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Research Note

Radio observations of the low-mass X-ray binary 2S 0921−630

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Abstract. The low-mass X-ray binary 2S 0921−630 has an orbital period of 9 d and therefore might be a Z source. To test this, we have performed 6 cm continuum observations of the low-mass X-ray binary 2S 0921−630 using the Australia Telescope Compact Array. The source was not detected and we determined an upper limit of 0.5 mJy (4σ) at 4.8 GHz. Comparing with earlier observations, we estimate that the probability that 2S 0921−630 has similar radio properties as prototype Z source Cyg X-2 is ~4%.

Key words: stars: individual 2S 0921−630; X-rays: binaries; radio sources: general; stars: neutron; accretion, accretion disks

1. Introduction

The persistently bright low-mass X-ray binaries can be divided into two classes, called the Z- and the atoll sources, on the basis of differences in their correlated X-ray spectral and timing behaviour (Hasinger & van der Klis 1989).

The Z sources have X-ray luminosities close to the Eddington luminosity for a neutron star. Two have known orbital periods; their values are 0.78 and 9.8 days, respectively, implying that their companions are low-mass (sub-)giants. Large interstellar extinction to other Z sources has precluded the determination of more orbital periods, which are most easily detected in the optical band. It has been suggested that the remaining Z sources also have (sub-)giant companions and therefore also must have orbital periods longer than 10 hr (Hasinger & van der Klis 1989). Recently a third Z source has been optically identified (Penninx & Augusteijn 1991), which will hopefully allow to test this conjecture.

The atoll sources are on average less luminous in the X-ray and optical bands than the Z sources. This is likely due to a lower accretion rate. Known orbital periods are shorter than those of the Z sources and range between 0.2 and 8.5 hours implying low-mass main-sequence or degenerate companions. Considerations of stellar evolution suggest that some atoll sources may also have subgiant companions (van der Klis 1991).

Z and atoll sources have different radio characteristics. All 6 known Z sources have been detected in the radio band, with fluxes that vary between <0.17 and 16 mJy at 6 cm; of the ~10 known atoll sources, only one has been detected in the 6 cm band, whereas upper limits of ~0.2 mJy have been reported for five (Penninx 1989; Hjellming et al. 1990; Tan et al. 1992; Cooke and Ponman 1991; Penninx et al. 1992). The origin of the radio emission of low-mass X-ray binaries is unclear. It is usually assumed that it is synchrotron radiation from ionized plasma ejected by the central emitting source, and comes from a region much larger than the binary system (see Hjellming & Penninx 1991). There are, however, models in which the radiation originates in the inner parts of the system (Kuijpers 1989).

Many of the less bright low-mass X-ray binaries have not been classified as either a Z or an atoll source, as their low X-ray fluxes make it impossible to determine the X-ray characteristics relevant to classifying them. 2S 0921−630 (also known as V395 Car) is among these unclassified sources. It is a faint X-ray source with a B magnitude of about 16 (Li et al. 1978). What makes the source particularly interesting is that it shows partial X-ray eclipses on a period of just over 9 d (Mason et al. 1987). Because the X-ray to optical luminosity ratio is relatively low, and because of the partial nature of the eclipses, the binary is believed to be observed almost edge-on, the X-rays having been scattered into the line of sight by an accretion disk corona (White & Mason 1985). If this model is correct then the real X-ray luminosity is much larger than the observed one, which may take 2S 0921−630 into the Eddington luminosity range.

The inferred high intrinsic X-ray luminosity and the long orbital period make 2S 0921−630 a Z-source candidate. We observed the source in the radio band in order to check on this. If 2S 0921−630 is a Z source, it would be expected to have a similar intrinsic radio luminosity as the other Z sources. As it is a near edge-on system, detection would allow to distinguish between the various proposed locations of the radio emission.

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2. Observations and results

We observed 2S 0921−630 on October 22, 1990 using the Australia Telescope Compact Array located at the Paul Wild Observatory, Culgoora, New South Wales. 2S 0921−630 was observed from 16:20 UT until 03:55 UT in continuum mode in the 6 cm band (ν = 4790 MHz), with a bandwidth of 128 MHz. The five antennas were in array-3 configuration, giving a maximum spacing of 2449 m and a minimum spacing of 61 m. A 15 min. calibration observation of the primary calibrator 1934-638 was made at the end of the observing run. During the run we made 5-min. observations of the secondary calibrator 1057-797 approximately every 0.5 hr.

Using the ephemeris and estimated eclipse duration of Mason et al. (1987) we find that the source was between phases 0.06 and 0.11 during the observation, and that it was in X-ray eclipse during the first ~3.5 hr of it.

The calibrated and cleaned map showed two sources, whose positions and fluxes were RA 09:22:35.89, Dec −63:16:56.87 and RA 09:22:18.68, Dec −63:20:40.89 (epoch 2000.0) and 3.15 and 3.57 mJy, respectively. At the position of 2S 0921−630 (RA 09:22:34.71, Dec −63:17:41) no source was detected. Using the observed 0.12 mJy rms noise of the map (which is four times the theoretical value), we estimate a 4σ upper limit for 2S 0921−630 of 0.5 mJy.

3. Discussion

If 2S 0921−630 is a Z source with a radio flux similar to that of the other Z sources, then we would expect, using radio luminosities seen in other Z sources (Penninx 1989), and taking into account their distances and that of 2S 0921−630 (9.2 kpc), its 6-cm radio flux to vary between less than 0.2 and 14 mJy. We cannot, therefore, from our upper limit of 0.5 mJy exclude that 2S 0921−630 has radio behaviour similar to that of the Z sources. Further observations are required to check that the radio flux is always as low as in our observation. However, our observation already makes the probability that 2S 0921−630 is a Z source with similar radio properties to prototype Z source Cyg X-2 quite small. On the basis of the fact that, among 49 measurements of the 4.8 GHz radio luminosity of Cyg X-2 (Hjellming et al. 1990), only 1 detection was below our observed upper limit for 2S 0921−630, and assuming that the distance to Cyg X-2 is similar to that to 2S 0921−630, Penninx 1989), we calculate this probability to be ~4%. This is evidence that either 2S 0921−630 is not a Z source, or the radio emission in Z sources is produced in a small region inside the binary system, and in edge on systems such as 2S 0921−630 is obscured along with most of the X-rays.

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