THE ASTROPHYSICAL JOURNAL, 189:L69–L70, 1974 April 15

AN UNUSUAL X-RAY SOURCE IN SCUTUM*

R. HILL, G. BURGINYON, R. GRADER, A. TOOR, J. STOERING, AND F. SEWARD
Lawrence Livermore Laboratory, University of California, Livermore, California 94550
Received 1974 February 4

ABSTRACT

Two previously unreported X-ray sources have been observed. The spectrum of one of them, Sct X-1 (l^{II} = 24°41), shows the strongest absorption of any source that we have ever observed. Both sources are probably variable.

Subject headings: spectra, X-ray — X-ray sources

Two previously unreported X-ray sources have been observed. The spectrum of one of them, Sct X-1, shows the strongest absorption of any source that we have ever observed. If the absorption is caused by cold interstellar material, then Sct X-1 is probably located on the other side of the Galaxy.

The X-ray astronomy payload was flown on a rocket from Kauai, Hawaii, on 1973 June 23 at 10:45:30 UT to survey the region of sky around Ser X-1. A complete report of the results of this observation will be presented in a later paper. In this *Letter* the two previously unreported X-ray sources are described.

The payload was essentially the same as those used for earlier galactic-plane survey experiments (Hill *et al.* 1972; Burginyon *et al.* 1973; and Hill *et al.* 1974). It consisted of two proportional counters in series separated by a 0.5-mil aluminized Mylar[1] sheet. The front, or low-energy detector, had a 60 μg cm^{-2} Formvar window and 1 atm of methane gas while the rear, or high-energy detector, contained 1 atm of P-10 gas (90 percent argon plus 10 percent methane). The energy range of the system was 0.2–2.5 keV for the front counter and 1.5–18 keV for the back. The collimator FWHM angles were 1°1 $\times$ 16°1.

After in-flight energy calibration, the payload performed a slow scan with the collimator axis moving along the galactic plane from $l^{II} = 16°$ to $l^{II} = 51°$. Figure 1 shows the counting rates of the P-10 counter for a portion of this scan. Two sources are clearly visible. We assign one to the constellation Scutum. Even though we can only locate the source in galactic longitude, the absorption of the soft X-rays is so large that the source probably lies near the galactic equator.

As can be seen from the figure, Sct X-1 (l^{II} = 24°41 $\pm$ 0.09°) is indistinguishable from the background below 4 keV while the other source, which we will call GX-21 for purposes of identification in this paper (l^{II} = 20°8 $\pm$ 0°1), is strong in both energy ranges

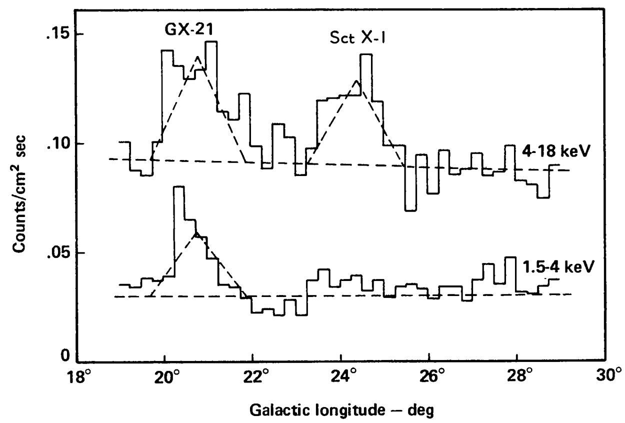

FIG. 1.—Count rate in two energy intervals plotted versus galactic longitude. Dashed line indicates the collimator angular response function.

and, in fact, is also easily seen in the methane counter data.

The same location was covered by a survey experiment in 1972 May, and these two sources were not seen (Burginyon *et al.* 1973). The sensitivity of this earlier observation was not great enough to determine whether or not these two sources were present.

We have fitted our spectral data with a simple exponential model for the source spectrum:

$$N(E) = \frac{C \exp(-E/KT) \exp(-\sigma_{BG} N_H)}{E} \quad \text{photons cm}^{-2}\,\text{s}^{-1},$$

where σ_{BG} is the Brown and Gold (1970) absorption cross-section for interstellar matter. Our data do not contain enough counts from either source to uniquely determine any spectral parameters since there is a strong coupling between these variables. We therefore assume a value of KT = 7.5 keV, which is reasonable (and perhaps a bit high) for most X-ray sources. The derived values for N_H are thus expected to be on the low side.

