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The flaring corona of UX Arietis

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Abstract. Here we present observational results on the RS CVn star UX Arietis from four very-long-baseline interferometry observations distributed in time to cover the rotational period of 6.44 days. The data are better fit by two Gaussian components than by the usual core-plus-halo model. In the first three days the sizes of the two components did not change much from hour to hour but their relative position and orientation changed from day to day. The origin of this evolution can be explained by geometrical factors (i.e., star rotation). The fourth day a large flare occurred and dramatic changes in the sizes of the Gaussian components were seen.

1. Introduction

RS CVn stars are binary systems characterized by an intense coronal activity at X-ray, UV and radio wavelengths. One of the most active sources at radio wavelengths is the system UX Arietis, formed by a G5V and a K0 IV star, with an orbital period of 6.44 days and an orbit diameter of 1.72 mas (Lestrade et al. 1999). Direct evidence of large structures with sizes comparable to the binary system have been provided by VLBI observations (Mutel et al. (1985), Massi et al. (1988), Beasley & Bastian (1996), Franciosini et al. (1999)). The latter, made at a post-flare phase, show a clear variation of the source morphology from day to day. The morphology can be reproduced with a model consisting of two extended elliptical Gaussian components with slowly decaying flux densities, that changed their relative position from day to day. These are interpreted to be two radio loops emerging from the position of the optical spots (see Elias et al. (1995)), intruding into each other.

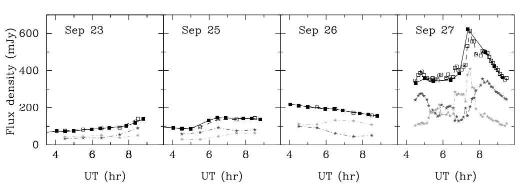

Fig. 1. Flux densities during the four observing runs. Filled boxes represent the single-dish Effelsberg measurements Massi et al. (2005). Empty boxes show the total flux densities obtained from model fitting the visibility data with the a priori calibration from the observing logs (uncertainties 5 %). Stars denote flux densities for the two model fit components (A in dark grey, B in light grey).

2. Results

We performed VLBI observations (see Table 1) with the Very Long Baseline Array (VLBA) and the 100-m Effelsberg telescope during a complete rotation cycle of the system to track the motion of the stellar radio-sphere. We also monitored the total and polarized flux density simultaneously with Effelsberg to distinguish

