

## Stellar activity in the RS CVn binary star UX Arietis

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**Abstract.** Using our data along with the photometric data available from the literature, we have made extensive analysis of the light variations of UX Ari. The parametric study of the photometric data for the last 22 years in the frame work of a starspot model indicates that the spot activity of UX Ari varies periodically with time-scale of nearly 18 years. The distribution of the reliable parameter, the spot longitude, indicates that spots have a tendency to concentrate within two longitudinal belts. The continuous observations of UX Ari during the period from November 1995 to February 1997 reveal appreciable variation in amplitude as well as in the shape of light curves over a time scale as short as a couple of rotation period.

**Keywords :** stars-variables, stars-binaries, stars-activity, stars-chromospheres, starspots.

### 1. Introduction

The well known non-eclipsing binary UX Ari has been frequently observed at different wavelengths by several investigators in the past two decades (Poe & Eaton 1985; Rodono & Cutispoto 1992; Raveendran & Mohin 1995; Padmakar & Pandey 1996 and the references therein). The double-lined spectroscopic binary system UX Ari comprises a hot G5 V and an active cool K0 IV stars. The strong emission of Ca II H & K lines and phase dependent H $\alpha$  emission have been detected in spectroscopic observations (Bopp & Talcott 1989; Raveendran & Mohin 1995). In order to investigate the physical characteristics of starspots, evolution of spotted regions as well as the overall long-term variation, it is essential to perform systematic monitoring of active stars for long time spans. The photometric monitoring of the stars using small telescopes is economical and relatively easy to perform and therefore it provides an effective means to trace out the evolution of starspots of the chromospherically active stars. Keeping this objective in mind we have started a systematic observing programme on RS CVn binaries, using a 0.35 m Celestron reflector telescope at the University Observatory. 62 Ari was taken as the comparison star for differential photometry; the details of our photometric observations and spot modelling are given in Padmakar & Pandey (1997).

## 2. Starspot modelling

The photometric variation can provide useful information about physical characteristics (size, location, effective temperature etc.) of the starspots. To evaluate the geometric parameters of starspots from observed light curves we have used our own computer program based on Dorren's (1987) analytical formulation for circular starspots. The prime indicator of the stellar activity as revealed from photometric observations is the amplitude of light variation, which in turn depends upon the total spot area. However, its strong correlation with latitude and stellar inclinations make it very difficult to determine starspot area unambiguously. That's why the results of earlier efforts to look for a long-term activity in terms of either amplitude or spot area were inconclusive (Fig 2b & 2c). As an alternative, we have adopted integrated amplitude as a parameter (see Mohin et al. 1985) to diagnose long-term stellar activity in UX Ari, and the results turn out to be very encouraging.

## 3. Results and discussion

*Short-term variation* : The RS CVn stars typically have highly variable light curves. Often appreciable changes are noticed in the light curves over a time-scale as short as a couple of rotational periods. Therefore, to investigate the nature of short-term variations we have taken continuous observations of the UX Ari during November 1995 to February 1997. Our observed light curves and spot parameters obtained from modelling of the light curves reveal that one spot was almost stationary at low longitude ( $\sim 15$ ) while the second spot situated at nearly opposite quadrant appears to be slowly migrating towards lower longitudes (Fig. 1). Both spots are located at higher latitudes and therefore, it is very difficult to explain our findings in terms of the differential rotation of the stellar surface. However, slow increase in the integrated amplitude during this period indicates strengthening of the spot activity (Fig. 2a).

*Long-term variation* : Using our data along with photometric data available from the literature, we have made extensive analysis of the light variations of this binary star to investigate the characteristics and evolution of spotted regions. The parametric study of the photometric data for the last 22 years in the frame work of starspot model reveals that the spot activity of the UX Ari appears to show periodicity. For the short period binaries it has been found that starspot formation is restricted into two regions of stellar longitude,  $180^\circ$  apart, called active longitudinal belt (Budding & Zeilik 1987; Zeilik et al. 1990), while recent analysis also indicates the existence of preferred longitude, in moderate rotation period RS CVn stars (Henry 1994; Olah et al. 1997). The distribution of the spot longitudes obtained from the modelling of the light curves of the UX Ari show that spots are preferentially concentrated in two longitudinal belts situated nearly  $180^\circ$  apart (Fig. 2d). It has been noticed that the spot latitude as obtained from modelling is not a very reliable parameter and therefore, it would be very difficult to give any conclusive remark about distribution of the spot latitude. However, from Fig. 2e it is evident that spots are located at high latitudes ( $\sim 40$  to  $80^\circ$ ), as indeed found by Doppler imaging technique for at least some of active stars including UX Ari. The plot of the brightness at light maximum and light minimum against the corresponding V amplitude (Fig. 2f) reveals that changes in the amplitude were mainly due to redistribution of spots on stellar surface rather than overall changes in the level of spottedness. The plot of the integrated

