THE ASTROPHYSICAL JOURNAL, 174:L53–L55, 1972 May 15

A NEW TRANSIENT SOURCE OBSERVED BY *UHURU*

T. A. MATILSKY, R. GIACCONI, H. GURSKY, E. M. KELLOGG, AND H. D. TANANBAUM
American Science and Engineering, Cambridge, Massachusetts
Received 1972 March 27

ABSTRACT

A strong X-ray source appeared sometime between 1971 March 25 and 1971 August 17. On August 23, its intensity, as observed by the *Uhuru* satellite, was about twice that of the Crab Nebula, corresponding to about 3.0×10^{-8} ergs cm^{-2} s^{-1} in the range 2–6 keV. On 1971 December 20, its intensity had declined to one-tenth of that value in the same energy range. Its spectrum was quite steep, and fit a power law with an average energy spectral index of 3.0. The variation of X-ray intensity over a 5-month period shows qualitative differences from the previously observed transient X-ray sources, Cen XR-2 and Cen XR-4.

I. INTRODUCTION

On 1971 August 17, a new X-ray source in the constellation of Lupus, designated as 2U 1543−47 in the *Uhuru* catalog (Giacconi *et al.* 1972) was observed from the *Uhuru* satellite at about one-tenth the strength of Sco X-1; the source was initially reported in I.A.U. Circular 2355. In late March, which was the previous time the satellite was oriented in a direction that the source could be detected, no fluctuations above the background were observed, so the limiting intensity at this location would be 10^{-4} that of Sco X-1. Furthermore, there is no indication in our previous data or in prior surveys of this part of the sky of an X-ray source at this location (Oda and Matsuoka 1970). Because of the sudden appearance of this source, its great strength, and its subsequent decline, we believe it to be another example of a transient X-ray source, as exemplified by Cen XR-2 and Cen XR-4.

II. EXPERIMENTAL RESULTS

Details of the *Uhuru* instrumentation are given by Giacconi *et al.* (1971). By obtaining sightings on the source at different orientations of the spin axis of the spacecraft, a 90 percent confidence error box for the location was derived. Pertinent data are given in table 1.

Figure 1 (plate L1) shows the error box superposed on the proper area of the sky. No optical nova has occurred within this region during the past two years down to a limit of about $m_v \approx 15$ as reported by Liller (1972) based on his examination of red, yellow, and blue photos taken with the Harvard College Observatory's patrol cameras located at the Boyden Observatory in South Africa. The most recent photos examined were taken on 1971 August 10.

Figure 2 shows the X-ray intensity variation of 2U 1543−47, with intensity in counts per second plotted with open circles versus days. The error bars are principally the result of the uncertainties in satellite pointing, and are much larger than the count statistics. Where the error bars are less than ± 100 counts s^{-1}, we were able to solve for the aspect of the spacecraft, and these errors reflect count statistics. Also shown (as X's, without error bars) is the intensity variation of Cen XR-4 (Evans, Belian, and Conner 1970) plotted as if August 17 marked the appearance of that source. Day-by-day variations in intensity of 2U 1543−47 are apparent in the data, and we have also searched for shorter time variability. Data from 1971 November 27 provided five consecutive sightings over a period of 206 minutes. No statistically significant fluctuations

