 2009.0 event. There is a fading of line emission as seen in the Hα observations. There is a narrow emission component seen near -50 km/s that fades and disappears at phase 0.0 (by the definition of Daminelli et al. 2008.). Our observations show that this component disappears at the expected epoch. Also, the profile undergoes a massive radial velocity shift from blue to red near phase 0.0. There is also a [Ni II] line (~-540 km/s) which remains present, but has a small decrease in strength through the event.

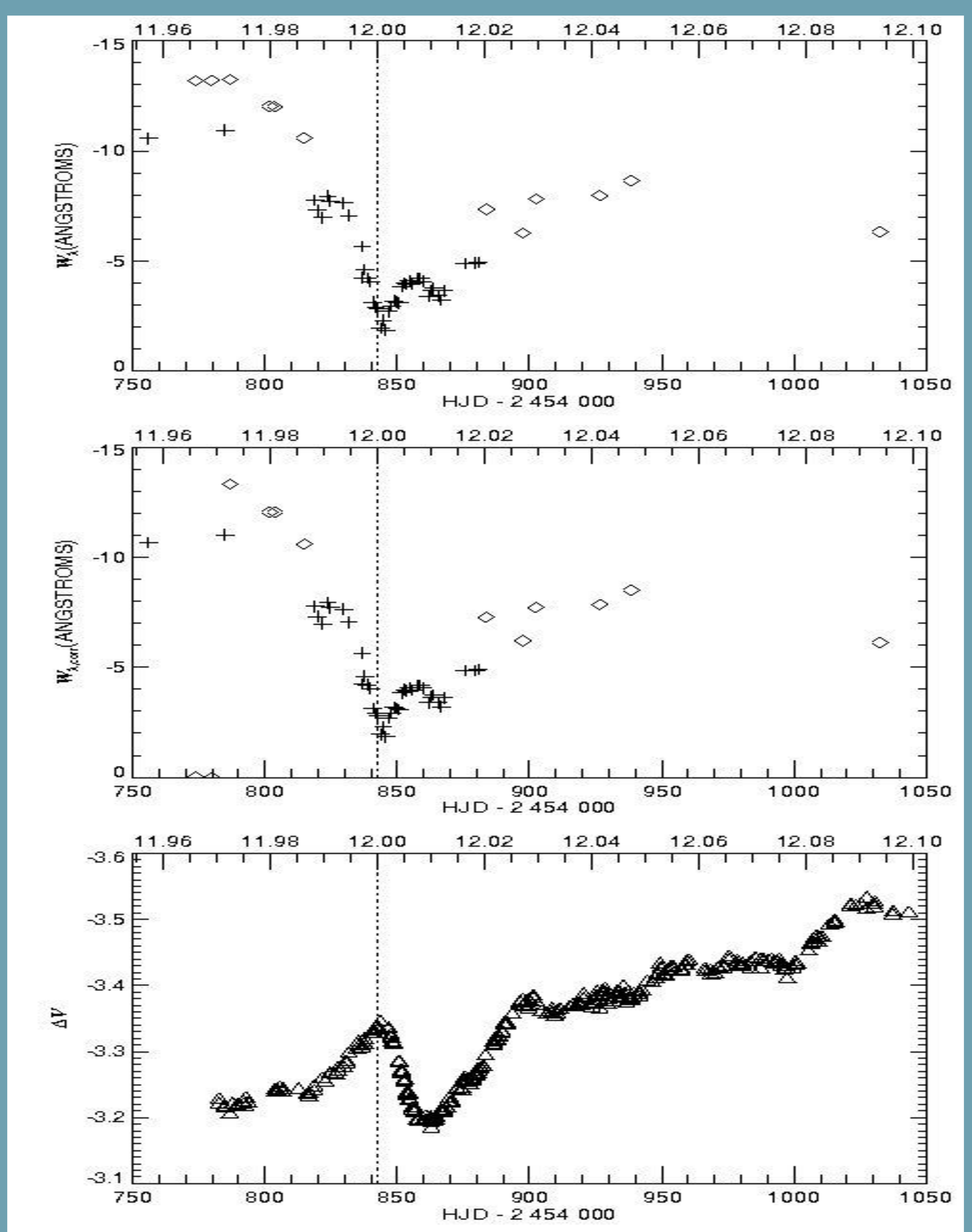
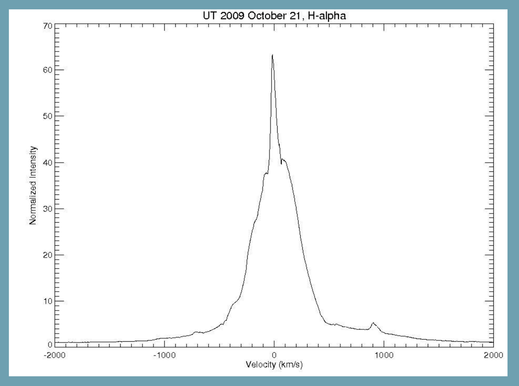
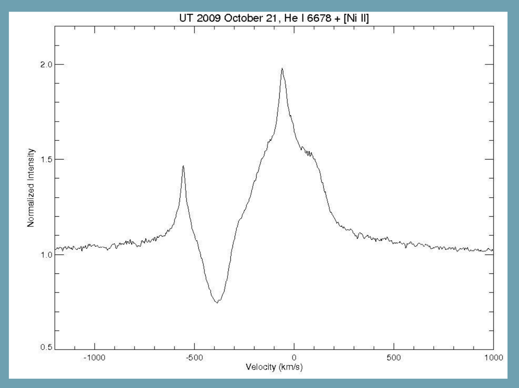


