APPLICATIONS OF THE DOPPLER IMAGING TECHNIQUE TO THE ANALYSIS OF HIGH-RESOLUTION SPECTRA OF THE 3 OCTOBER 1981 FLARE ON V711 TAURI

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ABSTRACT. An unconstrained four gaussian fit to the Mg II profile near the flare peak indicates that the flare occurred near the central meridian of the K1 IV star, perhaps above a spot. A more likely fit to the same data places the flare at +90 ±30 km s^{-1} relative to the K1 IV star, indicating significant downflowing plasma.

We obtained high resolution IUE spectra with both the SWP and LWR cameras of a bright flare on the RS CVn-type system V711 Tauri. Optical photometry at this epoch (Rodono et al. 1986) implies a two-spot model with central meridian passage of spot 1 occurring at phase 0.17. A flare was detected first in a low resolution, short wavelength spectrum (SWP 15161) at 0512 UT (ϕ=0.183) and then in a high resolution, long wavelength image (LWR 11668) at 0635 UT (ϕ=0.204). Subsequently four LWR high resolution spectra and two SWP spectra were obtained during the flare including a 2 hour high resolution, short wavelength spectrum (SWP 15103) centered at 1208 UT (ϕ=0.285). The peak radiative loss in the temperature range $4.0 < \log T_e < 5.2$ was 3 × 10^{31} ergs s^{-1}, and the estimated total emission was 6 × 10^{35} ergs.

The Mg II k lines were fit with four unconstrained gaussian profiles as described by Walter et al. (1987) and Neff (this volume). Examples of these fits are shown in Fig. 1 for two flare spectra and two non-flare spectra near the other quadrature (ϕ=0.680 and 0.677), where the radial velocities of the G and K stars are reversed. During the flare the flux in the G star remained constant while the flux and width of the K star profile both increased. At flare peak (ϕ=0.204) the centroid of emission was shifted +15±5 km s^{-1} relative to the K star, and the FWHM of the profile (after correction for instrumental broadening) was 85 km s^{-1}, compared to the nonflare value of 60 km s^{-1} and vsini = 38 km s^{-1}.

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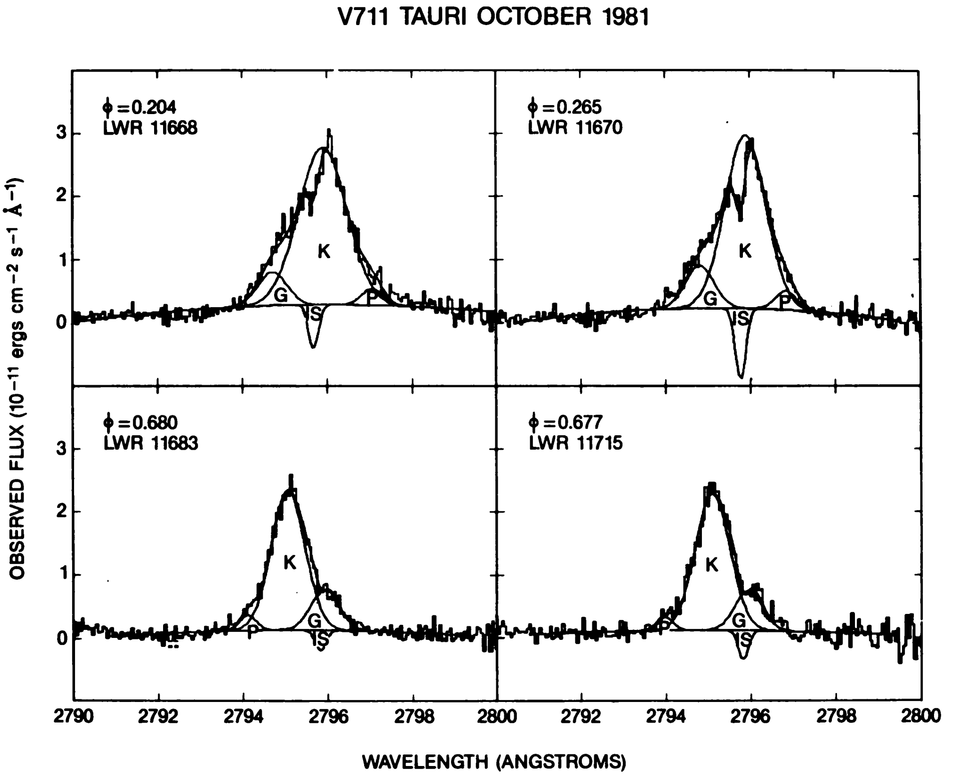

