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Radio Identification of GX 5-1

Milne and Dickel¹ have suggested that the galactic nonthermal radio source A4 (No. 56 in Milne's list²) should still be identified with the X-ray source GX 5-1. We show here why this identification seems to conflict with present ideas on X-ray emission from nonthermal galactic radio sources (supernova remnants) and that the positional coincidence of both objects is no more than fortuitous.

The X-ray properties of GX 5-1 are typical of a Sco-Sgr type source. It is one of the brightest objects in the 1–5 keV range. Its position is known to 1.2 arc minutes (ref. 3) and the present upper limit to its angular diameter is 1.5 arc minutes (refs. 3 and 4). The X-ray spectrum is consistent with thermal bremsstrahlung emission from a plasma having a temperature between $kT = 2.2$ keV (ref. 5) and $kT = 5.5$ keV (ref. 6); the source has not been detected in the 30–80 keV range⁷, and this is consistent with its exponential spectrum. The low energy end of the spectrum shows a cut-off at $E_a = 1.9$ to 2.2 keV (refs. 6 and 7), which (if due to interstellar absorption) indicates a lower limit to the distance to GX 5-1 of $d \geq 5.7$ kpc (ref. 8). This implies an intrinsic luminosity in the 1–5 keV band of $L_x \geq 9 \times 10^{37}$ erg s⁻¹. No outstanding optical object is present within the error circle down to $B \approx 17$ magnitudes (ref. 9). There is also no point radio source brighter than 0.1 flux units (1 flux unit = 10^{-26} W m⁻² Hz⁻¹) at the 2σ level at 650 MHz within the error boundaries¹⁰. All these facts are consistent with an object possessing intrinsic X-ray, optical and radio luminosities typical of a Sco-Sgr type source located at a distance comparable with that of the galactic centre^{11–13}.

The best radio data on A4 (refs. 1, 14, 15) indicate an extended source with a nonthermal spectrum ($\sim \nu^{-0.2}$), having an angular diameter of 30 arc minutes. Its flux density at 635 MHz is 40 flux units. Milne and Dickel give a linear diameter of $D \approx 20$ pc at an estimated distance of $d \approx 2.4$ kpc.

Of the six nonthermal radio sources at present identified with X-ray sources (see ref. 16 and references therein), the Crab Nebula, Cas A and supernova Tycho's have power-law spectra extending well into the keV region, which can be understood in terms of synchrotron X-ray emission by the high energy tail of the electron distribution responsible for the synchrotron radio emission (ref. 17 and unpublished work of Ilovaisky). The spectra have already steepened in the X-ray range due to synchrotron radiation losses. On the other hand, Puppis A, Vela X and the Cygnus Loop, all supernova remnants of large linear diameter, show soft X-ray exponential spectra ($kT = 0.3, 0.2$ and 0.4 keV respectively) consistent in principle with thermal bremsstrahlung emission from the shock-heated plasma predicted from the adiabatic expansion (hot blast) theory which applies to old supernova remnants

(unpublished work of Ilovaisky and refs. 18 and 19). Although the Cygnus Loop poses some problems¹⁹, the soft X-ray emission spectrum of Vela X can be fully accounted for in terms of the hot blast theory (Ilovaisky). There is insufficient data to discuss Puppis A. A fact of decisive importance is that whenever the angular resolution of the X-ray equipment has permitted it, it has been found that the X-ray and radio flux distributions are of comparable angular extent (refs. 20, 21 and unpublished work of Gorenstein *et al.*). In particular for Vela X and the Loop, the observations are consistent with X-ray emission originating in the shell of the supernova remnant.

As Milne and Dickel point out, the supernova remnant A4 is intrinsically similar to Puppis A and Vela X, so we expect the following X-ray characteristics—a soft ($kT \approx 0.2$ to 0.4 keV) thermal emission spectrum coming from an extended region (~ 30 arc minutes in diameter) and showing interstellar absorption effects due to a hydrogen column density of $N_H \approx 3 \times 10^{21}$ H cm⁻². This corresponds to a cut-off $E_a = 0.8$ keV, which would suppress most of the radiation at low energies. Because of the low expected plasma temperature of the source, only a very small fraction of the total power should be emitted above 1 keV. Thus the received X-ray flux of the supernova remnant A4 should be very weak at all energies. This is in obvious conflict with the known X-ray properties of GX 5-1 summarized at the beginning of this article.

In conclusion, we recommend that the identification of the X-ray source GX 5-1 with the nonthermal galactic radio source A4 should not be retained.

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