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THE X-RAY LIGHT CURVE OF NOVA OPHIUCHI 1977 (H1705−25)

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ABSTRACT

We present the X-ray light curve of Nova Ophiuchi 1977 (H1705−25), which shows unambiguously the fast rise and slow decline characteristic of "classical" X-ray transients. Comparison with the light curves of previous transient X-ray sources indicates that Nova Ophiuchi 1977 may be in the same class as A0620−00.

Subject heading: X-rays: sources

I. INTRODUCTION

The bright X-ray transient designated H1705 − 25 was discovered independently by the *HEAO 1* scanning modulation collimator (MC) (Griffiths *et al.* 1977, 1978) and the *Ariel 5* all sky monitor (ASM) (Kaluzienski and Holt 1977) at the beginning of 1977 September.

On the basis of the small MC error box, an associated optical nova (Nova Ophiuchi 1977) was discovered on plates taken at the Anglo-Australian Telescope and UK Schmidt Telescope (Longmore *et al.* 1977; Griffiths *et al.* 1978).

In this *Letter* we present the observations made of H1705−25 by two separate satellite experiments, the *Ariel 5* sky survey instrument (SSI) and the *HEAO 1* MC, which cover the initial rise to maximum intensity and subsequent irregular decline of this source. The light curve is compared with those of previous transient X-ray sources in terms of both time scales and intrinsic variability.

II. OBSERVATIONS

The source H1705−25 was in the field of view of the *Ariel 5* SSI (for details of the SSI and data analysis, see Villa *et al.* 1976; Cooke *et al.* 1978) from 1977 July 31 to 1977 August 31. At the end of this observation a satellite spin-axis maneuver took the source out of the field of view of the SSI (and into that of the ASM).

The data points plotted on Figure 1 are single orbit intensities (~2–3 s exposures in ~100 minute satellite orbit) in the 2–18 keV band, corrected for both collimator response and exposure time. The error bars shown reflect both the statistical errors and the additional error introduced via the collimator response correction by uncertainties in the spacecraft attitude.

We also show the data from the *HEAO 1* MC (Gursky *et al.* 1978) obtained from single-pass "quick-look" observations spanning 1977 September 7 to September 12 (energy band 1–13 keV). Because of the possibility of strong spectral evolution of this source (cf. A0620−00; Ricketts, Pounds, and Turner 1975), we have made no attempt to convert to absolute units. Instead, all the intensities are shown relative to the Crab Nebula (= 1000 units). We estimate that any correction of the MC points to the SSI energy band (2–18 keV) would be less than 10%.

The light curve of H1705−25 shown in Figure 1 clearly resembles that of a "classical" X-ray transient. It does, however, show several novel features, in particular the double-peaked maximum and rather irregular postmaximum decay.

The rise time to maximum intensity (measured between 0.1 I_{max} and 0.9 I_{max}) is ~1.7 days, somewhat faster than previous transients which have typical rise times of 3–7 days (Pounds 1976). The short pause (at ~0.7 I_{max}) in the rise to maximum intensity (near MJD 43,364.2) may be a precursor similar to those seen in A0620−00 (at ~0.1 I_{max}; Elvis *et al.* 1975) and A1524−61 (at ~0.5 I_{max}; Kaluzienski *et al.* 1975).

The decay of H1705−25 is characterized by an initial sharp drop in intensity in ~0.7 days, a rise to secondary maximum on the same time scale, a further fast drop to ~0.5 I_{max} in ~0.8 days, and then a slow, irregular decline for at least 30 days (and presumably longer). The complicated structure of the light curve is unique among the X-ray transients which have been observed near maximum light. The time scale for the slow decline is difficult to determine because of the variability of the source. The general trend indicates ~2–3 months for the decay time scale. We investigated the possibility that the postmaximum behavior of H1705−25 might be periodic by folding the SSI data (with the least-squares-fitted linear trend subtracted) modulo a range of trial periods between 0.5 and 20 days and examining the behavior of the χ^2 deviation from the hypothesis of source constancy with folding period. A broad peak appears in the χ^2 versus period plot centered on a period of 6.7 days. Examination of the light curve does not, however, show a clear modulation at or near this period, particularly when the *HEAO 1* MC observations are taken into account. The power spectrum of the SSI postmaximum data, obtained