Fig. 1. Observed and four gaussian fits to the Mg II k line profiles for two flare spectra (ϕ=0.204 and 0.265) and two subsequent quiescent spectra near the opposite quadrature (ϕ=0.680 and 0.677). The gaussian profiles are identified with the K1 IV star (K), G5 V star (G), a plage (P), and Mg II interstellar absorption (IS).

In the preceding analysis the known radial velocities of the G5 V and K1 IV stars were not assumed but rather the gaussian profiles with centroid velocities close to the two stars were presumed to represent each star. The natural interpretation of this analysis is that

- the flare occurred near the central meridian of the K star at the time of light minimum and perhaps above spot 1,
- the flaring plasma showed little line-of-sight motion,
- the plasma was highly turbulent with additional broadening corresponding to a gaussian FWHM of about 60 km s^{-1}.

Analysis of the rather noisy C IV 1548 Å profile obtained from the high resolution SWP spectrum is consistent with the flare occurring near the central meridian and perhaps over spot 1 of the K1 IV star, and thus with solar analogy in which flares occur over spots.

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There is an alternative and we believe more plausible interpretation of the same data. Outside of the flare the integrated Mg II fluxes are nearly constant for each star. We have therefore refit the flare peak profile (Fig. 2), constraining the Mg II fluxes and widths to be the mean nonflare values for each star and the centroids of the gaussians for the G and K stars to lie at the known radial velocities (relative to the interstellar medium) at ϕ = 0.204. The residual emission is then fit by a fourth gaussian with its centroid at +90±30 km s^{-1}. The flaring plasma must have a significant line-of-sight systematic flow and be turbulent. This flow would be about +90 km s^{-1} downward if the flare occurred over spot 1 or about +50 km s^{-1} (away from the observer) if the flare occurred near the K star receding limb. The Mg II profiles after flare peak did not have sufficient flux in the flare to be fit with this technique.

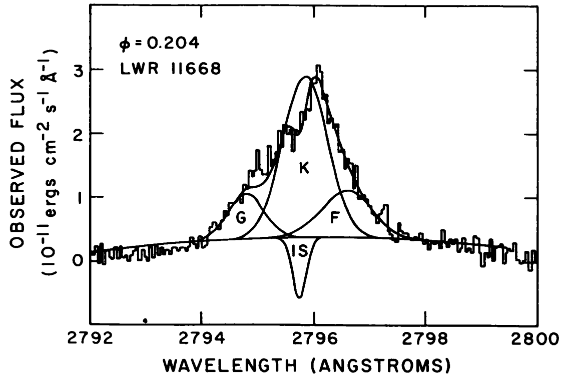

Fig. 2. The observed flare peak Mg II k line profile (ϕ=0.204) and a four gaussian fit for which the strength and width of three gaussians are constrained to be the mean quiescent values for the G star, K star, and interstellar medium and the radial velocities are those predicted. The parameters of the fourth gaussian (F), selected to fit the resulting residuals, can be ascribed to the flare. It is centered at 90 ± 30 km s^{-1} relative to the K star.

We believe that the alternative interpretation (Fig. 2) is more likely, since during the flare most of the K star should be quiescent and thus contribute a mean quiescent profile. During a bright flare on UX Ari, Simon, Linsky and Schiffer (1980) also observed red-shifted Mg II emission but with larger line of sight velocities. A complete analysis of this flare will be published elsewhere. We acknowledge NASA grant NAG5-82 to the University of Colorado.

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