SPOTS ON II PEG

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1. Introduction

II Peg is a single-line spectroscopic RS CVn binary. RS CVn binaries are characterized by short periods, generally up to 2 weeks. One of the components is chromospherically active and is typically a K giant. A photometric wave is commonly observed indicating the presence of large surface spots analogous to sunspots. The H and K lines of Ca II are almost always seen strongly in emission. In some systems the Balmer lines are also seen in emission.

The orbital period of II Peg is 6.72 days and it has a visual magnitude of approximately 7.50. It is classified as a K2 subgiant. For a review of II Peg’s observational history the reader is referred to Rodono et al (1986).

Here we make a preliminary report on a photometric and spectroscopic study of the star during mid-1984.

Figure 1. (a) V light curve of II Peg from Kaluzny et al (1984).
(b) (V-I)$_{Ko}$ colour variation with phase.
Figure 2. (a) Ca K emission-line fluxes with phase in units of $10^{-9}$ erg s$^{-1}$ m$^{-2}$. The Ca II H line flux is almost identical to that of the K line.
(b) As (a) for the H$_e$ line.
(c) As (a) for the H$_\alpha$ line.
(d) Velocity of H$_\alpha$ central absorption feature, relative to line centre, with phase (km s$^{-1}$).
2. Observations

The spectroscopic observations were carried out over 4 nights from 15th to 18th July, 1984 on the Isaac Newton Telescope at La Palma using the Cassegrain spectrograph with the Image Photon Counting System. On each of the first 3 nights one exposure was obtained in each of 4 bands centred on the Ca II H and K and Hα emission lines and on 6260 Å and 6820 Å. Each band was about 200 Å wide. On the final night we only obtained spectra at Ca II H and K and Hα. Resolution was 0.2 Å or better.

Observations on the first and last nights were also taken with IUE using both the long and short wavelength cameras at high dispersion. Resolution was again about 0.2 Å.

Some photometric observations in the UBV(RI)K system were kindly obtained for us by Mr. Chris Engelbrecht and Mr. Fred Marang of the South African Astronomical Observatory with the 0.5 m telescope at Sutherland.

3. Spot interpretation of the light curve

Due to inadequate phase coverage of the SAAO data we have used the published V data of Kaluzny (1984) to establish the variation in V light at the time of our

![Figure 3. Hα profiles from night to night, adjusted to zero velocity shift. The arrows indicate the moving absorption feature.](image-url)
observations (Figure 1(a)). The resulting V lightcurve can be interpreted using 2 large spots, analogous to sunspots, one transitting the stellar meridian near phase 0.8, the other in the region of phase 0.25. By analogy with sunspots, starspots are assumed to be strong concentrations of magnetic flux which cool an area of the photosphere and produce higher densities in the overlying chromosphere and corona. Previous modelling of spots on II Peg shows that they can cover a significant part of the visible hemisphere, as large as 50 deg. for the largest. The $(V-I)_{K0}$ colour variation (Figure 1(b)) is consistent with a cool-spot interpretation, being readdest (coolest) at primary spot minimum. Phases were calculated from $JD_0=2443033.47$, according to the ephemeris of Vogt (1981).

4. **Emission-like fluxes and profiles**

Our spectra were calibrated for flux by dividing by calibrated spectra of II Peg kindly supplied by Dr. G. Wegner of Dartmouth College for this purpose. Figures 2(a), (b) and (c) show the line-flux variation of the Ca II K, Hα and Hγ emission lines with phase. They peak at about phase 0.8, when the larger spot is crossing the line of sight. This is consistent with a spot-associated plage region.
Figure 5. Ca I, Fe I and Ba I profiles from night to night, adjusted to zero velocity shift.
The Ca II lines showed no changes in profile over the period of observation, although the profile of Hα appears variable. Considerably more interesting are the Hα profiles (Figure 3). These show marked changes from night to night. There appear to be several strong absorptions superimposed on the emission profile. Alternatively we can interpret these as discrete emission features. One of the “absorption dips” appears to move across the profile from night to night (arrowed in Figure 3). The velocity of this feature, reckoned relative to line centre (Figure 2(d)), is zero at about phase 0.8 indicating a possible association with the dominant spot. The range of velocity implied (30 km s\(^{-1}\) with respect to line centre) is about the same order as the rotational velocity of II Peg i.e. a 2.8 R\(\odot\) star rotating once every 6.72 days.

The Mg II h and k emission lines, like those of Ca II, show no change in profile over the 2 nights of observation. The interstellar absorption feature is near line centre on the first night and lies in the far red wing on the last night.

The Lyα emission (Figure 4) clearly shows both an interstellar absorption feature and a strong geocoronal component. There is also a marked change in overall width, measured at the level of the background, from the first to last nights. On the first night, when the dominant spot was near maximum visibility, the width of the line was approximately 3.5 Å, whereas on the last night, when the dominant spot was over the limb of the star, the line width was about 2 Å. This may reflect the effect of greater optical depth over the dominant spot.

5. General remarks on the spectrum

Atmospheric O\(_2\) bands were clearly resolved near 6866 Å, and as expected showed no change in profile or relative strength from night to night.

The stellar absorption spectrum, however, exhibits remarkable changes in profile and line strength. Lines of Ca I, Fe I and Ba I (Figure 5) amply illustrate this. As a whole the Fe-peak element profiles vary systematically from night to night. We intend to quantify these effects in the context of spots in later publications.

References
