Spectroscopic Observations of δ Sco Through the 2011 Periastron Passage

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Abstract:

We present prelimiary results from a coordinated spectroscopic campaign in 2011, centered on the δ Sco periastron passage in July. Data have mostly been obtained with the FEROS/2.2m at La Silla and ESPaDOnS/CFHT at Mauna Kea echelle instruments. Main results include the absence of tidally induced disturbance to the main β Cephei pulsation mode and the absence of tidally triggered mass-ejection at time of periastron proper. The observed (as far as yet analyzed) variations are compatible with the picture of a disk that is disturbed on its outer radius, with the disturbance propagating inwards *after* the periastron.

Keywords: Astronomy | Spectroscopy | periastron

Article:

1. Introduction

The bright B0 IV β Cephei type star δ Sco (7 Sco, HR 5953, HD143275) has drawn considerable interest in the past decade (see, for instance, contributions by Miroshnichenko et al., Jones et al., Štefl et al., and Bednarski et al. in these proceedings). It is a high eccentricity binary (e = 0.94) with a period of about 10 years. In July 2000, close to a periastron, a rapid brightening occurred, and spectra showed Hα emission, making it the second brightest Be star. Initially thought to be an example of tidal mass ejection during periastron, it became clear afterwards that the periastron occurred about two months after the brightening, in September, and the disk was present already months before (see Miroshnichenko et al., these proceedings for a timeline and references).
In anticipation of the next periastron (July 4, 2011, MJD55 746), the object has been observed intensely. Here we show the results from spectroscopic observations in 2011.

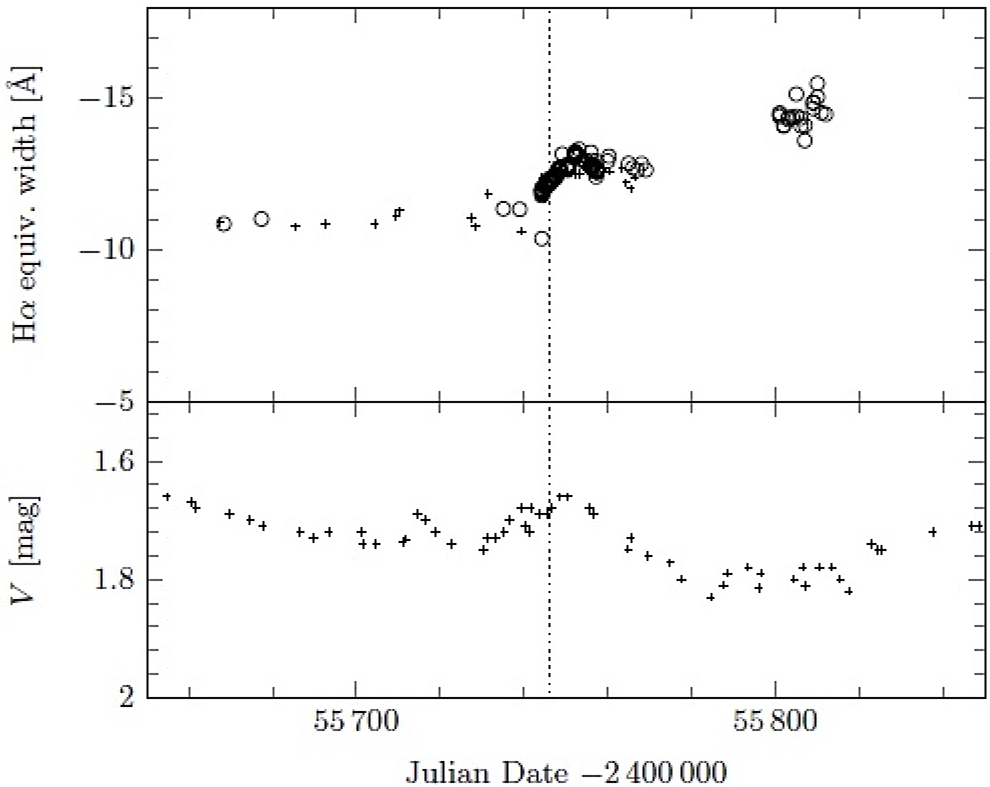

Figure 1. The Hα equivalent width and *V*-band photometry over the periastron (marked by a dotted line). Circles represent own spectroscopic data, plus-signs are from the BeSS database (Neiner et al. 2011). The visual photometry is by SO (Details will be in Rivnius et al. in prep.).

2. Observations

Observations were carried out with FEROS at the 2.2m telescope on La Silla and with ESPaDOnS at the CFHT on Mauna Kea. Both are echelle instruments, with *R* = 48 000 and 68 000, respectively, and a coverage from about 370 to 880 nm. *S*/*N* was well above 100 in all observations. In 2011, a total of 50 FEROS spectra were taken in 32 nights between Jan. 24 and Sep. 8, while ESPaDOnS took 304 individual spectra in 14 nights between Jun. 8 and Aug. 17. Figure 1 shows the evolution of the *V*-band magnitude together with the Hα equivalent width in the year 2011, with the periastron being marked by a dotted line.