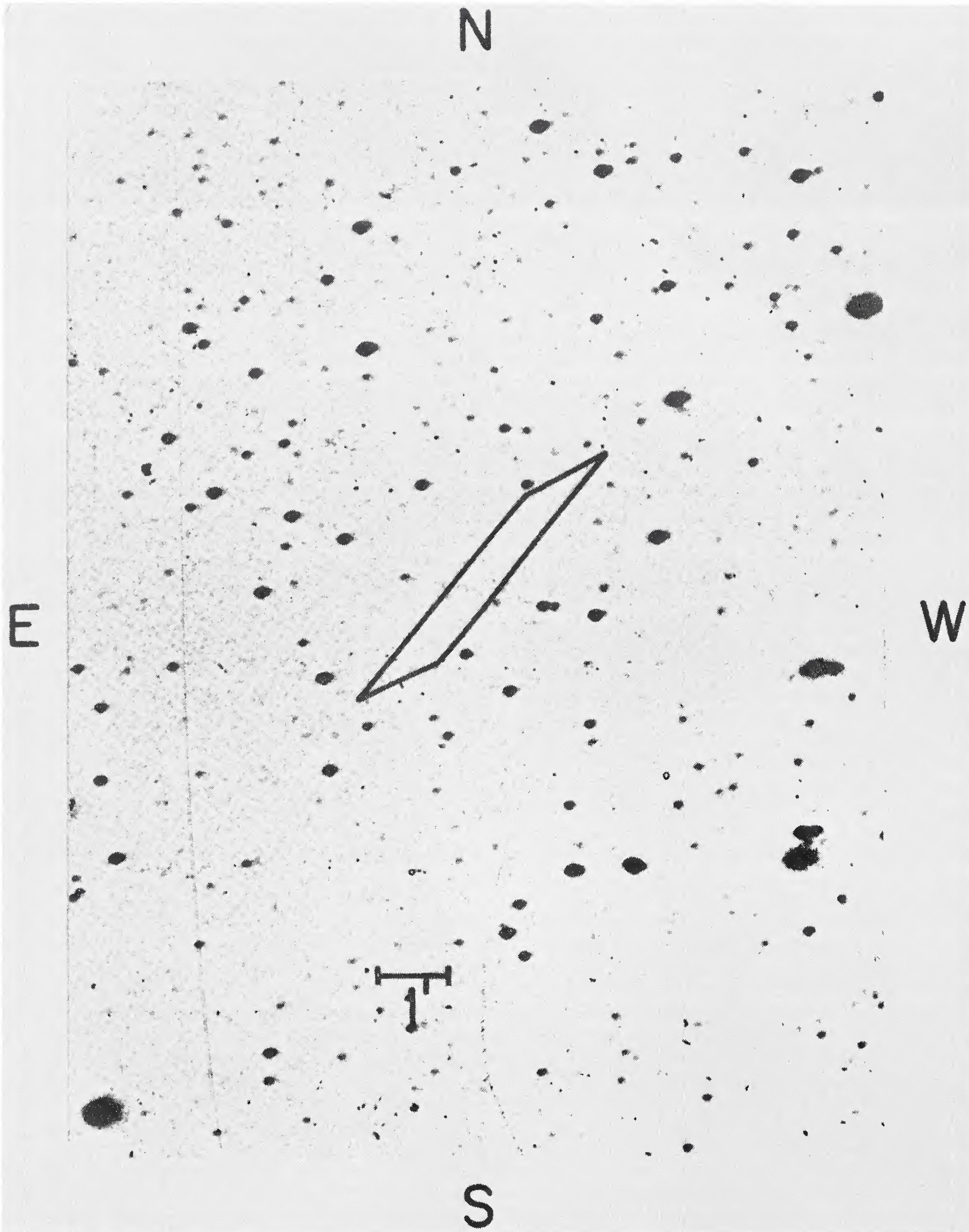

FIG. 1.—90 percent confidence error box shown superposed on a blue-sensitive plate taken in the 1920's at the Harvard College Observatory in Peru. Limit of detectability is $m_v \approx 18$. SAO 226182 is the bright star near the upper right edge.

MATILSKY *et al.* (*see* page L53)

TABLE 1

LOCATION OF 2U 1543−47

Location of centroid	$\alpha = 15^h43^m50^s.4$, $\delta = -47°33'36''$
Corners of error box (equinox 1950.0)	$\alpha = 15^h44^m02^s.4$, $\delta = -47°35'28''$
	$\alpha = 15^h43^m46^s.8$, $\delta = -47°32'31''$
	$\alpha = 15^h43^m39^s.6$, $\delta = -47°32'02''$
	$\alpha = 15^h43^m54^s.0$, $\delta = -47°35'02''$
Centroid in galactic coordinates	$l^{II} = 330°.94$, $b^{II} = 5°.37$

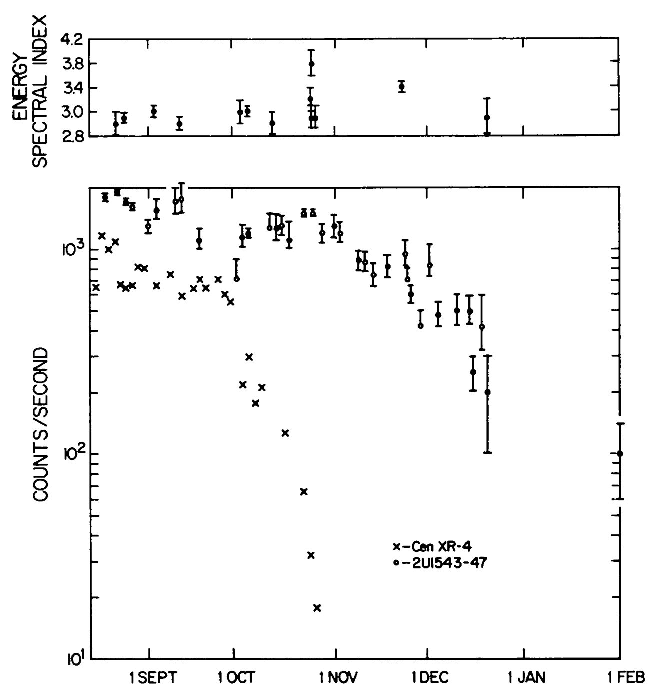

FIG. 2.—Counting rates of transient source in Lupus from 2–6 keV compared with that of Cen XR-4, in the range 3–12 keV, plus energy spectral index for 2U 1543−47. To get fluxes in ergs cm^{-2} s^{-1} for the observed spectral ranges, multiply the counting rate for 2U 1543−47 by 1.5×10^{-11} and that of Cen XR-4 by 4.2×10^{-10}.

are observed, placing an upper limit on the intensity variation over this timescale at 10 percent. On a shorter timescale, data on November 25 yielded 130 seconds of continuous observation, and for 1017 independent measurements, a χ^2 of 1.07 per degree of freedom was obtained by using a triangular response, which indicates essentially no second-by-second variability.

