X-661-76-113

PREPRINT

NASA TM X- 71131

X-RAY EMISSION FROM THE SUPERNOVA REMNANT G287.8-0.5

R. H. BECKER
E. A. BOLDT
S. S. HOLT
S. H. PRAVDO
R. E. ROTHSCHILD
P. J. SERLEMITSOS
J. H. SWANK

JUNE 1976

GSFC — GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

X-RAY EMISSION FROM THE SUPERNOVA REMNANT G287.8-0.5

R. H. Becker**, E. A. Boldt, S. S. Holt, S. H. Pravdo*, R. E. Rothschild, P. J. Serlemitsos, and J. H. Swank**

NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771

ABSTRACT

The GSFC Cosmic X-ray Spectroscopy experiment on OSO-8 observed a weak galactic X-ray source near $\ell^{II} \approx 288°$, $b^{II} \approx -1°$ for three days during July, 1975. The spectrum for this source between 2-20 keV is well represented by a thermal spectrum of $kT = 7.34^{+3.6}_{-2.6}$ keV with an intense iron emission line centered at $6.5 \pm .2$ keV. The error box of the UHURU source 4U1043-59, the only known X-ray source in our field of view, contains the radio supernova remnant G287.8-0.5. The possible association of the X-ray source with this supernova remnant is discussed.

I. INTRODUCTION

The OSO-8 observing program includes long-term observations of some of the weakest known galactic sources so that detailed spectra can be obtained. Such a source at ℓ^{II} = 288.0 was detected in a survey at the galactic plane by UHURU (Forman et al., 1976) and subsequently designated 4U1043-59 (Jones and Forman, 1976). This letter will report on observations of 4U1043-59 by the GSFC Cosmic X-ray Spectroscopy Experiment made during three days in July, 1975, the results of which lead to the association of this X-ray source with the supernova remnant G287.8-0.5

II. EXPERIMENT

The observations were made on July 17-19, 1975 with a pointed argon-filled proportional counter. The detector has an effective area

---

**NAS/NRC Resident Research Associate

* Work supported by U. of Maryland Grant NGR-21-002-316

of 36.7 cm^2 and an energy range from 2-20 keV divided into 63 channels. The 3^o collimation isolated 4U1043-59 in the field of view. During the three day observation, counting rates from the detector had a time resolution of 160 msec while spectral data had a 40 sec time resolution. A total integration time of $\sim 10^5$ sec was obtained. Background for the observation was accumulated two days prior to the observation when the detector was pointed 18^o off of the galactic plane.

The procedure used for analyzing the spectral data have been described in previous papers (Serlemitsos et al., 1975; Pravdo et al., 1976). Errors quoted on the best fit spectral parameters are for 90% confidence and are calculated by allowing the minimum acceptable value for χ^2 to vary by an amount consistent with the number of parameters in the model (Lampton et al., 1975).

III. RESULTS

The X-ray spectrum accumulated over the three day observation of 4U1043-59 could not be adequately fit by either a featureless power-law or thermal spectrum, the principle discrepency resulting from an excess of photons between 6-7 keV. With the addition of a narrow line centered at 6.5 ± 0.2 keV, both the power-law and thermal spectra gave acceptable fits.

To approximate a thermal spectrum we used the analytic form

$$\frac{dN}{dE} = C\, g(E,kT) \exp \quad - (E_A/E)^{2.7} \quad \exp(-E/kT)/E$$

where C is a normalization constant, $g(E,kT) = (E/kT)^{-.4}$ is an approximate form for the Gaunt factor, and E_A is related to the low energy cutoff in the spectrum from cold matter along the line of sight. With the narrow line an acceptable fit to the data was obtained with χ^2 = 15.3 for 14 degrees of freedom.

The best fit values for the variable parameters and their errors are

$$kT = 7.34 {}^{+3.6}_{-2.6} \text{ keV}$$

$$E_A = 0.09 {}^{+1.16}_{-0.09} \text{ keV}$$

with 1.46 $\pm$ .39 x 10^{-3} photons/cm^2-sec in the narrow line. The line has an equivalent continuum width of 1730 $\pm$ 460 eV.

Similarly, for a best fit power-law spectrum, $E^{-\alpha}$, with low energy absorption and a narrow line at 6.5 $\pm$ .2 keV, the best fit had χ^2 = 15.5 with values for the variable parameters of

$$\alpha = 2.24 {}^{+.36}_{-.39}$$

$$E_A = 1.36 {}^{+0.42}_{-1.36}$$

with 1.52 $\pm$0.41 x 10^{-3} photons/cm^2-sec in the narrow line. The observed spectrum of 4U1043-59 is shown in Fig. 1. The integrated flux between 2-6 keV is 7.4 $\pm$ 0.2 x 10^{-11} ergs/sec-cm^2 where the error quoted is only the statistical error. The error in the flux due to the background subtraction may be as large as 10 percent.

