LETTERS TO NATURE

Further Radio Observations of Cygnus X-1

PREVIOUS observations with the NRAO interferometer and the Westerbork synthesis radio telescope have led to the discovery of the radio counterpart of the X-ray source Cyg X-1 (refs. 1 and 2). A near positional coincidence suggested that this radio source is associated with the ninth magnitude B0 Ib star HDE 226868 (AGK2 +35° 1910). Recently, this star was shown to be a spectroscopic binary with a period of 5.60 day, possibly containing a heavy companion³. To study the variability of the Cyg X-1 radio source, we have continued to monitor it with the Westerbork array at 1,415 MHz, and in this communication we present the results.

Fig. 1 The 1415 MHz flux density of Cyg X-1 as a function of time. The point for July represents the average of observations taken on four consecutive days (see Table 1). The vertical bars indicate r.m.s. errors.

Our data are listed in Table 1 and plotted in Fig. 1. The sudden appearance of the source in April 1971 is confirmed by the independent results at 2,695 MHz of Hjellming and Wade¹, who failed to detect it on March 21 and 22, but observed a flux density of 0.015 f.u. from it on May 13. Apart from a slight decrease in flux after its initial appearance, there is little evidence from our data that the source subsequently varied. Certainly there was no indication of either the 5.60 day binary period or the 2.98 day X-ray period suggested by Dolan⁴.

According to Hjellming *et al.*⁵, the flux density at 2,695 MHz also remained constant at least until July 10. Our July

measurements cover the same period and a comparison yields a spectrum slightly flatter below 2,695 MHz than their Fig. 1 indicates.

Table 2 Positions of Cyg X-1

	R. A. (1950)				Decl. (1950)			
	h	m	s	s				
X-ray	19	56	27.5	±1.2	+35°	03'	57"	±15"
Radio	19	56	28.80	±0.10	+35°	03'	56.1"	±1.5"
Optical	19	56	28.81	±0.03	+35°	03'	54.1"	±0.4"

A combination of the 52 h of Westerbork data has enabled us to refine our initial estimate of the radio position of Cyg X-1. This improved position is given in Table 2, together with the X-ray location of the source taken from Schreier *et al.*⁶, and the SAO position of HDE 226868 corrected for proper motion. The peculiar red star pointed out by Kristian *et al.*⁷ is about 9" from HDE 226868 and cannot therefore be identified with the radio source. From an inspection of Table 2 it seems very probable that the radio emission is indeed connected with the HDE star.

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Asymmetries in Compact Sources at 2,298 MHz

SINCE 1967, experiments have been carried out over two inter-continental baselines, Island Lagoon, near Woomera, to Goldstone, California, and Island Lagoon to Johannesburg. The purpose of these experiments has been to measure the secular variations on a 0.001 arc s scale of a number of compact sources.

The antenna at Goldstone is a 210-foot dish, whereas the other two stations of the NASA-JPL Deep Space Network involved in the measurements operate with 85-foot antennae. The system we use¹ has recently been improved by increasing the sampling rate to 48 kHz and the bandwidth to 14 kHz. The samples are single bit samples.

Table 1 Westerbork Observations of Cyg X-1 at 1,415 MHz

	Universal time 1971						Flux density (f.u.)	
	d	h	m	d	h	m		
February	28	10	29	—	28	15	02	< 0.005
April	28	23	04	—	29	11	06	0.021 ± 0.002
July	5	04	42	—	5	06	41	0.017 ± 0.005
July	6	01	05	—	6	06	37	0.012 ± 0.003
July	7	01	36	—	7	06	31	0.017 ± 0.003
July	8	01	47	—	8	06	27	0.014 ± 0.003
August	5	22	30	—	6	04	34	0.013 ± 0.003
September	20	17	23	—	20	20	22	0.017 ± 0.004
September	26	22	08	—	27	01	12	0.012 ± 0.004
October	4	14	58	—	4	17	58	0.018 ± 0.004
October	18	15	33	—	18	18	32	0.015 ± 0.004