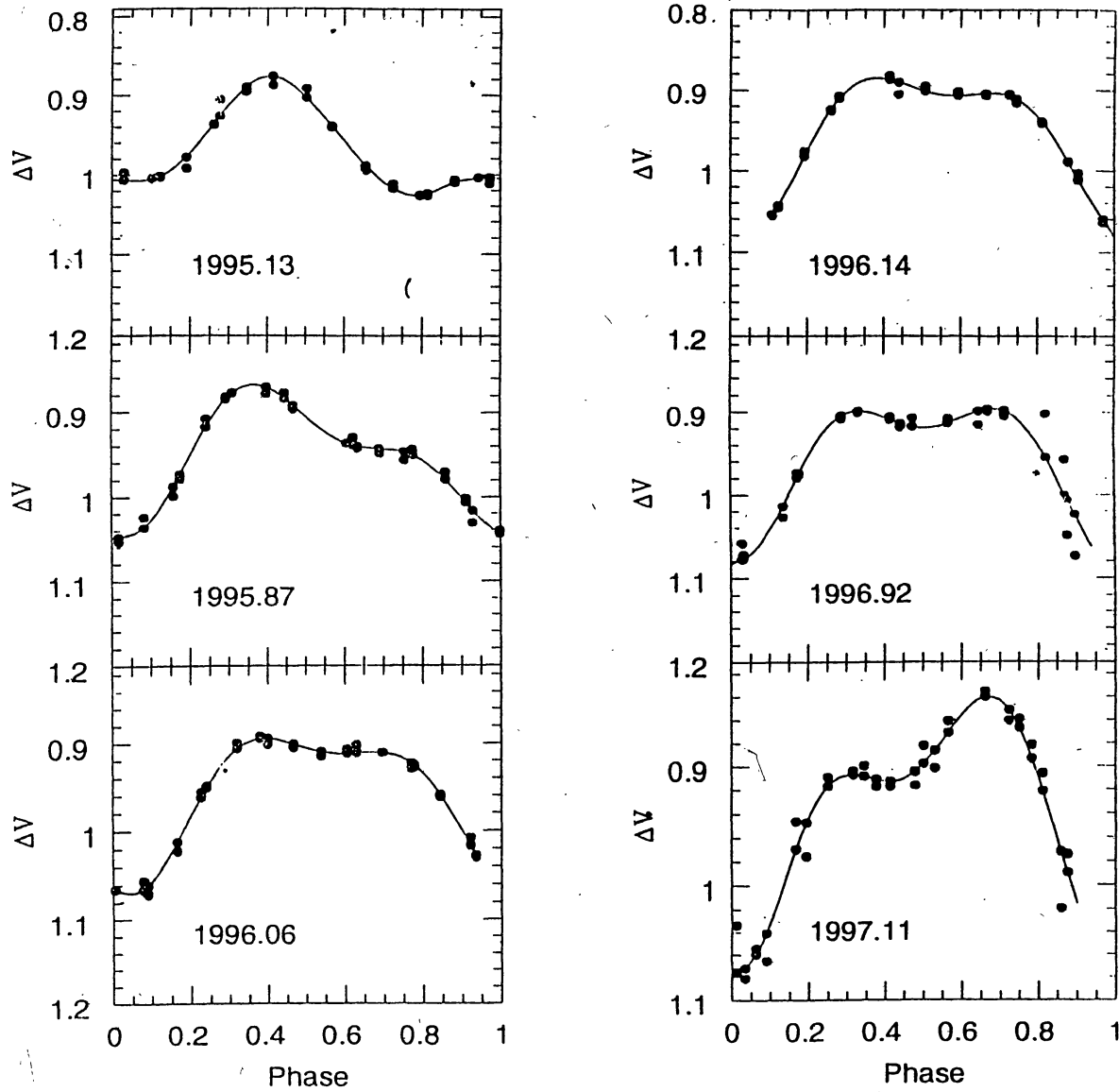


Figure 1. Short-term variation in UX Ari light curves during November 1995 to February 1997.

