Mem. S.A.It. Suppl. Vol. 9, 250

Memorie della
Supplementi

A Hα lighthouse on II Peg

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Abstract. Observations extended over four consecutive rotations of II Peg, one of the most luminous members of the magnetically active binary RS CVn systems, reveal a cusp-like shape of the Hα emission line flux versus orbital phase. The flux peak corresponds to the conjuction phase of the system, with the primary at the back. Such a behavior is repeated over the four observed rotations and it is therefore interpreted as due to chromospheric rotational modulation rather than to a long-term flare. Contemporaneous V-band photometric observations confirm the presence of a spotted photospheric area close to the chromospheric active region. The longitude corresponding to the direction of the secondary, together with the opposite one, is known to be a preferential site for the formation and emersion of active region in some RS CVn systems, characterized by large photospheric spots and chromospheric plages. The observed Hα emission is therefore consistent with the presence of an extended active region with a longitude corresponding to the direction of the secondary. Furthermore, the cusp-like behavior of the observed flux versus time suggests an extension in height of the chromospheric active region with a consequent increase of the Hα optical depth in the direction of the secondary star.

Key words. Stars: activity – Stars: binaries: spectroscopic – Stars: chromospheres – Stars: individual: II Peg – Stars: rotation – Stars: late-type

1. Introduction

II Pegasi (HD224085) is one of the most active RS CVn binaries showing variable Hα and Ca II H&K emission, photometric variability and UV, radio and soft X-ray emission. The activity is attributed to the primary, whose position on the HR diagram corresponds to a K2 IV star, rather than to the unseen secondary, which is thought to be a M0-M3 V star (Berdyugina et al. 1998a).

Berdyugina et al. (1998b) found that two high-latitude active region dominate at all seasons in their high-resolution spectroscopic observations (1992-1996) and determined the spectroscopic and photometric variability. From the spot positions they deduced the presence of two active longitudes separated by about 180° with no preferred orientation. These are compatible with the results of the two-spot photometric modeling of Henry et al.

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Table 1. Summary of the 2002 II Peg spectroscopic observations.

HJD 2452500+		rot.	ϕ	
start	end		start	end
19.577		-4	0.227	
20.598		-4	0.379	
21.544		-4	0.519	
38.567		-1	0.051	
42.510		-1	0.637	
45.365	45.622	0	0.061	0.099
46.351	46.633	0	0,207	0.249
47.340	47.620	0	0.354	0.396
48.328	48.531	0	0.501	0.531
49.341	49.601	0	0.652	0.690
50.387	50.585	0	0.807	0.837
63.540		2	0.764	
64.546		2	0.914	
65.563		3	0.066	

(1995) for 1990-1992. They found that the largest spot tended to be close to the line of centers in the binary and faced toward the secondary and observed a switching of activity between the two longitudes in 1994.

Rodonò et al. (2000), from the analysis of twenty-five years of wide-band photometry, found that the spot pattern on the active K2 IV star can be subdivided into a component uniformly distributed in longitude and a second unevenly distributed component, which is responsible for the observed photometric modulation and is mainly concentrated around three major active longitude. The spot activity was found practically permanent at one longitude and is discontinuous at the other two longitudes, switching between them with a cycle of $\approx$ 6.8 yr with a transition phase of $\approx$ 1.05 yr during which both longitudes are active.

Here we report spectroscopic and V-band observations carried out in 2002 showing the presence of an active region close to the longitude corresponding to the direction of the secondary and a peculiar behavior of the Hα flux vs phase.

2. Observations

The observations consist of spectra acquired with the REOSC echelle spectrograph mounted on the 91 cm telescope and *UBV* photometry acquired with the Automated Photometric Telscope APT-80 at the *M. G. Fracastoro* station of Catania Astrophysical Observatory on Mt. Etna and with the Phoenix-25 telescope at Washington Camp (AZ/USA).

The main spectroscopic set consists of a six-day continuous monitoring of the Hα and Ca II H&K. Other spectra were acquired on periods corresponding to the previous rotation of the system, four rotations earlier, and two rotations after, achieving, therefore, information on four rotations over a time spanning seven rotations of the system (Table 1). For our purposes we assume a period of 6.7243d (Berdyugina et al. 1998a) and we count rotations and phases starting from HJD = 2452544.950 which marks the passage at the ascending node at the beginning of the main spectroscopic observations (27 September 2002) as deduced from the radial velocity derived using Ca I (6572.779 Å) and Ni I (6586.310 Å).

