THE ASTROPHYSICAL JOURNAL, 183:L117–L119, 1973 August 1

OPTICAL STUDIES OF *UHURU* SOURCES. V. A PRIME CANDIDATE FOR THE "TRANSIENT" X-RAY SOURCE 2U 1543-47

WILLIAM FORMAN* AND WILLIAM LILLER*
Harvard College Observatory, Cambridge, Massachusetts
Received 1973 May 16

ABSTRACT

We describe a rapidly and irregularly varying late-type star which appears within 20″ of the center of the 90-percent confidence error box surrounding the X-ray source 2U 1543-47. We suggest that this star may be the optical counterpart of the X-ray source.

Subject headings: variable stars — X-ray sources

I. INTRODUCTION

In 1972 May we undertook a photographic survey of the star fields surrounding 18 *Uhuru* X-ray sources characterized by 90-percent error boxes mostly smaller than 0.01 square degrees and with coordinates $11^h < \alpha < 19^h$ and $\delta < 10°$. The photographs were taken with the 60-inch (152-cm) reflector of the Cerro Tololo Inter-American Observatory through a special interference filter which has a flat transmission maximum of approximately 90 percent extending from wavelengths of 5900 to 7400 Å.

Both direct and near-focal-plane grating plates were taken, the latter with a Bausch and Lomb replicated transmission grating with 300 grooves mm^{-1} and blazed at 6100 Å. The grating was located approximately 10 cm toward the objective from the focal plane and produced a dispersion of 900 Å mm^{-1}; see Hoag and Schroeder (1970) for a full discussion of this technique. At the focus an S-20 Westinghouse image tube with an extended red response provided a field of view diameter of 7′. The focal scale of the telescope was 10″ mm^{-1} which, with seeing of about 2″, gave a spectral resolution of $\sim$ 180 Å.

II. OBSERVATIONS OF 2U 1543-47 AND ITS OPTICAL CANDIDATE

We report here on a peculiar variable star located 20″ south of the centroid location given in the *Uhuru* catalog (Giacconi *et al.* 1972) for the X-ray source 2U 1543-47 ($l^{II} = 330°$, $b^{II} = +5°$). Matilsky *et al.* (1972) have described its X-ray behavior in detail. Since the star and the source are extremely close in position and both are variable, we believe that the star is very likely the optical counterpart of the X-ray source.

Figure 1 (Plate L4) is a reproduction of a direct red plate taken on 1972 May 14–15 on which we have plotted the X-ray position and indicated the unusual star.

The spectrum taken through the pre–focal-plane grating appears to be that of an early M-type star in which moderately strong TiO bands modulate the red continuum. However, a second spectrogram obtained approximately 4 minutes earlier shows the continuum at 7400 Å to be substantially weaker (by an estimated factor of 2) relative to the center of the TiO band at 6800 Å.

On the following night, 1972 May 15–16, *UBV* observations using the standard

* Visiting Astronomer, Cerro Tololo Inter-American Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation.