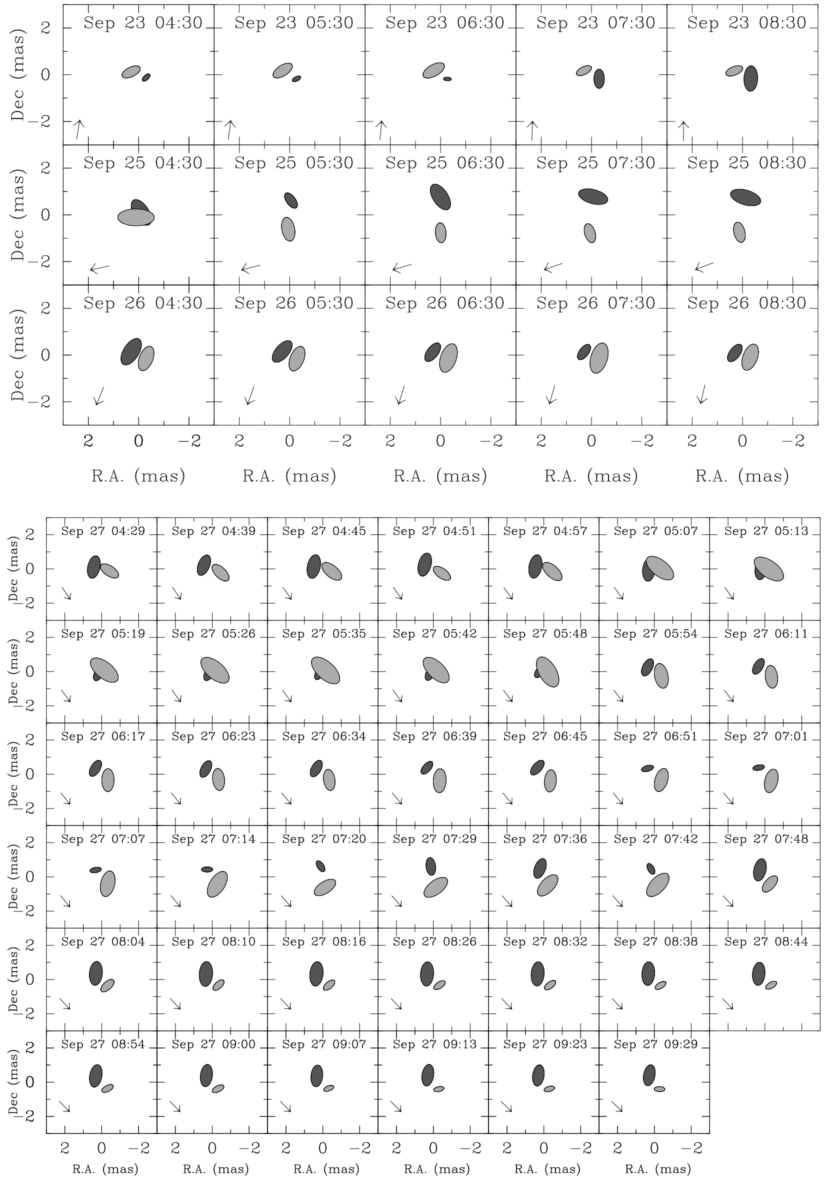

Fig. 2. Top: Relative positions and sizes for the elliptical Gaussians that model the visibilities of UX Arietis at epochs 23, 25, and 26 September 2001. We used 1 hr segments to perform the model fitting. The component A is shown with dark gray tones, the component B with light gray. The arrows at the bottom, left represent the P.A. from the optical phase (not projected at the orbit inclination of 60°). A phase 0°implies the K0 IV star to be to the south, and between the G5V star and the observer. The axis ratio of both Gaussian functions was fixed at a value of 0.5. We solved for flux density, position, major axis, and position angle for the major axis. **Bottom** Relative positions and sizes of A and B for Sep 27. The time binning is made scan by scan of lEduardoRos.pdfength 4 min.

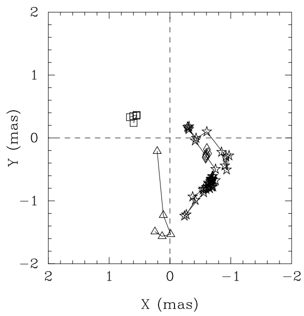

Fig. 3. Relative positions in the sky of component B with respect to component A for the four observing epochs (squares: Sep 23; triangles: Sep 25; diamonds: Sep 26; stars: Sep 27).

Table 1. Observation log

Exp.[1]	Date[2]	Orb. Phase
BM140B	2001 Sep 23	0.46 to 0.49
BM140C	2001 Sep 25	0.78 to 0.81
BM140E[3]	2001 Sep 26	0.93 to 0.97
BM140D	2001 Sep 27	0.10 to 0.13

[1] The array used was the VLBA+Effelsberg in all cases. [2] The UT range was 03:30 to 09:30 for all four observing runs. [3] Observation initially scheduled on Sep 21, but shifted due to scheduling problems in Effelsberg.

temporal flux density variations from structural variations (see Fig. 1). Activity in UX Arietis was present during all epochs, and a flaring event occurred during the last observing day, Sep 27.

Since UX Arietis changed in flux density during the observations, we could not image the radio source using the whole data set, since the assumption of an unchanging source, upon which the aperture synthesis principle is based, was violated. We analyzed the data by splitting them in time in 1 hr segments for the first three epochs, and for each observing scan of length 4 min the fourth epoch. The results of this procedure are shown in Fig. 2 and Fig. 3.

We interpret our observing results as follows:

1st day; $\langle\varphi\rangle$=0.5: The spotted hemisphere is eclipsed by the K0 IV star itself -- the optical spots were not visible except for those at high latitudes (60°)

2nd day; $\langle\varphi\rangle$=0.8: the distance between components was maximized, the K0 IV star was to the SW of the GV5 star.

3rd day; $\langle\varphi\rangle$=0.9: the K0 IV star was in the foreground

4th day; $\langle\varphi\rangle$=0.1: The big flare – observations revealed dramatic changes in flux density and size of the model-fit components.

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