WHERE DOES $\text{H}\alpha$ ARISE IN THE RS CVN STAR, II PEG?

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INTRODUCTION

A problem in active late-type stars is how $\text{H}\alpha$ plages are related to photospheric spots. $\text{H}\alpha$ emission is prominent in optical spectra of these objects, while modulation of visible light signals spots. Detection of $\text{H}\alpha$ rotational modulation is made difficult by $\text{H}\alpha$'s variability and its sensitivity to flaring. Here we describe simultaneous optical photometry and high-resolution spectroscopy of the 6.72 d SB1 RS CVn star, II Peg and derive the distribution of both spots and plages.

OBSERVATIONS

II Peg was photometered in $\text{UBV(RI)}_{KC}$ at the S African Astr Obs (SAAO) and in $\text{UBV}$ at Stephanion Observatory (SO) and the Bulgarian National Observatory (BNO) Jul – Nov 1991. $\text{V}$ and $(\text{V−I})_{KC}$ curves are given in Fig.1a.

Spectra were taken at the 1m JKT at the Obs del Roque de los Muchachos using the QUBES spectrograph on six nights 26–31 Aug 1991. Spectra were taken at $\text{H}\alpha$, $\text{H}\beta$ and $\text{HeI}D_3$ on each night except the last when only $\text{H}\alpha$ was recorded. A mean spectrum in each line is given in Fig.1b.

SPOT DISTRIBUTION AND TEMPERATURES

The light and colour curves were modelled using the program SPOTPIC and the resulting fit is given in Fig.1a and Table I. The following should be noted.

- A minimum of three spot groups are necessary to fit the $\text{V}$ light curve.
- These spot groups must have different $T_{\text{eff}}$ in order to fit $(\text{V−I})_{KC}$.
- The $T_{\text{eff}}$ of Spot No.1 has a $\Delta T_{\text{eff}} = 2000^\circ \text{K}$.

This is the first evidence for three spots on II Peg and for different spot $T_{\text{eff}}$. The lower spot $T_{\text{eff}}$ agrees with that from molecular bands.
FIGURE I  (left) a) V and (V-I)_{K_C} curves for II Peg in the second half of 1991. Superimposed are the model curves discussed in the text. (right) b) Overall mean Hα, Hβ and HeI D_3 spectra. Superimposed on the Hα profile is a 2-gaussian fit as described in the text.

EMISSION LINE VARIATION WITH SPOT PHASE

Fig.IIa shows that the three chromospheric lines' EWs do not correlate with spot phase. We note the following, however.

- Hα and Hβ EWs peak when Spot No. 2 crosses the line-of-sight.
- The second largest Hα EW occurs close to meridian passage of Spot No. 1.
- Light maxima correspond to lower Hα EW but Hα is weakest at φ ≈ 0.88, midway between light maximum and minimum.
- There is no evidence of Hβ variation, apart from the point near meridian passage of Spot No. 2. Hβ was not measured near the deeper light minimum.
- There is no convincing evidence of HeI D_3 variation with phase.

Each night's Hα can be fit by 2 gaussians of fixed λ and FWHM (cf. Fig.Ib). There is excess emission over the fits in the wings whose EW and asymmetry vary with phase. Fig.IIb plots wing EW against phase. They are a maximum at φ ≈ 0.44. The blue wing EW stays the same at φ ≈ 0.58 but the red drops. The wings are symmetric at φ ≈ 0.03 - 0.44 but show a weak blue asymmetry at φ ≈ 0.73 and 0.88. EW_{abs} is greatest when Spot No. 2 crosses the line-of-sight and drops when it is on the limb.

Models show Hα symmetric in a stationary atmosphere suggesting that the wing emission and asymmetry reflect velocity fields. We derive a consistent picture by proposing a large plage between the major spot groups and upflow
associated with the leading edge of Spot No. 2, downflow near Spot No. 3 and weaker upflow near Spot No. 1. Further details of this work are given in a paper in preparation.

**TABLE I**   Spot model for II Peg in 1991. The unspotted configuration is $V = 7.42, (V-I)_{K_C} = 1.21, T_{\text{eff}} = 4650^\circ \text{K}, i = 90^\circ$. All spots are on the stellar equator.

<table>
<thead>
<tr>
<th></th>
<th>$\phi$</th>
<th>$R$</th>
<th>$T_{\text{eff}}$</th>
<th>$A$</th>
</tr>
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<tr>
<td>Spot No. 1</td>
<td>0.98</td>
<td>21$^\circ$</td>
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<td>Spot No. 2</td>
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<tr>
<td>Spot No. 3</td>
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<td>13.5$^\circ$</td>
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<td>1.4%</td>
</tr>
</tbody>
</table>

**FIGURE II**  (left) a) $H\alpha$, $H\beta$ and HeI $D_3$ line flux vs phase with the spot model from Fig. I. (right) b) $H\alpha$ excess wing emission (*upper panel*) and absorption reversal (*lower panel*) vs phase.