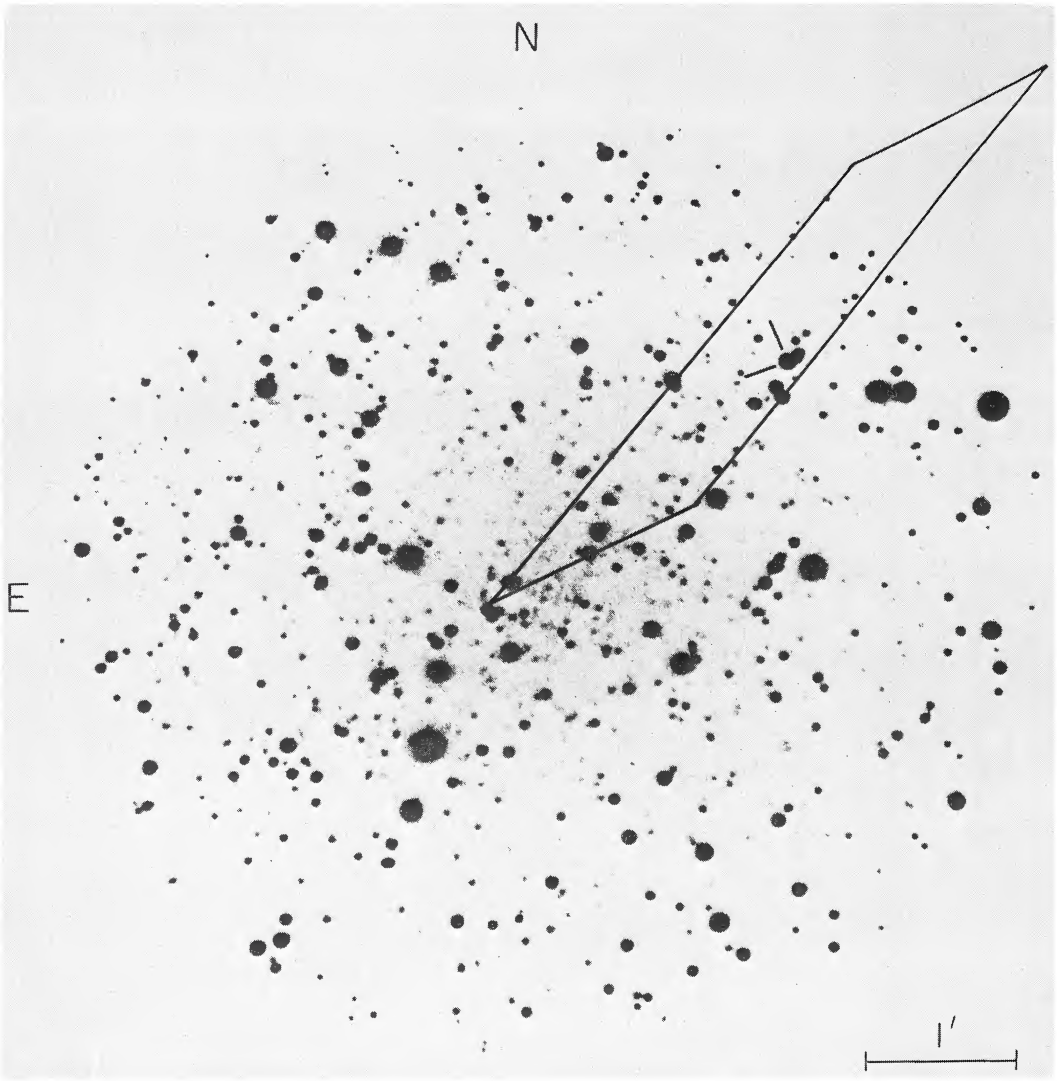

FIG. 1.—Reproduction of a 5-minute exposure made of the region of 2U 1543-47 with the 60-inch reflector at Cerro Tololo, a Westinghouse image tube, and a special red-transmitting filter. The 90-percent error box associated with 2U 1543-47 is shown, and the unusual variable star is marked.

FORMAN AND LILLER (*see* page L117)

photoelectric photometer attached to the 60-inch telescope yielded the following results:

$$V = 15.1; \qquad B - V = +2.2; \qquad U - B = +2.7.$$

Continued photoelectric monitoring of the star in the B-band confirmed that the star was variable on a time scale of minutes and, in the 80 minutes during which it was observed, the star fluctuated irregularly with a maximum rate of change of 0.060 ± 0.015 mag in 10 minutes.

On 1972 May 16–17, we obtained an unwidened spectrogram (225 Å mm^{-1}) with the image-tube spectrograph mounted at the Cassegrain focus. The spectrogram shows in greater detail the broad features seen on the grating plates plus other TiO absorptions with band heads at $\lambda = 5167$, 4955, and 4761 Å. Because the Ca I and Ca II resonance lines are of comparable strength, we conclude that the star is a giant, and have adopted the spectral classification M2 III.

If we assume that the absolute visual magnitude $M_V = 0$, that the interstellar absorption A_V amounts to 0.08 mag $(\text{kpc})^{-1}$, and that the ratio of total to selective absorption $A_V/E_{B-V} = 3.2$, we arrive at the following intrinsic parameters, all of which seem quite reasonable:

$$\text{Distance from Earth} = 3.2 \text{ kpc},$$

$$(B - V)_o = +1.5; \qquad (U - B)_o = +2.2; \qquad A_V = 2.6.$$

III. DISCUSSION

We point out several interesting facts in connection with our proposed identification of the late-type variable star and 2U 1543-47. We note that the X-ray light curve of 2U 1543-47 (and also that of another "transient" source, Cen XR-4) is quite similar to the light curves of optical "slow" novae; see figure 2 of Elliot and Liller (1972). Further we note the association of both X-ray sources and cataclysmic variables with close binary systems (Kraft 1964 and Jones *et al.* 1973, table 1) many of which show short-term optical variations (Warner and Nather 1972).

Therefore, we believe it entirely reasonable that the source discussed here, 2U 1543-47, is also involved in a binary system. The only striking difference between our candidate star and the cooler companion of optical cataclysmic variables is one of luminosity. In conventional novae, the cooler star is always a late-type dwarf, while here we are dealing with a late-type giant. It is perhaps because of this difference that one star becomes an X-ray transient source, presumably with little or no optical flare-up, and the other a bona fide nova.

As of 1973 February, 2U 1543-47 continues to radiate at X-ray frequencies at about 20 counts s^{-1} as monitored by the *Uhuru* satellite with occasional flaring to $\sim$200 counts s^{-1} (Matilsky and Jones 1973). But should another major flare-up occur like the one seen in 1971, when it became the second strongest X-ray source in the sky, further optical observations would be extremely important.

We should like to thank the National Science Foundation for partial support of this program and the Smithsonian Astrophysical Observatory for making travel funds available to one of us (W. F.). Dr. Malcolm Smith demonstrated unusual patience in showing us the use of the image tube cameras, and we are especially grateful to him. Lastly, we thank Dr. A. A. Hoag for discussion on the nature of our low-resolution spectrograms and advice on how to secure them.

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