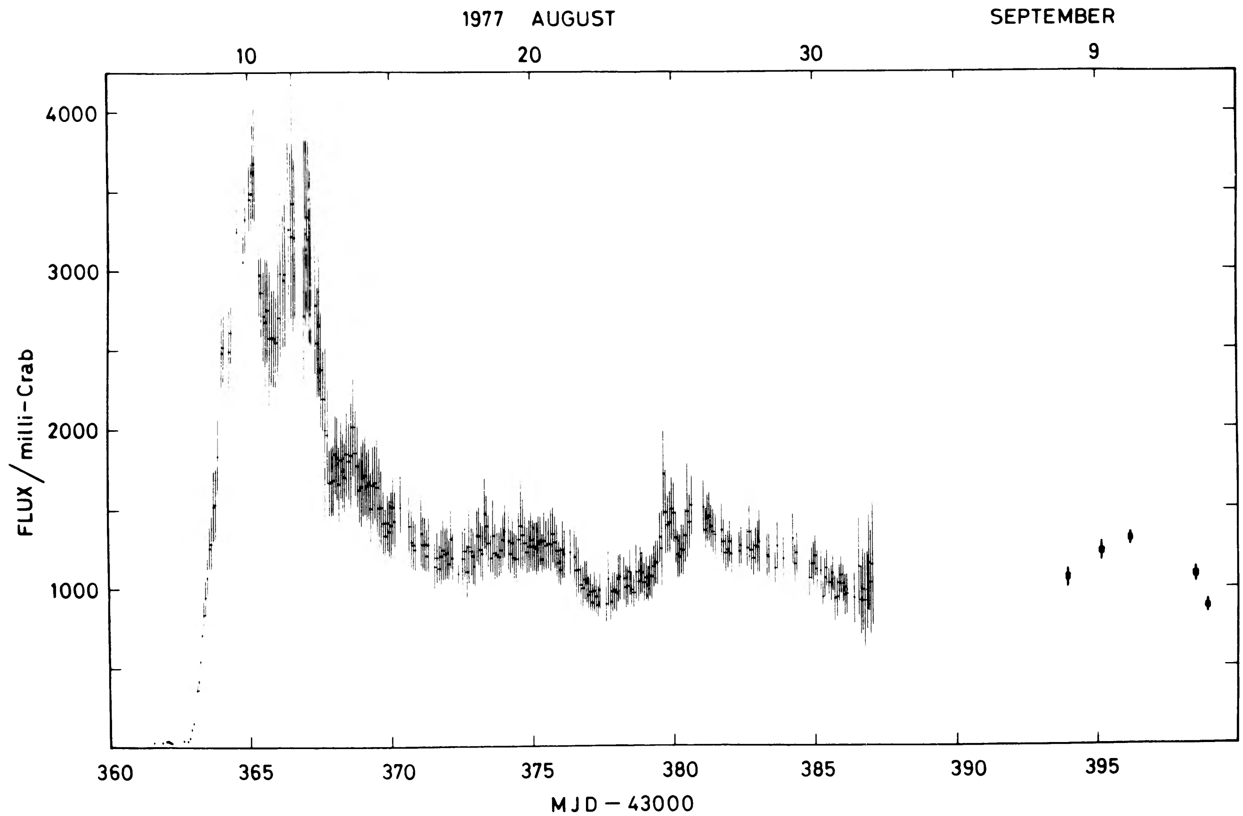

FIG. 1.—The X-ray light curve of H1705−25 (Nova Ophiuchi 1977). The time axis is given in MJD = JD − 2,400,000.5. All vertical error bars are ±1 σ where shown. Horizontal bars indicate the length of each observation. Data are from *Ariel 5* SSI (2–18 keV) (†) and *HEAO 1* MC (0.9–13.3 keV) (♦).

by using the Cooley-Tukey algorithm, shows no significant peaks. We interpret this as implying that there is no *regular* periodicity in the light curve.

We note that an ~8 day period was reported in both the X-ray and optical observations of A0620−00 (Matilsky *et al.* 1976; Chevalier, Ilovaisky, and Mauder 1976) during the later stages of the decay of this source. However, this periodicity is *not* evident in the SSI observations (unpublished) which partially overlap those of Matilsky *et al.* (1976). It is quite possible that such "periods," including the modulation seen in H1705−25 in the folding $-\chi^2$ analysis, reflect some characteristic time scale within the accretion disk rather than the orbital motion of the X-ray source.

III. DISCUSSION

Kaluzienski (1977) discusses the division of transient X-ray sources into two classes based on observational criteria, but which may reflect two different types of system. The "high-luminosity" class, for which the prototype is A0620−00, is characterized by large intensity ($I_{max} > I_{Crab}$) which ensures high luminosity provided the source is not too near, "soft" postmaximum X-ray spectra, and long decay time scales (> 1 month).

Membership of this class of transients for H1705−25 is indicated by its large maximum intensity (~3.5 I_{Crab}), and long decay time (2–3 months). In addition, the postmaximum X-ray spectrum was best fitted by a thermal bremsstrahlung with $kT \sim 3$ keV (Griffiths *et al.* 1978), and the optical counterpart (Nova Ophiuchi 1977) shows strong similarities to that of A0620−00 (V616 Mon) in terms of both spectrum and colors (Griffiths *et al.* 1978).

Several differences between the light curve of H1705−25 and the "high-luminosity" transients exist. In particular, the double-peaked maximum is unique and the early decay does not appear exponential in form. The standard model for such transients involves accretion by a compact object (neutron star) in a close binary orbit about a low-mass, late-type dwarf (e.g., Endal, Devinney, and Sofia 1976; Avni, Fabian, and Pringle 1976). In such a model instabilities in the accretion flow either within the accretion disk or at the inner Lagrangian point could easily produce the variability seen in the light curve. If further observations confirm that the decay of the X-ray light curve is nonexponential, as suggested here, then this may be more difficult to explain in the context of such a model.

We would like to acknowledge the contribution made by Dr. Clive Page in completely revising the SSI analysis system. The new system was used for the first time for this *Letter*. We would also like to thank Danny Rolf for his assistance in obtaining a power spectrum of the SSI data.

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