Possible chromospheric activity cycles in II Peg, UX Ari and V711 Tau

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Abstract. We study the Mount Wilson indices we obtained indirectly from IUE high and low resolution spectra of the RS CVn-type systems II Peg (K2IV), UX Ari (K0IV+G5V) and V711 Tau (K1IV+G5V), extensively observed by IUE from 1978 to 1996. We analyze the activity signatures, which correspond to the primary star, with the Lomb-Scargle periodogram. From the analysis of V711 Tau data, we found a possible chromospheric cycle with a period of 18 years and a shorter ∼3 year cycle, which could be associated to a chromospheric flip-flop cycle. The data of II Peg also suggest a chromospheric cycle of ∼21 years and a flip-flop cycle of ∼9 years. Finally, we obtained a possible chromospheric cycle of ∼6 years for UX Ari.

Keywords: Stars: activity, binaries close, Ultraviolet: stars, Techniques: spectroscopic

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INTRODUCTION

RS CVn-type stars are binary systems where the most massive primary component is a G-K giant or subgiant and the secondary is a subgiant or dwarf of spectral classes G to M. These systems are well known due to their strong chromospheric plages, coronal X-ray emission, and strong flares in the optical, UV, radio, and X-ray.

Most long-term stellar activity studies of RS CVn stars are derived from the easily detected optical photometric variations produced by their long-lived large spots. In most cases, the mean magnitude reflects a stellar activity cycle similar to the 11-year solar one. On the other hand, the peak-to-peak magnitude shows a shorter cycle, called flip-flop cycle, which reflects the non axisymmetrical redistribution of the spotted area on the stellar surface.

The IUE database provides a large number of UV high and low resolution spectra of these type of stars. Furthermore, the IUE satellite monitored these stars continuously during several seasons. In the present work, we have measured the Mg II line-core fluxes on the IUE low and high resolution spectra of three RS CVn-type stars (II Peg, UX Ari and V711 Tau) and then converted the fluxes to the Mount Wilson index $S$ [1,2]. For each star, we analyzed the mean annual index $\langle S \rangle$ with the Lomb-Scargle periodogram [3,4] to search for a long-term chromospheric cycle. Following Díaz et al. [5], we obtained the rotational modulation of the $S$-index for several seasons by fitting the light-curves with a harmonic function. We analyzed the amplitude of each curve with the Lomb-Scargle periodogram to search for a chromospheric flip-flop cycle.
II PEG-HD 224085

II Peg (HD 224085) is a single-lined RS CVn-binary system composed by a K2IV star and an unseen companion of an estimated spectral class M0-M3V [6]. In Fig. 1 we plot the Mount Wilson index $S$ derived from the IUE high and low resolution spectra obtained between 1979 and 1995.

To search for cyclic patterns in the chromospheric data, we first studied the mean annual index $\langle S \rangle$ of the data plotted in Fig. 1 as a function of time with the Lomb-Scargle periodogram. We obtained a peak at 7741 days ($\sim 21$ years) with a false alarm probability (FAP) of 35%.

Secondly, we analyzed the rotational modulation of the index $S$ during the seasons indicated with arrows in Fig. 1. To do so, we phased each season’s light-curve $S$ vs. time with the 6.724-day rotation period [7] (see Fig. 2) and we fitted each set of data with the harmonic function: $a_0 + a_1 \cos(2\pi\phi) + a_2$.

We analyzed the amplitude $A = \sqrt{a_1^2 + a_2^2}$ against time with the Lomb-Scargle periodogram and we obtained a cyclic pattern of $3310 \pm 253$ days ($9.07 \pm 0.69$ years) with

FIGURE 1. II Peg-HD 224085. Mount Wilson index $S$ derived from the IUE high resolution spectra ($\triangle$), and from the IUE low resolution spectra ($\bigcirc$). Arrows indicate the seasons for which we analyzed the modulation.

FIGURE 2. Variability on II Peg-HD 220485. Light curves $S$ vs. $\phi$ of the datasets indicated with arrows in Fig. 1, the harmonic curve that best fit the data and the reduced $\chi^2$ of the fit.
a FAP of 31%. This periodic behaviour seems to be well correlated with the flip-flop cycle with a period of 9.30 years obtained by Berdyugina and Tuominen [8] for the spot activity.

UX ARI-HD 21242

UX Ari (HD 21242) is a RS CVn-type system composed by a K0IV star and a G5V companion in a 6.483-day orbit [7]. In Fig. 3 we plot the index $S$ obtained for this star between 1978 and 1996.

We analyzed the mean annual $\langle S \rangle$ of the indexes plotted in Fig. 3 as a function of time with the Lomb-Scargle periodogram. We obtained a period of $2180 \pm 32$ days (~6 years) with a FAP of 29%.

V711 TAU-HD 22468

V711 Tau (HR 1099, HD 22468) is one of the most active RS CVn non-eclipsing spectroscopic binary system, consisting of a K1 subgiant primary and a G5 dwarf secondary in a 2.837 day-orbit [9]. In Fig. 4 we plot the index $S$ for this star between 1978 and 1995.

We analyzed the mean annual $\langle S \rangle$ as a function of time with the Lomb-Scargle periodogram and we obtained a peak at $6589 \pm 1170$ days with a FAP of 11%. This
period of $18.05 \pm 3.21$ years is in agreement with the ones reported in the literature [10, 11, 12].

FIGURE 5. Variability on V711 Tau. Light curves $S$ vs. $\phi$ of the datasets indicated with arrows in Fig. 4 and the harmonic curve that best fit the data and the reduced $\chi^2$ of the fit.

On the other hand, we analyzed the amplitude of the rotational modulation of the datasets indicated with arrows in Fig. 4 and we obtained a cyclic pattern in the amplitude $A$ of the curves plotted in Fig. 5 of period $1207 \pm 45$ days ($\sim 3.3$ years) of $23\%$ FAP, which is consistent with the one obtained by Lanza et al. [11] for the spot activity.

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