IV. DISCUSSION

The X-ray intensity initially reported for 4U1043-59 was 4.8 $\pm$ 2.2 x 10^{-11} ergs/sec-cm^2 between 2-6 keV (Forman et al., 1976). Analysis of additional UHURU data indicates an intensity of 5.8 $\pm$1.2 x 10^{-11} ergs/sec-cm^2

and an improved error box which is shown in Fig. 2 (Jones and Forman, 1976). This intensity is in fair agreement with our observed intensity and suggests the source has a constant luminosity.

Jones (1973) discovered a radio supernova remnant G287.8-0.5 with coordinates of

$$\text{R.A. (1950)} = 10^h\ 45^m$$
$$\text{Dec. (1950)} = -59^\circ 23'$$

which is close to the position of 4U1043-59 (see Fig. 2). This radio remnant is at a distance of less than 2.5 kpc with an angular diameter less than 0.42 degrees implying a linear diameter less than 18 pc. There is good agreement between the position of the radio remnant and 4U1043-59 but the size of the X-ray error box is too large to conclusively identify 4U1043-59 with G287.8-0.5.

However, this identification is also supported by the X-ray properties of 4U1043-59. The two galactic X-ray sources which have thermal spectra of kT $\simeq$ 4-5 keV with strong iron line emission are Cas A and Tycho's supernova remnant (Pravdo et al., 1976; Davison et al., 1976). In addition, the young remnant of SN1006 is also a source of thermal X-rays of kT $\simeq$ 4 keV (Winkler and Laird, 1975). The apparently constant X-ray intensity of 4U1043-59 is also consistent with its identification as a supernova remnant.

If the association between 4U1043-59 and G287.8 - 0.5 is correct, we find an upper limit for the X-ray luminosity L_x above 2 keV of 3.4 x 10^{34} ergs/sec based on the upper limit for the distance to G287.8-0.5. This is comparable to L_x above 2 keV for SN1006 and Tycho's supernova remnants (Davison et al., 1976; Winkler and Laird, 1975).

If the X-rays from 4U1043-59 are produced in a hot plasma with a temperature of 7.5 keV, then the presence of an iron line emission feature is expected. Model calculations for such a plasma by Raymond and Smith (1975) which include Gaunt factor calculations of Mewe (1972), line emission contributions from dielectronic recombinations, new calculations of ionization equilibrium, predict an iron emission line equivalent width of 913 eV for a cosmic abundance of iron. The observed width of 1730 eV suggests that iron is overabundant by a factor of ~ 2 in the X-ray emitting plasma, three times the abundance of iron estimated for Cas A from an identical calculation (Pravdo et al., 1976). A high abundance of iron in a supernova remnant may be an indication that the remnant is very young. If the material ejected in a supernova event is iron-rich, then the remnant will be iron-rich until the mass ejected in the explosion is diluted by material swept up from the surrounding interstellar medium. Therefore, in the early evolution of a supernova remnant, the iron abundance will be at its highest. Both the relatively high iron abundance and the relatively high temperature of the X-ray emission from 4U1043-59 suggest that the supernova remnant G287.8-.5 is a young object.

Additional observations are needed to confirm the identification of 4U1043-59 with G287.8-.5. In particular, a smaller error box for the location of the X-ray source could be conclusive. It is also important that additional radio observations of G287.8-0.5 are made so that an accurate determination of the radio diameter is available. Nonetheless, the observations of 4U1043-59 from OSO-8 and UHURU already provide strong evidence that the association between 4U1043-59 and G287.8-0.5 is real.

REFERENCES

Davison, P. J. N., Culhane, J. L., and Mitchell, R. J. 1976, preprint.

Forman, W., Jones, C., and Tananbaum, H. 1976, preprint.

Jones, B. B. 1973, Aust. J. Phys. 26, 545.

Jones, C., and Forman, W. 1976, private communication.

Lampton, M., Margon, B., and Bowyer, S. 1975, preprint.

Mewe, R. 1972, Astron. Astrophys. 20, 215.

Pravdo, S. H., Becker, R. H., Boldt, E. A., Holt, S. S., Rothschild, R. E., Serlemitsos, P. J., and Swank, J. H. 1976, Ap. J. (Letters), in press.

Raymond, J., and Smith, B. 1975, private communication.