Figure 4 - The temporal variations of the He I 6678 and V-band magnitude. The plots are similar to Figure 2 (Hα). The overall minimum of the integrated flux is at the predicted minimum (phase 0.0). There is a second minimum that happens during the V-band eclipse-like minimum. The correction for a changing continuum is much less pronounced with the He I lines due to a much lower contrast in the line flux with the continuum.

Post-Event Observations





Figures 5 & 6 (left): We have begun a continued monitoring of η Car with the echelle spectrograph on the CTIO 1.5m telescope. Shown here are our first observations obtained in 2009B (October of 2009). We are trying to obtain at least one observation per week while the star is observable. The echelle spectrograph was upgraded in December, so no observations were obtained in December 2009.

Note the P Cygni absorption in the He I line, and the disappearance of the P Cygni and anomalous absorption in the Hα line. The narrow emission component has returned in the He I line(s).

Observations will continue through all of 2010.

Qualitative Model

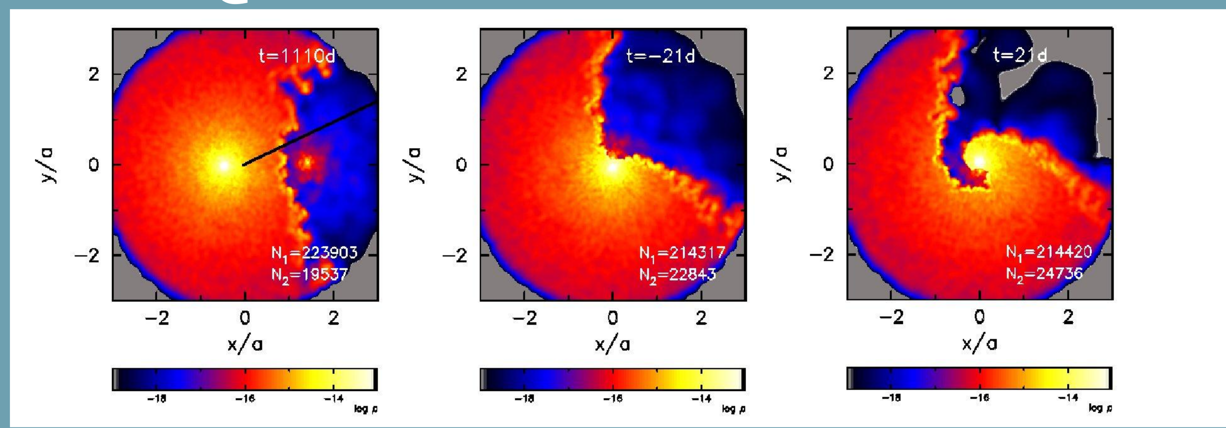


Figure 7: Isothermal models of the colliding winds in the binary system from the simulations by Okazaki et al. (2008). Each panel shows a density map in the orbital plane (in spatial units of the semi-major axis). The left panel shows the primary (surrounded by its wind; left side) and the secondary (dot on right side) at maximal orbital separation. We expect the Hα flux to form in the densest regions of the wind. Our assumed line of sight is indicated by the black line in the left panel (inclined by 45 from below the plane of the figure). The time in days relative to periastron is given in the upper right of each panel, and the diagrams show how the colliding winds change the density distribution from the usual situation near apastron (left) to that at times just before (middle) and after (right) periastron.

Conclusions

- The narrow feature observed on the He I lines collapsed and disappeared at the predicted minimum.
- The line profile variability is qualitatively similar to previous events, and support a wind-wind collision, and collapse of the emitting region of the system near periastron.
- **Our temporal resolution will provide the necessary observations to model the system and lead to an understanding of the enigmatic binary star.**
- The large number of lines present in our data are being analyzed and the timing effects of the collapse of the various lines will lead to a better understanding of the wind structure and geometry of the system, especially near periastron.

Acknowledgements

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