The current state of delta Scorpii´s circumstellar disk

The Hα-emission line profiles resulting from a rotational motion in Be star envelope (additional line broadening mechanisms such as Stark effect and expanding motions will be neglicted). On basis of a calibration of the effective rotation velocity of the star (v sin i) with the half maximum intensity (FWHM = full width half maximum) of the spectral line [1], this FWHM (in km/s) is used as measure for the projected rotation velocity of the disk gas [2]. He found also, that this correlation generally exhibits a certain scatter and non-kinematical contribution for Hα.

The profile and the distribution of the Doppler-broadening of the emission line can be viewed in principle as a Gauss-function. The measured FWHM-velocities of the Hα emission line depends on S/N, since in noisy spectra extended wings can hardly be distinguished from the stellar continuum. In addition it depends on the instrumental profile and on the spectral resolving power R of the used spectrograph. The used spectrograph in this paper was the type LHIRES III with R ~ 17000.

The orbital velocity v of the gas rotating around the star in the envelope decreases with increasing distance from the star according to Kepler´s third law $v \sim r^{(-0.5)}$. Higher velocity corresponds to smaller distance from the primary and vice versa. The Hα FWHM velocity (rotational and/or radial) of the circumstellar matter as inverse indicator for disk diameter in Fig. 1 shows since January 2011 (JD 2455578) until the periastron in July 2011 (JD 2555747) a more or less continuously increase. This means that the diameter of the disk was decreasing until that point.