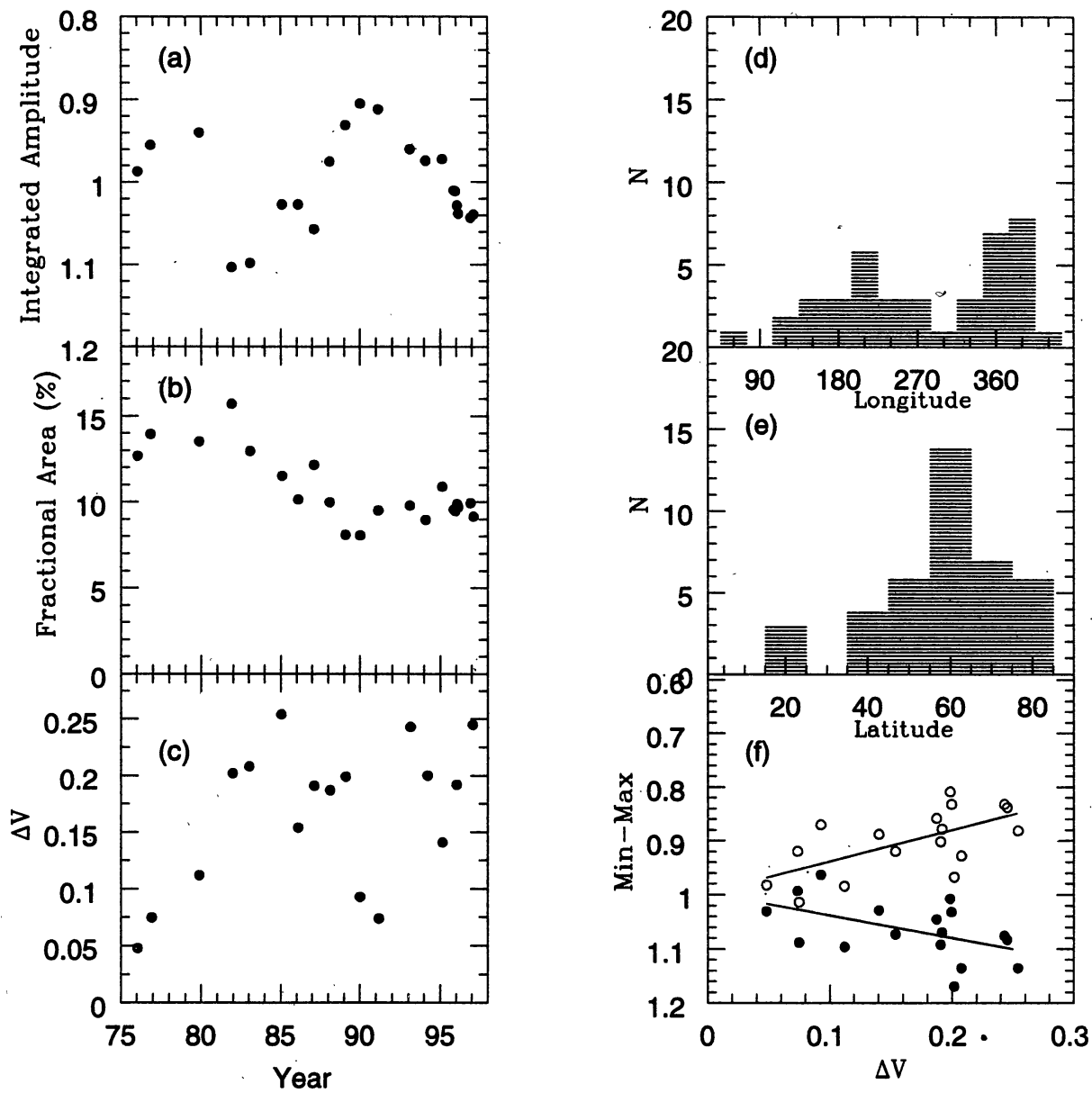


Figure 2. Long-term variation of different activity indicators in UX Ari.

amplitude with respect to time (Fig. 2a) exhibits that spot activity varies systematically with time. Although we do not have sufficient data to derive the activity cycle, our results indicate that UX Ari appears to have a periodicity of 18 years in its spot distribution.

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