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Optical Flares on the RS CVn-type Binary II Pegasi

Shenghong Gu and Huisong Tan

Yunnan Observatory, Chinese Academy of Sciences, Kunming, Yunnan Province, The People's Republic of China
E-mail: gus2000@263.net

National Astronomical Observatories, Chinese Academy of Sciences, The People's Republic of China

The united laboratory for optical astronomy, Chinese Academy of Sciences, The People's Republic of China

Abstract. The new high-resolution echelle spectra of II Peg obtained in Dec. 1999, Feb. 2000, Sep. 2000 using 2.16m telescope at Beijing Astronomical Observatory, are analyzed here. By means of spectral subtraction technique, the chromospheric contribution in several chromospheric activity indicators (H_α, HeI D_3, and CaII IRT) has been determined. Three optical flares with HeI D_3 emission are detected during these three observing runs. The intensity of these flares is discussed. Orbital phase modulation of the chromospheric activity indicators is derived.

1. Introduction

II Peg is known as one of the most active RS CVn-type binaries with significant photometric variability(Tas & Evren 2000), strong H_α emission above continuum spectrum and CaII H&K, IRT core emission (Rucinski 1977, Montes et al. 1997, Berdyugina et al. 1999). It is a single-lined spectroscopic binary in which the activity of the system is from the primary component. The primary is a K2IV star and the unseen secondary is a low-mass main-sequence M-dwarf(Berdyugina et al. 1998). Because of its strong activity, it attracts many astronomers' interest. We also made it as one of several long-term monitoring candidates. Here we give out the preliminary result from our 1999-2000 observing seasons.

2. Observations and Data Reduction

The observations of II Peg were carried out at Beijing Astronomical Observatory with the Coude echelle spectrograph feed 2.16m telescope during December 21 to 23, 1999, February 19 to 24, 2000, and September 15 to 18, 2000. The spectral images were obtained with a 1024X1024 pixels Tektronix CCD detector. The reciprocal dispersion achieved with above instrument in HeI D_3, H_α, and CaII IRT wave bands is 0.081Å /pixel, 0.091Å /pixel, 0.118Å /pixel, and 0.120Å /pixel, respectively, which yield spectral resolution of 0.162Å - 0.240Å .

These spectral images have been reduced by means of IRAF package according to the standard fashion. The operation includes image trimming, bias subtraction, flat-field division, spectrum extraction, and cosmic rays removing. The wavelength calibration is obtained by taking spectra of a Th-Ar lamp. Finally, the spectra have been normalized by a cubic spline fit to the observed continuum.

On some nights, the telluric lines were strong. In order to remove these telluric lines from observed spectra, we took spectra of the fast-rotating early-type stars HR 8858 and HR 7894, and then derived telluric line template spectra using high order cubic spline fit to observed spectra. After the spectra were reduced using the standard fashion, we used these templates to remove telluric lines from obervational spectra of II Peg. Figure 1 is an example in H_α wave band, in which the middle spectrum is original observational spectrum of II Peg on September 15,2000, the lower spectrum is a template which is derived from the observational spectrum of HR 8858 obtained on the same night, and the upper spectrum is the resulting spectrum after telluric lines are removed.

