Emission Line Variability in XX Ophiuchus

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ABSTRACT

We present the results of an analysis of nine years of spectra taken with the Coudé Feed telescope at KPNO of the Iron Star XX Oph. In addition to numerous iron lines, other metals such as Ti and the hydrogen Balmer series are seen in emission. Our study covers the years 2003 to 2012 and includes an episode in 2004 where photometry from the AAVSO shows a 1.5 magnitude drop in brightness. A corresponding change in the spectral features of the star including variations in the equivalent width of the most prominent lines is discussed.

BACKGROUND

There is only one other known “iron star”, AS 325. Its spectrum is similar to XX Oph’s that the physical nature of the two is likely identical. Howell et al. (2009) have proposed a model of the AS 325 system shown below. The XX Oph system is likely similar. The H emission lines are likely from the Be star’s wind and the metallic emission lines originate in the shock region where the Be star wind collides with the slower moving but denser M star wind.

Model of AS 325 from Howell, et. al. (2009)

REFERENCES

AAVSO data: http://www.aavso.org
Bopp & Howell, 1989 PASP, 101, 981
Cool et al., 2005 PASP, 117, 462
Howell et al., 2009 PASP, 121, 1
Merrill, 1924 PASP, 36, 225

RESULTS and DISCUSSION

We have acquired high signal-to-noise spectra of XX Oph from 2003-2012 using the Coudé Feed Telescope at KPNO. Samples are shown below in the blue spectrum from 3750 – 5100 Å. Spectra in the red from 6400 – 9000 Å are not shown.

AAVSO Light Curve

The plot below shows the light curve of XX Oph from AAVSO data for the period 2003 to 2012. Note the drop in brightness during 2004. The green data points are V magnitudes from CCDs, all other points are visual estimates. The arrows indicate the dates on which we acquired the two spectra shown above.

Three of the plots above show the change in the equivalent width (EQW) of the absorption (blue diamonds) and emission (blue triangles) components of the P Cygni profiles for Hδ, Hγ and Hβ as a function of time. The fourth plot shows the variation in the ratio of the EQW of the absorption to the emission components of each line. A timeline of spectral changes:

- September 2003: Our last spectrum prior to the March 2004 photometric event. Weak or no P Cygni profiles.
- March 2004: Shown as a vertical pink line above, this marks the approximate beginning of the photometric event.
- June 2004: Our first spectrum after the March 2004 photometric event. Emission strengths have increased by a factor of 2-3, but the absorption component is either absent or weakly present.
- March 2005: P Cygni profiles are now present in all Balmer and metal emission lines. The absorption component peaks while the emission component has weakened by a factor of 2 or more from its maximum in June 2004.
- After March 2005: The Balmer emission strength continues to decrease to less than values in 2003. Absorption strength decreases but remains above its near zero value prior to the March 2004 event.
- May 2012: Emission line strengths may be increasing. Additional spectra from October 2012 and future 2013 spectra will determine if this trend is real.

- A Balmer emission is from the hot wind of the Be star; metal-line emission arises in the shock region where the Be star wind strikes the slower moving, denser wind from the M star. P Cygni absorption lines arise in the expanding but denser material around each star in the system.
- It is noteworthy that all 3 Balmer lines have no or weak P Cygni profiles prior to the March 2004 event.
- Balmer emission line strength increases dramatically after March 2004, but prior to the appearance of P Cygni profile absorption lines; which we did not detect until our March 2005 observations.
- The overall system shows a dimming of light in 2004; the subsequent rise in the Balmer absorption strength corresponds to a decrease in the Balmer emission strength.

Future Work

- Analyze additional nights of archival and future coude spectra from 2008-2013
- Examine the change of line strength in metallic species of different ionization levels

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