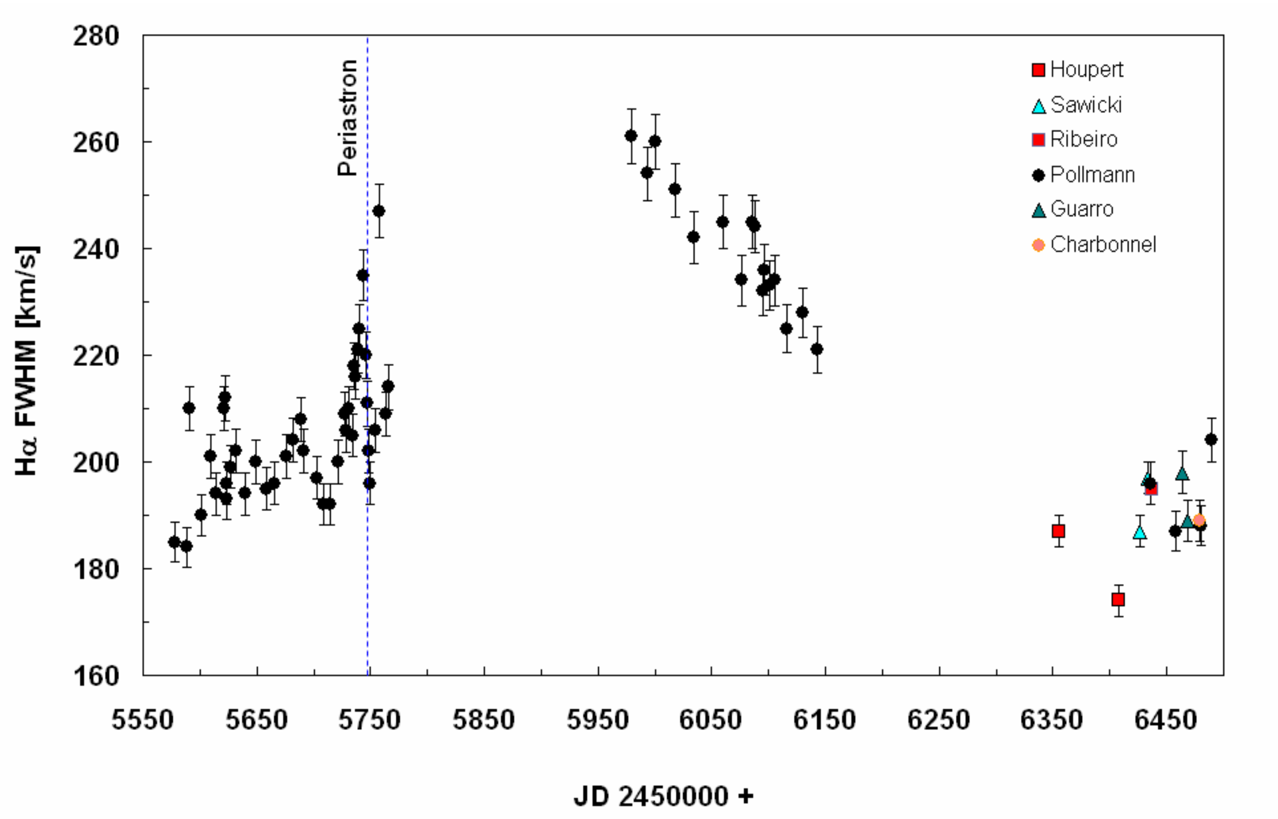

Fig. 1: Time behaviour of the Hα FWHM velocity
before and after the periastron passage July 2011 (JD 2555747)

After the periastron the Hα FWHM velocity did decrease constantly, while the disk diameter increases until now. Unfortunately there is a lack of observation afterwards until February 2012 (JD 2455979). Fig. 2 shows for both sections, before periastron and afterwards until August 2012 (JD 2456131) the Hα FWHM versus optical brightness development based on visual estimations of S. Otero (Argentina) & DSLR measurements of W. Vollmann (Austria).

