LETTERS TO NATURE

PHYSICAL SCIENCES

Radio Detection of Cygnus X-3

DURING a continuing search for radio emission from X-ray sources with the Westerbork synthesis telescope, we have detected a highly variable radio source near the X-ray location of Cyg X–3 (2ASE 2030+40). Its 1950 position is: $\alpha = 20\text{ h }30\text{ m }37.6\text{ s} \pm 0.1\text{ s}$, $\delta = +40^\circ\,47'\,12.7'' \pm 1.5''$.

The observations consisted of four 12 h measurements at a frequency of 1,415 MHz, spanning a period of eight months. Altogether, 80 interferometer baselines ranging in length from 48 to 1,470 m with steps of 18 m were used, and the baseline coverage was such that from a combination of the four measurements a complete synthesis of the brightness distribution in the Cyg X–3 region could be obtained. A profile display of the resultant $1^\circ \times 1^\circ$ synthesis map is shown in Fig. 1. It illustrates the crowded nature of the field which is part of the well known Cygnus X-radio complex. The extended sources, one of which coincides with the Cyg OB2 (VI Cyg) association and others with H II regions, will be the subject of a forthcoming publication.

The point source at the edge of the 2ASE error box for Cyg X–3 stands out by its three concentric diffraction grating rings which no other object in the field exhibits. These multiple rings would not be present in a complete synthesis map, unless the source had varied greatly during the period covered by the observations.

The strongly variable nature of the source is clear from separate analysis of each of the four 12 h observations. Dates and mean flux densities for these observations are given in Table 1. It appears that over a period of a few months the source has varied by an order of magnitude, whereas none of the other objects in the field showed any sign of variability. Both this extreme variability and the near positional coincidence make us confident that it is the radio counterpart of Cyg X–3.

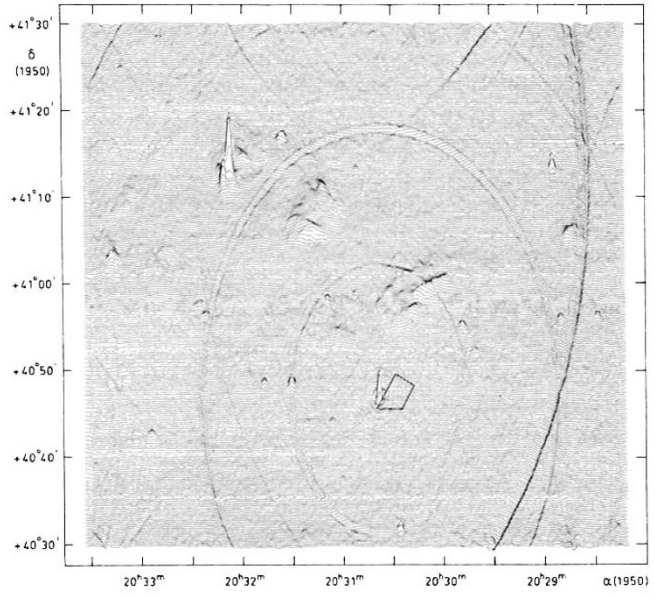

Fig. 1 1,415 MHz brightness distribution in a $1^\circ \times 1^\circ$ region surrounding Cyg X–3, presented as a series of intensity profiles in right ascension. The quadrilateral marks the 90% confidence limits of the ASE X-ray position from the Uhuru Catalogue.

Table 1 Westerbork 1,415 MHz Data for Cyg X–3

Universal time	Flux density (10^{-29} W m^{-2} Hz^{-1})	Polarization Linear	Circular
1971 July 19 d 18 h–20 d 06 h	57±2	—	—
1971 Oct. 12 d 13 h–13 d 01 h	23±2	—	—
1972 Mar. 7 d 03 h– 7 d 15 h	230±2	<2%	<2%
1972 Mar. 9 d 03 h– 9 d 15 h	106±2	<5%	<4%

From a preliminary analysis it appears that the 1,415 MHz flux density also varies appreciably on a time scale of hours. On March 7, while the source was strongest, the flux decreased by about 30% in less than three hours; during the other days it was relatively steady. In this respect, the behaviour of Cyg X–3 contrasts with that of Cyg X–1 which does not show such rapid variations.

The elements of the Westerbork array have at their focus a pair of crossed dipoles; by taking four cross correlations for each baseline all Stokes parameters of the incoming radiation can be derived. We have thus been able to set stringent upper limits to the mean linear and circular polarization for the days when the Cyg X–3 source was strongest. These mean values are also given in Table 1. It is possible that the source is still highly polarized on a short time scale, and that rapid changes of the position angle and sign during the course of a measurement cause the low mean values. This possibility is being investigated further.

There is no optical object at our radio position on the Palomar Sky Survey prints, but this is not surprising since the area is heavily obscured by the Great Cygnus Rift. From earlier X-ray data, Giacconi *et al.*[1] noted the positional coincidence of Cyg X–3 with the Cyg OB2 association. The radio source lies at the edge of this highly reddened group of stars, and if it is indeed connected with them, its distance would be 2.1 kpc (ref. 2).

With a peak flux density of 230×10^{-29} W m^{-2} Hz^{-1}, Cyg X–3 is so far the brightest galactic X-ray object at 1,415 MHz (except for known supernova remnants). The ratio of its radio to X-ray luminosity is about 50 times greater than for Cyg X–1 and exceeds that for Sco X–1 by more than two orders of magnitude. This, together with the unique character of its X-ray spectrum[3], suggests that we are dealing here with a completely different type of object. Simultaneous measurements at radio and X-ray wavelengths to investigate possible correlations may provide further insight into its nature.

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