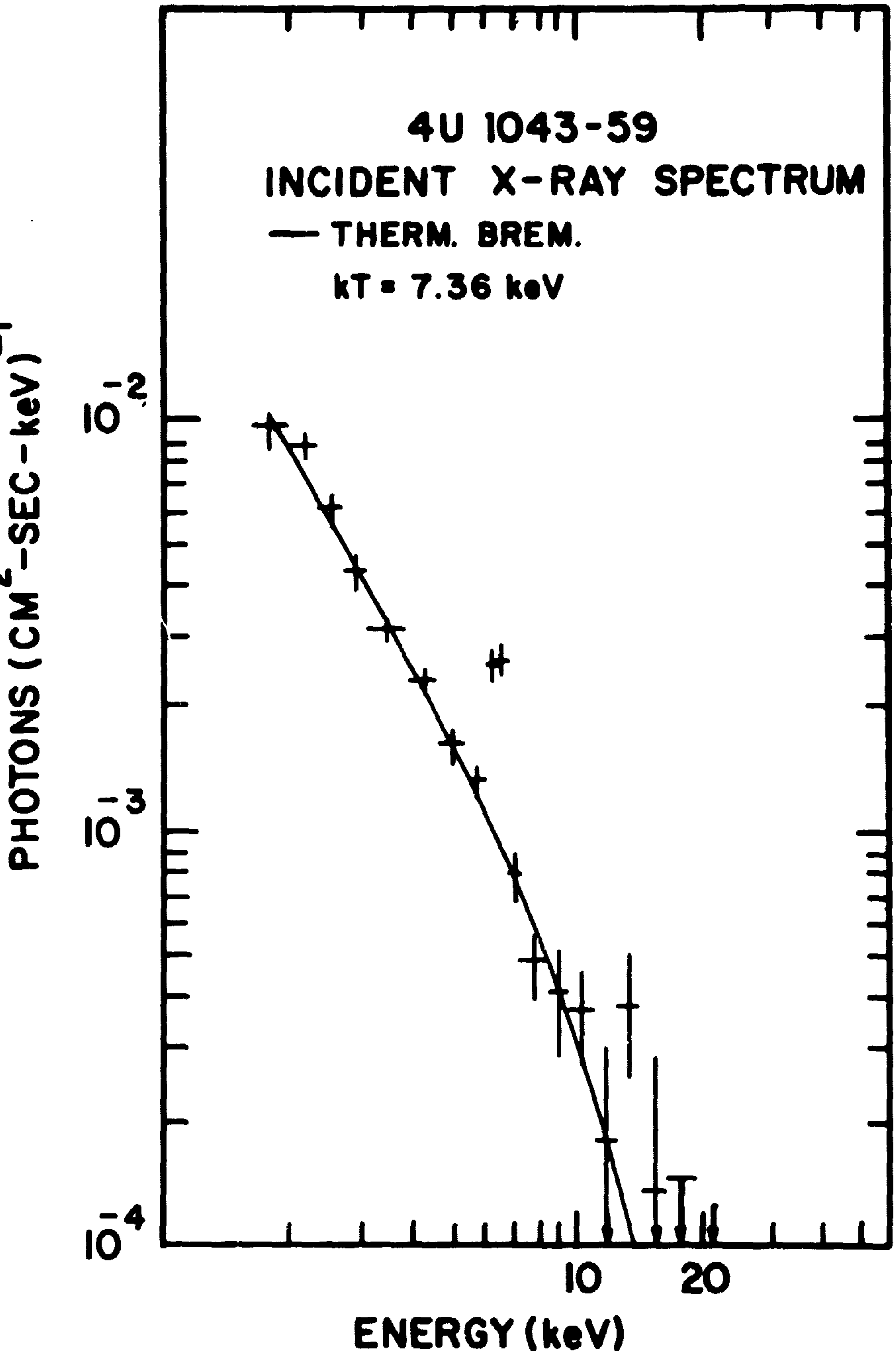
Serlemitsos, P. J., Boldt, E. A., Holt, S. S., Rothschild, R. E., and Saba, J. L. R. 1975, Ap. J. (Letters) 201, L9.

Winkler, P. F., and Laird, F. N. 1976, Ap. J. (Letters) 204, L111.