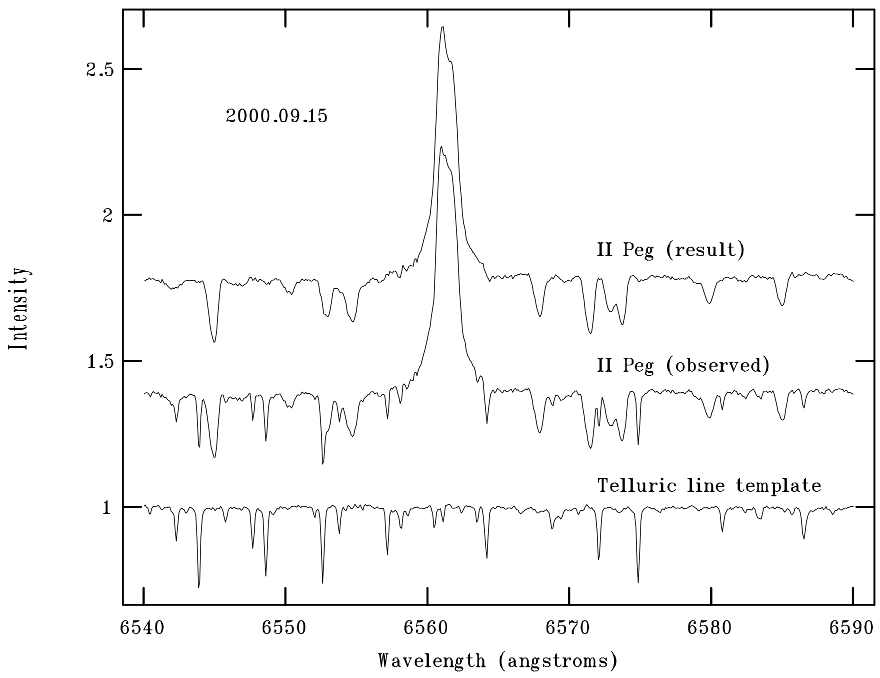

Figure 1. An example for telluric lines removing in H_α wave band.

The final reduced spectral lines of H_α, HeI D_3, and CaII IRT are displayed in Figures 2, where we have also marked the observational date and orbital phase calculated using the Berdyugina et al.'s (1998) orbital ephemeris.