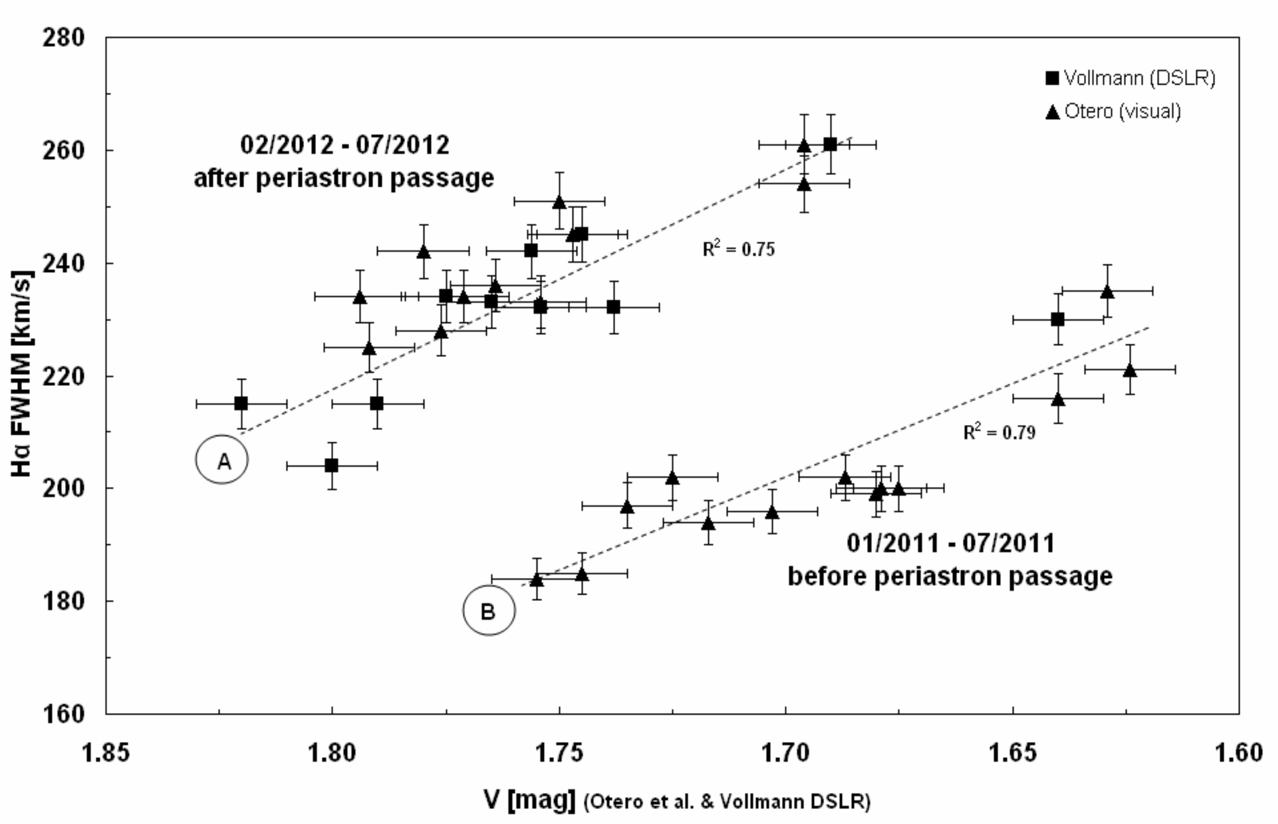

Fig. 2: Inverse correlation between total V brightness of δ Sco and the disk diameter as Hα FWHM. Contemporaneous FWHM measurements in BeSS spectra of F. Houpert, C. Sawicki, J. Ribeiro, E. Pollmann & Vmag measurements of S. Otero & W. Vollmann.

First of all, there is for both curves (A & B) an inverse correlation between the disk diameter (Hα FWHM) and V-mag of better than 0.7. Since the disk absorbs the UV radiation of the primary and re-radiates in the optical and IR regions, a correlation between optical brightness and disk size should exist [3] [4].

Although the result in Fig. 1 shows, that the disk after periastron was much larger than before, in Fig. 2 is recognizably, that δ Sco have had in spite of different disk sizes same brightness, how it is demonstrated by the curves A & B. When we take e.g. V = 1.7 mag or V = 1.75 mag, the difference in disk size between A & B is (according to Kepler´s third law $v \sim r^{(-0.5)}$) approx. 1.7 !

This can be explained by a higher disk density after periastron, because only the disk inner parts contribute to the brightness most significantly. Higher disk density means more radiation from the same area of the disk. A smaller size disk (after periastron) with a higher density will produce the same optical brightness as a larger size disk (before periastron) with a lower density.

However, we have to consider the fact that the disk density effect on the object's brightness may not be easily separated observationally from the disk size effect on it. When new material joins the disk from the star, it starts rotating around the star and also moving away from the star due to the viscous energy transfer. Therefore, the disk grows as the amount of matter increases in it. At the same time the disk density becomes larger at all distances from the star.

If the matter ejection from the star stops, the disk turns into a ring [5]. When a disk becomes a ring, the Balmer lines become narrower, because the most rapidly rotating matter from the inner parts of the disk does not exist. Such an effect should lead to a different behavior of the curves in Figure 2. That means: the curves A and B both depend on the disk size and density, but the density of the disk after periastron is higher than that before it.

The circumstellar disk, viewed at the observed inclination angle, covers half the star disk unless the disk is very small. In the case of δ Sco, one can safely suggest that the disk covered the same fraction of the stellar surface before and after the periastron. Since the disk seems to be optically-thick in the inner regions that covers the star in the observers inclination angle (38°), the star's contribution to the brightness will always be the same.

Acknowledgements:
I am grateful to Prof. Dr. Anatoly Miroshnichenko for his patient support and improvements of this observation report.

References

[1] A. Slettebak et al. “A system of standard stars for rotational velocity determination”, ApJS 29, 137, 1975
[2] R.W. Hanuschik, Astrophysics and Space Science 161, 61-73, 1989
[3] A. S. Miroshnichenko et al. 2001, A&A, 377, 485-495
[4] A. S. Miroshnichenko et al. 2003, A&A, 408, 305-311
[5] Th. Rivinius et al. 2001, A&A, 379, 257

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July 2013