The photometric data were collected differentially with respect to the nearby comparison star HD 224016. After sky background subtraction and atmospheric extinction correction, the differential magnitudes were transformed into the standard UBV system. Observations, reduction procedure as well data quality are described by Rodonò et al. (2000).

3. Discussion and conclusions

In Fig. 1 we report the Hα equivalent with and the V-band measurement vs phase. The spectroscopic data of the 27 Sep. – 2 Oct. week show a cusp-like shape with a peak at approximately phase 0.5, when the line joining the two components is directed toward the observer. The V-band measurements indicate that the maximum of the photospheric spotted area is approximately at phase 0.6. A correlation between photospheric spots centered at phase$\approx$0.7 and plages in the outer atmosphere, up to the transition region layer, was observed by Rodonò et al. (1987), but the chromo-

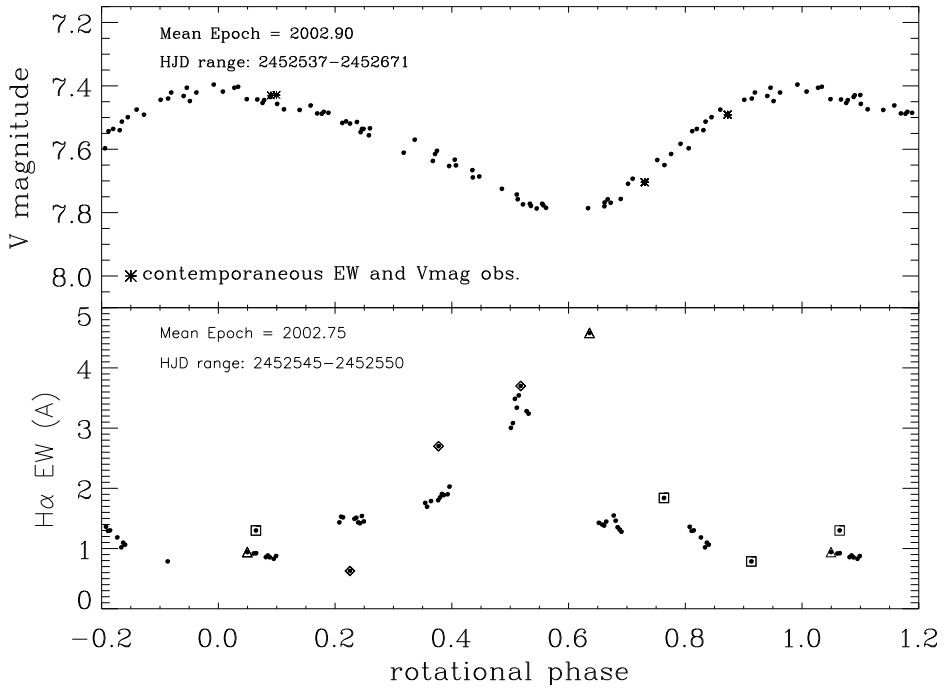

Fig. 1. V-magnitude and Hα equivalent vs orbital phase for II Peg. On the top panel (V-mag) the measurements marked with a star are contemporaneous with Hα observations. On the bottom panel, data from rotation -4 is marked with diamonds, rotation -1 triangles, rotations 2-3 squares.

spheric Mg II k line didn't show a cusp-like shape like in the Hα observation reported here. The Hα observations at 4 and 1 rotations earlier and 2-3 rotation after the main data set, although sparse, confirm that the cusp-like Hα EW behavior is not due to long-term flare but to rotational modulation of a chromospheric active region roughly above the photospheric region with the largest spot coverage. During the previous rotation a larger EW maximum appeared at phase 0.6, but the limited coverage in this case does not allow to disregard the possibility that this was caused by a flare.

The cusp-like shape of the Hα flux vs phase suggests a significant extension in height of the emitting chromospheric structure, which is likely to be sustained by magnetic fields with a possible role played by the gravitational field configuration of the binary system.

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