Certain preliminary statements about the spectrum can be made at this time, although systematic effects are still not sufficiently well known to determine the spectrum with very great precision. It is very steep, corresponding to an average energy spectral index of 3.0 ± 0.2 (with no indication of a low-energy cutoff to a limit of about 1.7 keV). This spectrum applies over the entire period with two exceptions. On November 25, the spectrum appeared as a power law with energy spectral index of 3.4 ± 0.1, corresponding to a 25 percent decrease in temperature, from $17 \pm 1 \times 10^6$ °K to $13 \pm 0.1 \times 10^6$ °K, for an isothermal bremsstrahlung fit. However, this is not necessarily unusual, because the spectral data points on either side of November 25 span almost 1 month. However, on 1971 October 25 the energy spectral index changed from 2.9 ± 0.2 to 3.8 ± 0.2 in the span of 6 hours, and then returned to 3.2 ± 0.2 on the very next orbit, about 90 minutes later. This corresponds to a 30 percent decrease in temperature, from about $17 \pm 1 \times 10^6$ ° K to $12 \pm 1 \times 10^6$ ° K for an isothermal bremsstrahlung fit. We have no indication of spurious effects in the spacecraft during this period. No significant variation in Sco X-1 was found on orbits either during or after the change. Also, background counts on either side of 2U 1543−47 were normal, and the intensity variations of the source were within statistics (10 percent). Furthermore, each individual spectral channel was examined for deviations from a uniform triangular response; none were found. The spectral data are plotted above the intensity points in figure 2.

III. DISCUSSION

Figure 2 compares the decay histories of Cen XR-4 (Evans *et al.* 1970) with that of the new source. Although the date of the appearance of Cen XR-4 is known to within 3 days whereas 2U 1543−47 is known only to within 5 months, certain conclusions can be drawn by superposing the Lupus source as if August 17 marked its initial appearance. The new source is considerably more persistent than Cen XR-4, which had diminished by a factor of approximately 10^3 within 80 days after onset while 2U 1543−47 had barely declined to half-maximum within this same interval. However, during the early phase, both sources displayed a similar average rate of decline which was about 2 percent per day for 2U 1543−47 for 170 days and 2.5 percent per day for Cen XR-4 for 40 days.

The intensity curve also shows recovery phenomena in 2U 1543−47 as seen in the relative maxima on ~September 10, ~October 20, and ~November 30. Centaurus XR-4 shows evidence of a similar phenomenon, and these may be indicative of secondary events.

As was discussed by Evans *et al.* (1970) with respect to Cen XR-4, the slow rate of decline of the X-ray intensity and the lack of a systematic change in the spectral index are not compatible with simple models involving a blast wave or the expansion of a hot gas. The greater persistence of this effect in 2U 1543−47 makes these models less likely. Furthermore, the change in spectral index that occurred on October 25 is not compatible with a large object. Thus the conclusion from these data and the Cen XR-4 data as well is that the X-ray emission does not originate in a continuously expanding region. However, they may be compatible with the nova model proposed by Rose (1968) in which energy is stored in the form of pulsations on the surface of a white dwarf and is subsequently released during their decay.

The absence as yet of an optical nova may be important to understanding these objects. If the distance is ~1 kpc, the optical object could not have been brighter than +5 absolute magnitude, which is 10 mag fainter than the range for novae based on the Harvard observations. This may mean that there is little or no optical emission associated with these X-ray novae. Alternatively, they may be much more distant. However, if 2U 1543−47 is at 10 kpc (a distance consistent with a luminosity about equal to that of optical novae), then its X-ray luminosity was of the order of 10^{39} ergs s^{-1} for more than 100 days.

We would like to express our appreciation to Drs. Martha and William Liller of Harvard University for the plate of the region containing 2U 1543−47.

This research was sponsored under NASA contract NAS5-11422.

REFERENCES

Evans, W. D., Belian, R. D., and Conner, J. P. 1970, *Ap. J.* (*Letters*), **159**, L57.
Giacconi, R., Gursky, H., Kellogg, E., Murray, S., Schreier, E., and Tananbaum, H. 1972, submitted to *Ap. J.*
Giacconi, R., Kellogg, E., Gorenstein, P., Gursky, H., and Tananbaum, H. 1971, *Ap. J.* (*Letters*), **165**, L27.
Liller, W. 1972, private communication.
Oda, M., and Matsuoka, M. 1970, *Progress in Elementary Particle and Cosmic-Ray Physics*, p. 305.
Rose, W. K. 1968, *Ap. J.*, **152**, 245.