* This work was performed under the auspices of the U.S. Atomic Energy Commission.

[1] Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Atomic Energy Commission to the exclusion of others that may be suitable.

The best fit to the Sct X-1 data are $C = 0.5 \pm 0.05$ photons cm^{-2} s^{-1} keV^{-1}; KT = fixed at 7.5 keV; and $N_H = (5100 \pm 1250) \times 10^{20}$ hydrogen atoms per cm^2. The total count rate in the argon detector from this source was 0.06 counts cm^{-2} s^{-1}.

Since we did not obtain a large number of counts, it is possible to fit the data with several models. The variation in N_H with model type is about a factor of 2, but in no case is N_H less than 2000×10^{20} H atoms per cm^2.

For the source GX-21 we get: $C = 0.10 \pm 0.01$ photons cm^{-2} s^{-1} keV^{-1}; KT = fixed at 7.5 keV; and $N_H = (18 \pm 8) \times 10^{20}$ hydrogen atoms per cm^2.

The total count rates in the argon and methane detectors from this source (if the collimator was pointed directly at the source) are 0.066 and 0.075 counts s^{-1}, respectively.

Sometimes the absorption is approximated by the expression

$$\exp\left[-(Ea/E)\right]^{8/3}.$$

If we do this, the spectral forms given above yield $Ea = 6.1$ keV for Sct X-1 and $Ea = 0.5$ keV for the source at $l^{II} = 20.8$.

Neither source is close to anything listed in the *Uhuru* 3U catalog (Giacconi *et al.* 1973). By using the spectral parameters listed, the *Uhuru* counting rates can be predicted. The source GX-21 should appear with a strength of 35 counts s^{-1} and Sct X-1 with a strength of 15 counts s^{-1} in the 2–6 keV channel. The 3U catalog lists all sources with strengths greater than 3 counts s^{-1}. Therefore, the two sources we have discovered would seem to be highly variable.

GX-21 is probably relatively close to us judging by its N_H value. The observed absorption is about the same as that of the Crab Nebula which is about 2 kpc distant (Hill *et al.* 1974).

Scutum X-1 is more unusual. The derived value of N_H is the highest of any of the sources we have investigated. Its spectrum appears to be more heavily attenuated than those of GCX (3U 1743−29) or Cyg X-3 (3U2030+40) for which the attenuation has been respectively characterized by $Ea = 2.2$ and $Ea = 4.0$ by other observations (Kellogg *et al.* 1971; Bleach *et al.* 1972).

If we assume that Sct X-1 is at the far side of the Galaxy (d = 20 kpc), then the integrated luminosity is 2.7×10^{38} ergs s^{-1}, which puts it in the class of strong sources (Seward *et al.* 1972). The average density of hydrogen atoms is about 8 atoms per cm^3, a larger than expected density. The observed absorption of distant galactic sources has been noted by Seward *et al.* (1972) to be large. Scutum X-1 is another example of this phenomenon.

REFERENCES

Bleach, R., Boldt, E., Holt, S., Schwartz, D., and Serlemitsos, P. 1972, *Ap. J.*, **171**, 51.
Brown, R. L., and Gould, R. J. 1970, *Phys. Rev.*, **D1**, 2252.
Burginyon, G., Hill, R., Palmieri, T., Scudder, J., Seward, F., Stoering, J., and Toor, A. 1973, *Ap. J.*, **179**, 615.
Giacconi, R., Murray, S., Gursky, H., Kellogg, E., Schreier, E., Matilsky, T., Kock, D., and Tananbaum, H. 1974, *Ap. J. Suppl.*, No. 237, **27**, 37.
Hill, R. W., Burginyon, G., Grader, R., Palmieri, T., Seward, F., and Stoering, J. 1972, *Ap. J.*, **171**, 519.
Hill, R. W., Burginyon, G., Seward, F., Stoering, J., and Toor, A. 1974, *Ap. J.* (to be published).
Kellogg, E., Gursky, H., Murray, S., Tananbaum, H., and Giacconi, R. 1971, *Ap. J.* (*Letters*), **169**, L99.
Seward, F., Burginyon, G., Grader, R., Hill, R., and Palmieri, T. 1972, *Ap. J.*, **178**, 131.