

A Search for the Secondary Spectrum of ϵ Aurigae

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1. The observations

The enigmatic long period ($P=27.1$ yr) eclipsing binary, ϵ Aurigae, recently emerged from its 2009–2011 eclipse. We have analyzed out-of-eclipse observations (Chadima *et al.* 2010) obtained over the past 17 years: 306 medium-resolution, high S/N, spectroscopic observations from 6300–6700 Å. Of these, 105 spectra were obtained at the Dominion Astrophysical Observatory (DAO) near Victoria, Canada, from 1994–2010, and 201 spectra were obtained at Ondřejov Observatory (OND), from 2006–2010. Analyzing these data, Chadima *et al.* (these proceedings) reported on a positive, but ultimately spurious, detection of a secondary spectrum. Their attempts at disentangling the binary spectra were foiled by line profile variations of the F star primary. The 6300–6700 Å spectral region contains several strong stellar lines but space limitations allow us to present only the results for Si II 6347 Å. We examine the centroids and higher moments of this prominent F star spectral line for any evidence of a secondary spectrum. Even if secondary contributions are blended with the F star lines, contamination by the secondary star should produce a centroid shift that is anti-correlated with the orbit of the F star primary.

2. The analysis

The stellar line profiles observed in ϵ Aur are quite asymmetric (Figure 1a), and vary on timescales of 50–100 d (Chadima *et al.* 2011), complicating the detection of radial velocity (RV) variability from the companion. Spectra were transformed to the F star reference frame using the Chadima *et al.* (2010) orbital solution. Observations acquired after the start of spectroscopic eclipse, taken to be JD 245 4850, were discarded because of strong absorption from the companion's disk. A small number ($\sim 10\%$) of low S/N observations were omitted. Also, two DAO observations with highly anomalous shifts of tens of km s^{-1} were rejected. This left 163 spectra: 76 DAO and 87 OND observations. These spectra were then cross-correlated with DAO or OND reference standards, using a spectral region of weak stellar lines (6375–6447 Å), to remove intrinsic stellar radial velocity (RV) variations (Figure 1a). The velocity corrections found were typically small ($\sim 3 \text{ km s}^{-1}$). Then, the first four central moments μ_1, \dots, μ_4 , were evaluated, and the line centroid μ_1 (Figure 1b), width $\sigma = \mu_2^{0.5}$, and skewness $\gamma_1 = \mu_3/\mu_2^{1.5} = \mu_3/\sigma^3$ were derived for each observed profile. We also evaluated mean profiles for each quintile of orbital RV, because any profile anomalies associated with the companion should be negatively correlated with the F star's orbital RV, and thus with the RV quintiles.

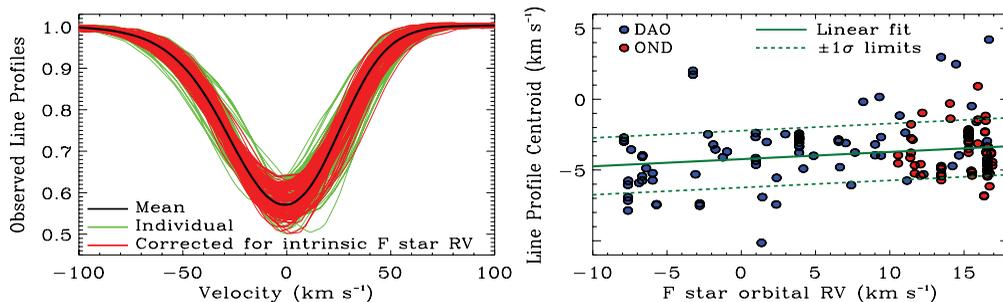


Figure 1. (a) Left: The 163 individual profiles of Si II 6347 Å observed from 1994–2010. Green profiles are in the F star frame, red are corrected for intrinsic RV variations, the black curve is the mean profile. (b) Right: Centroids of DAO (blue) and OND (red) out-of-eclipse observations.

3. The results

The mean line absorption profile of Si II 6347 Å is significantly asymmetric. One possibility is that the intrinsic F star line profiles are symmetric, and these asymmetries are produced by additional absorption or emission from the companion star. Since any absorption or emission from the companion should be negatively correlated with F star orbital phase, a phase-dependent asymmetry should be present in the observed line profiles. To reduce the observed RV scatter, mean line profiles were computed for observations in each of five equal bins, or quintiles, of the F star's orbital RV (Fig. 2).

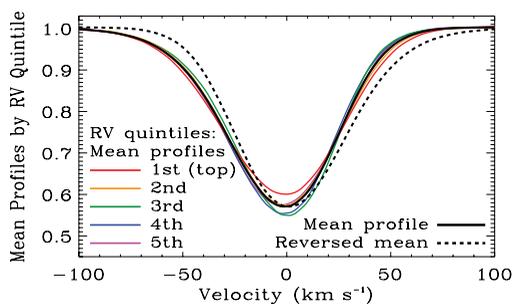


Figure 2. Mean profiles of ϵ Aur Si II 6347 Å, computed over F star RV quintiles. The overall mean profile is solid black; the mirror-reversed mean profile is the dashed black curve.

4. Conclusions

In the far ultraviolet, ϵ Aur has an emission line spectrum (Bennett, Ake, & Harper 2005). However, the quintile centroid shifts of Si II 6347 are too small, and do not show the expected proportional relation to the F star RV, to be consistent with infilling emission. Neither is circumstellar absorption a probable cause, because the line cores are shallowest near the onset of eclipse, when any circumstellar absorption should be large.

We conclude that the line profile variations in the optical spectrum of ϵ Aur do not arise from contamination by the companion. The asymmetric shape of the F star line profiles is probably intrinsic, as is the variability of these profiles.

Acknowledgements

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References

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