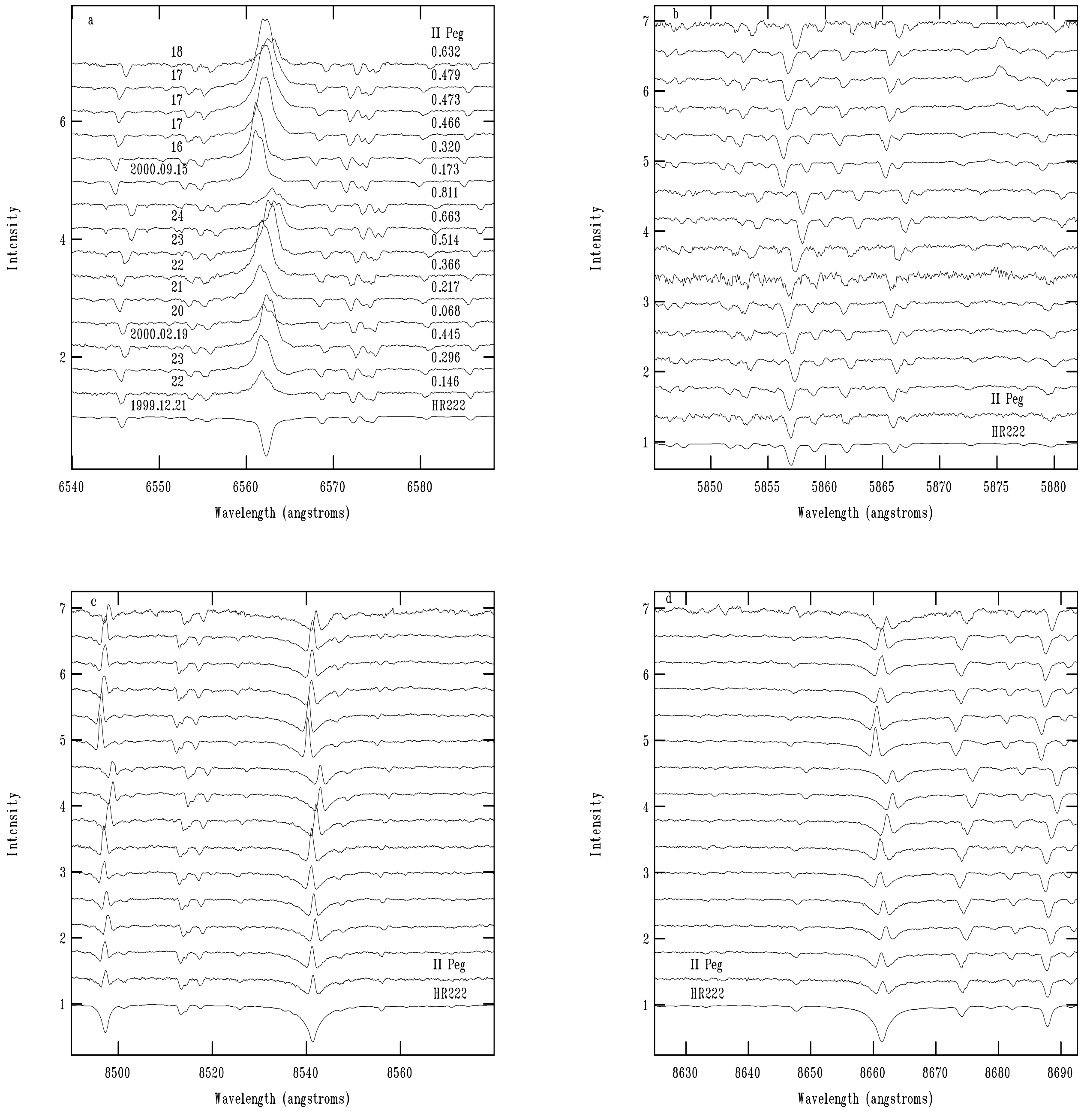

Figure 2. The profiles of the H_α (a), HeI D_3 (b), and CaII IRT (c, d) lines. The lowest spectrum is a synthesized spectrum constructed using HR 222.

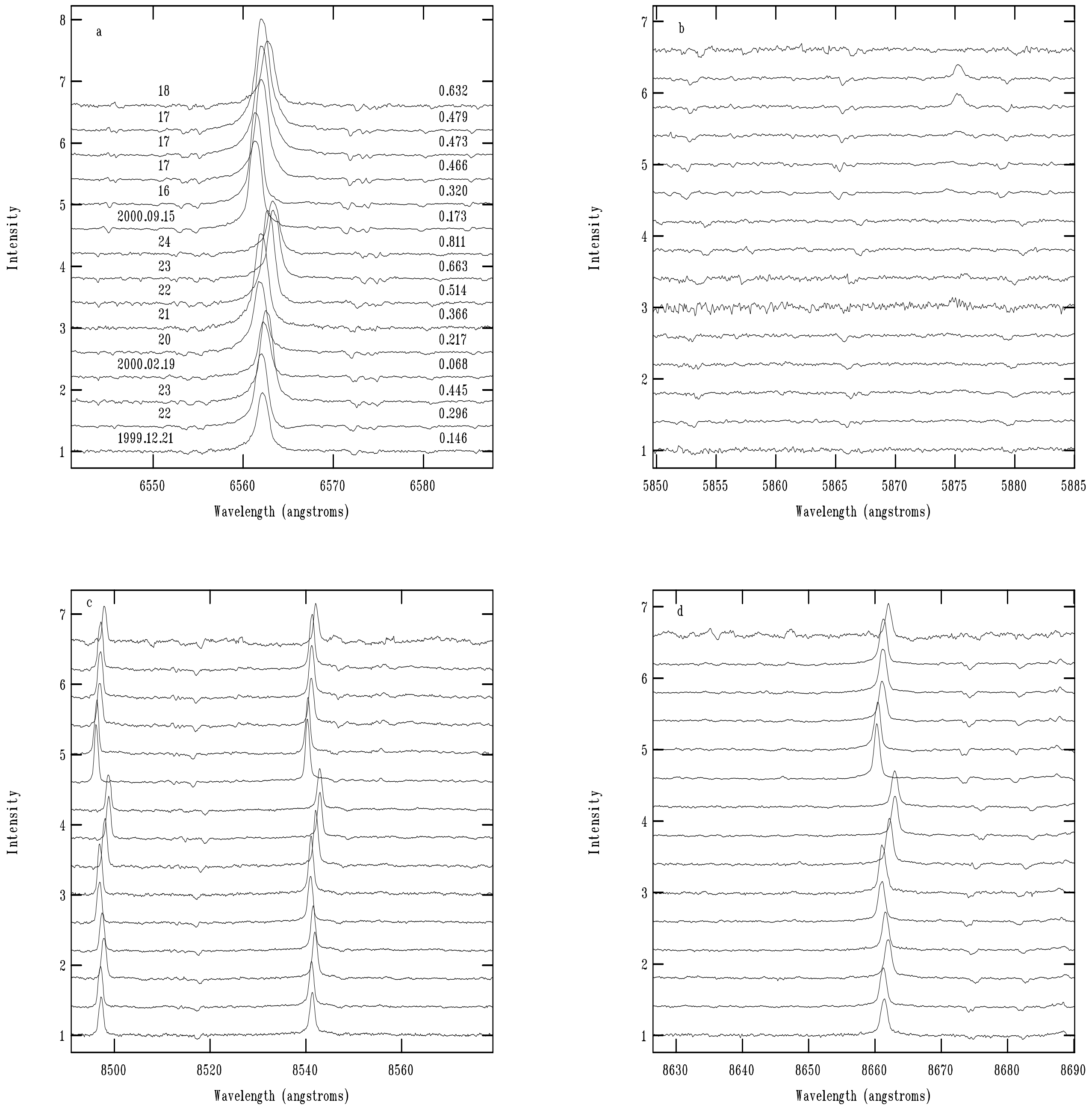

Figure 3. The subtracted spectra for H_α (a), HeI D_3 (b), and CaII IRT (c, d) wave bands.