3. Emission Line Variations

Before periastron (the choice of “before” MJD55 401–55 413, “during” 55 744–55 748, and “after” 55 760–55 811 is governed by the availability of spectroscopic data, details will be given in Rivinius et al, in prep.), the equivalent width of H_ was well stable at about −11Å, while the brightness was slowly decreasing (see Fig.1). As close as one week to periastron, the emission showed Be-star typical *V*/*R* asymmetry. The value of *V*/*R* was slowly decreasing. *V* = *R* was reached in Hβ a few weeks before periastron (see Fig. 2).

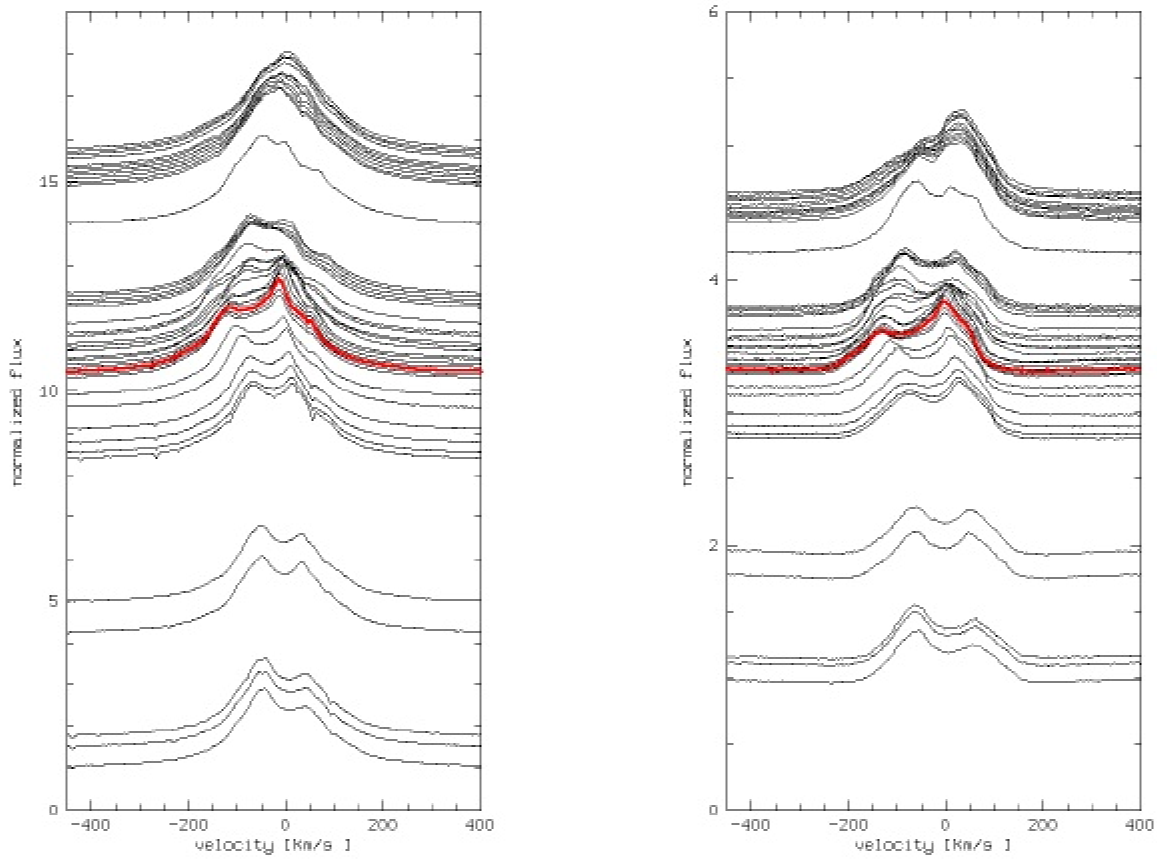

Figure 2. The Hα (*left*) and Hβ (*right*) profile variations in 2011. The vertical offset is proportional to time, increasing upwards. The profile at periastron is marked in red.

During the periastron, in which the primary approaches and the secondary recedes from the observer, excess emission was seen in Hα and Hβ, on the red side (see Fig. 2 and Fig. 3, left). It remained there for several weeks after the periastron as an extended "shoulder". If orbital and disk angular momentum vector are aligned (see, however, Štefl et al., these proceedigns), this is in the region between primary and secondary. The inner disk, probed by spectral lines of e.g. He $_{\rm i}$ and Fe $_{\rm ii}$ did not show such an excess.

