VLBI OBSERVATIONS OF STELLAR BINARY SYSTEMS +

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Since 1982 July we have been engaged in a systematic investigation of the milliarcsecond structure of the radio emission from several binary star systems, mainly in the RS CVn class (Hall, 1976). The first few observations utilized the MkII VLBI recording scheme, but no useful data were obtainable because of the relatively low flux levels involved ($\bar{S} \leqslant 30$ mJy). Beginning in 1982 December, we have been using the MkIII system with large telescopes and have successfully detected seven binary systems (UX Arietis, HR 1099, Algol, II Peg, σ Crb, and the distant system LSI 61°303). A summary of the three experiments already completed is given in Table 1.

The scientific goals are twofold: (1) to measure the source sizes and brightness temperatures which, when combined with polarization and spectral information, should allow a detailed model of the radio emission mechanism and (2) to make precise position measurements relative to nearby extragalactic objects so that future optical positions from the Hipparcos program can be used to tie the optical and radio reference frames together at the ~ 2 mas level (cf. Preston, Lestrade, and Mutel, 1983). In this paper we report preliminary progress which has been made in the astrophysics area, since we have not yet attempted any astrometric measurements.

During the first two VLBI observations, the sources were barely resolved and only upper limits to the sizes could be made. During the first experiment (1982 December), a moderate outburst of HR 5110 was detected, yielding a brightness temperature limit $T_B \geqslant 4 \times 10^8$ K. The second experiment (1983 February) provided interesting lower limits to the brightness temperatures ($T_B \geqslant 1.4 \times 10^{10}$ K for UX Arietis and $T_B \geqslant 2.9 \times 10^{10}$ K for HR 1099). The 1983 March observation showed clear

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resolution of a very large ($S \sim 400$ mJy) outburst of the source HR 1099 on continental U.S. baselines, so that an accurate source size of $\ell \sim 4 \times 10^{11}$ cm could be measured. This is about equal to the size of the primary star (KO IV, diameter = 6 $R_{\odot}$). The data rule out a coherent process, such as cyclotron maser mechanism (Melrose and Dulk, 1982) at least for the outbursts which we observed.

If we assume that incoherent emission from a gyrosynchrotron process is responsible for the emission (Owen et al., 1976), then the brightness temperature limits constrain the magnetic fields to $\overline{B} \leqslant$ 6 gauss and the energetic electron densities to $10^6 \leqslant n_e\ 10^8$ cm^{-3} and energies $\overline{E} \sim 1$ MeV. The measured values of circular ($\sim 5 - 10\%$) and linear ($< 2\%$) polarization during the 1983 February events on HR 1099 and UX Arietis are also consistent with this picture.

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Table 1

Summary of Results

Date	Telescopes	Freq. (GHz)	Sources	Flux (mJy)	Size (mas)	T_B(K)	Ref.
19 Dec 82	DSS13, DSS14, GRAS, OVRO	8.4	HR 5110	32	$\leqslant 1.4$	$\geqslant$ 4 E 8	a
13 Feb 83	VLA, OVRO, NRAO	1.65	UX Arietis	95	$\leqslant 2.1$	$\geqslant$ 1.4 E 10	b
			HR 1099	$\sim$ 200	$\leqslant 2.1$	$\geqslant$ 2.9 E 10	b
20 Mar 83	DSS14, DSS13, OVRO, WEST, GRAS	8.4	UX Arietis	$\sim$ 12	*	*	c
			HR 1099	$\sim$ 400	0.7	2 E 10	c
			Algol	30-48	$\leqslant 1.4$	$\geqslant$ 4 E 8	c
			σ Crb	10	*	*	c
			LSI 61°303	18	*	*	c
			II Peg	7	*	*	c

Telescope identification (diameter): DSS13 (26 m), DSS14 (64 m), Goldstone, CA; OVRO (40 m), Owens Valley, CA; GRAS (26 m), Ft. Davis, TX; WEST (18 m) Westford, MA; NRAO (43 m), Green Bank, WVA.

References: (a) Lestrade et al. (1983a), (b) Mutel et al. (1983), and (c) Lestrade et al. (1983b). * = too weak for detection on long baselines (unresolved on DSS14-OVRO).

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