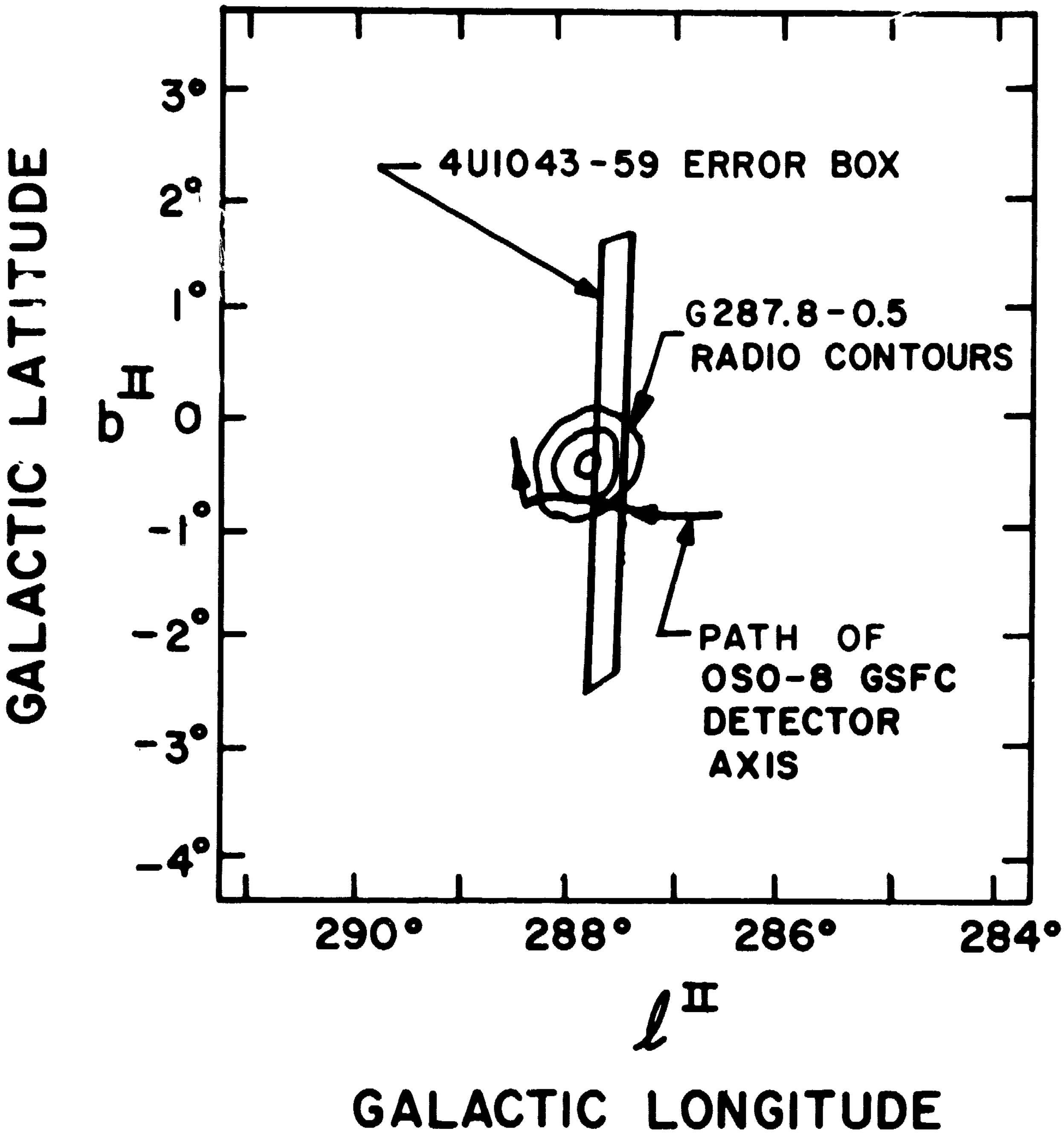
FIGURE CAPTIONS

Figure 1 -- The inferred incident X-ray spectrum for 4U1043-59. The solid curve represents the best fit thermal continuum to the data.

Figure 2 -- The rectangle is the 90% confidence error box for 4U1043-59 (Jones and Forman, 1976). The circular contours indicate the radio position of the supernova remnant G287.8-0.5 (Jones, 1973). The path of the axis of the X-ray detector projected onto the sky is also shown.



4U 1043-59
INCIDENT X-RAY SPECTRUM
— THERM. BREM.
kT = 7.36 keV
PHOTONS (CM^2-SEC-keV)$^{-1}$
10^{-2}
10^{-3}
10^{-4}
10
20
ENERGY (keV)


GALACTIC LATITUDE
b^{II}
3°
2°
1°
0
-1°
-2°
-3°
-4°
4U1043-59 ERROR BOX
G287.8-0.5
RADIO CONTOURS
PATH OF
OSO-8 GSFC
DETECTOR
AXIS
290°
288°
286°
284°
ℓ^{II}
GALACTIC LONGITUDE