He $_{\rm i}$ lines probe a smaller region, i.e. closer to te primary. During periastron, these lines showed a moderate increase in emission, and only some weeks *after periastron* the emission started to fill in the wings at high velocity (see Fig. 3, middle).

Finally, Fe ii 5317 and similar metal emission lines showed the largest peak separation, i.e. are formed closest to the primary. Their profiles remained remarkably undisturbed, just slightly increasing in strength (see Fig. 3, right).

4. Stellar Pulsation

Smith (1986) reported line profile variability (*lpv*) in δ Sco, being interpreted as nonradial pulsation. The period is about 2.3 h (0.097589(3) d), with a typical β Cephei appearance. Before, throughout, and after the periastron, period, phasing, amplitude, and pattern of the *lpv* was unaltered, apart from a small phase shift fully consistent with the light travel time effect (see Fig. 4). Tidal forces had no impact on the main β Cephei pulsation mode of δ Sco A.

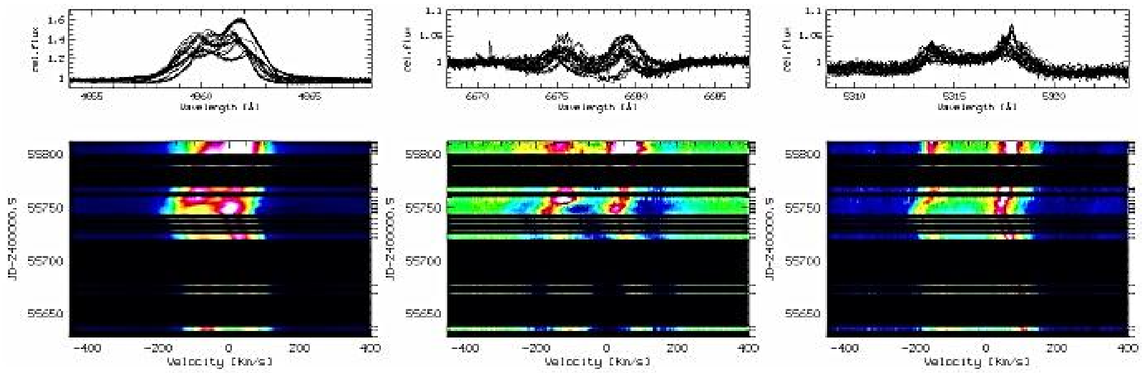

Figure 3. Line profile variations of emission lines observed in 2011. From left to right: Hβ, Hei 6678, and Feii 5317. The periastron at MJD54 746 coincides with quadrature.

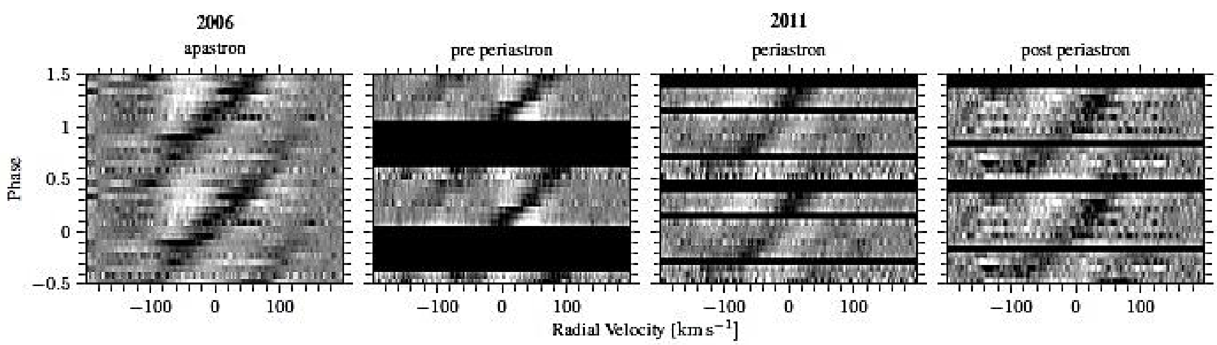

Figure 4. The pulsational βCephei *lpv* of the residuals vs. the mean of the Si $_{\rm iii}$ 4553 line in 2008 (MJD53 889–54 007), and 2011 before (55 401–55 413), during (55 744–55 748), and after (55 760–55 811) periastron. Note that two full cycles are shown.

5. Conclusions

- Before the periastron, the circumstellar environment of the Be star δ ScoA was not affected by the approaching companion.
- One week before periastron on July 4, Hα equivalent width and photometric variability started, peaking with a strong hydrogen excess emission a few days after periastron.
- The closer to the primary an emission line is formed, the less and the later it is affected by tidal perturbations.

- The pulsational behavior of δ Sco A did not change at all through the periastron, no tidal effect was observed.

References

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Smith, M. A. 1986, ApJ, 304, 728