3. Chromospheric Activity Indicators

Using simultaneous observations of different chromospheric activity indicators formed at different height in the chromsphere, we can derive very useful information about its structure. The best method to obtain the contribution of some chromospheric activity indicators is to subtract the photospheric contribution from original observational spectrum using the spectral subtraction technique (Barden 1985, Montes et al. 1995a, b). We construct a synthesized stellar spectrum from an inactive star with the same spectral type and luminosity class by artificially including rotational broadening, a radial velocity shift, and luminosity weighting, and then subtract it from the observational spectrum. Uisng this method, we can derive the pure chromspheric emission.

The usual chromospheric activity indicators are CaII H&K, HeI D_3, NaI D_1, D_2, H_α, CaII IRT, and so on (Gunn & Doyle 1997, Montes et al. 1995a, b). For our observations, we have discussed five indicators H_α, HeI D_3, and CaII IRT. The H_α line is an important chromospheric activity indicator, it is formed at the middle chromosphere. The HeI D_3 line is formed at the upper chromosphere, and this line in emission is a probe for the detection of flare-like events(Zirin 1988). The CaII IRT lines are formed at the lower chromsphere and thus probe the temperature minimum region.

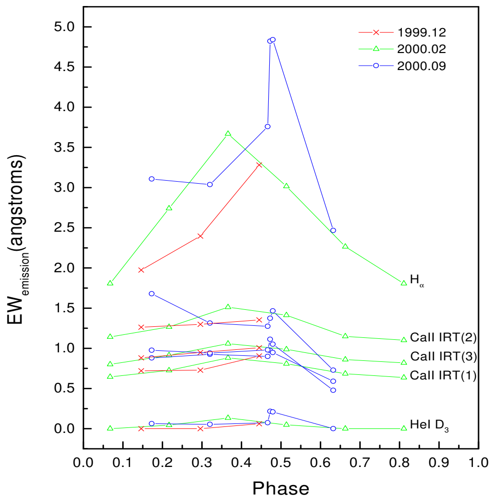

Figure 4. The excess emission EW of H_α, HeI D_3, and CaII IRT lines vs. orbital phase.

In our observations, we had taken spectra of two inactive template star HR 495 with spectral type K2IV and HR 222 with spectral type K2V. By comparison, we found HR 222 is a better template star for II Peg. So, we chose HR

222 as template star to construct synthesized spectra for all spectral data of II Peg. The synthesized spectra in H_α, HeI D_3, and CaII IRT wave bands are also displayed in Figures 2, and the result subtracted spectra are displayed in Figures 3. For the subtracted spectra we have measured excess emission equivalent width ($EW_{emission}$) and plotted them in Figure 4. In this figure, the symbol "$\times$", "$\triangle$", and "$\circ$" represent the data on Dec. 1999, Feb. 2000, and Sep. 2000, respectively.

4. Discussion and Conclusion

From above results, we found three flares that occurred during our observing seasons, in which HeI D_3 line appears to emission. The three flares become strong gradually from Dec. 1999 to Sep. 2000, and reach the strongest emission on Sep. 2000. During the flares, the wings of subtracted profile of H_α line change to very broad, like Montes et al.'s (1997) result. The five chromspheric activity indicators are correlated, namely the variation modes of these indicators coincide with each other.

In the observing run Sep. 2000, the chromspheric activity level is higher than that of the other two observing runs. This flare is also variable, from strong on Sep. 15, to weak on Sep. 16, and then to very strong on Sep. 17. On the night of Sep. 17, we took three spectra, which showed a remarkable increase in all of the chromospheric activity indicators. This demonstrates a large flare was in progress, because the intensity of HeI D_3 line emission changes to very strong. Based on the three flares, we have found II Peg has an active longitude region at phase about 0.17 to 0.51 during our observing seasons.

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