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X-RAY OBSERVATION OF A NEW SOFT SOURCE IN CYGNUS

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ABSTRACT

We have detected a new point X-ray source in Cygnus whose incident flux is confined to the energy range 0.5–1.3 keV. Its spectrum is consistent with line emission at ~1 keV or thermal bremsstrahlung at $\sim 10^6$ ° K with significant interstellar absorption.

I. INTRODUCTION

We report here some X-ray point-source observations obtained 1969 December 5 during a scan along the galactic plane between the Tycho and Cygnus Loop supernova remnants. The payload, discussed elsewhere (Bunner *et al.* 1971), was pointed 2°.5 away from Tycho for about 10 s. In a later publication we will discuss our data on this supernova's spectrum. From Tycho, the 6° s^{-1} scan crossed several known point sources. In addition, we detected a new soft X-ray source, hereafter designated Cyg X-6, whose flux is concentrated between 0.5 and 1.3 keV. We discuss first its position on the sky.

II. THE LOCATION OF CYGNUS X-6

Figure 1 shows the scan path in new galactic coordinates as determined from in-flight photographs of the star field. Preflight calibrations confirmed the alignment of the X-ray collimators (6° FWHM, 14° FWB) relative to the camera axis to within 1°.5. This figure also shows the counting rates for three different pulse-height bins.

The observation of several known sources adds considerable confidence to these aspect data. With Cas A about 5° off-axis, our observed 100 counts net from this source is within a factor of 1.5 of the expected count based on the spectral forms of Gorenstein *et al.* (1970). We detected no excess counts at closest approach to Lac XR-1. Cygnus X-1 and Cyg X-2 were too far off-axis to be observed. A pronounced peak in the high-energy counting rate coincides well with the nearly simultaneous crossing of Cyg X-3 and Cyg X-4. The net flux due to this peak is about 2.4 times higher than expected based on the results of Giacconi *et al.* (1967). However, in view of the relative weaknesses and uncertain spectra of these sources, this discrepancy is probably not significant. The combined flux of these two sources is confined to the energy interval 2.0–6.0 keV.

The new source, Cyg X-6, had a counting rate which peaked 7°.2 ± 1°.7 before the Cyg X-3 and Cyg X-4 crossing. Thus, our best estimate for the position of this source is 21^h8^m (R.A.), 45°.6 (δ); or 88°.0 (l^{II}), −1°.5 (b^{II}) with a ±1°.7 uncertainty in the scan direction and a ±6° uncertainty perpendicular to the scan direction. The uncertainty in the time of maximum counting rate determined the 1°.7 value while the 5°.5 ± 1° FWHM of the counting-rate curve was consistent with the source being up to 6° off axis.

III. ENERGY SPECTRUM

Our polycarbonate window counter detected Cyg X-6 only in the 0.5–1.3-keV pulse-height interval. Within this interval, we acquired a total of 44 counts from the source above a diffuse X-ray and non–X-ray background of 18 ± 3 counts.

The midpoint of our error box had a zenith angle of 80° and occurred at an altitude of 142 km. For this line of sight, the *U.S. Standard Atmosphere Supplements* (1966) model atmosphere predicts atmospheric transmissions of 74 percent at 0.24 keV and

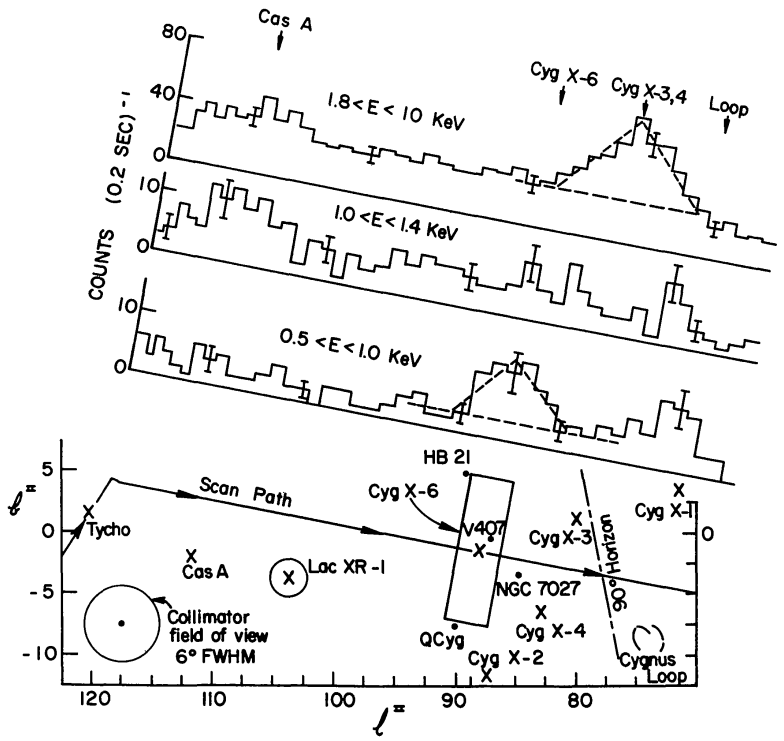

FIG. 1.—Location of Cyg X-6. The counting rates (uncorrected for background) for three different pulse-height bins are plotted versus angle along the scan path. The data above 1.0 keV are for all counters; the 0.5–1.0-keV bin is for the polycarbonate counter only. The error box for Cyg X-6 is 3°.4 × 12°. *Crosses*, reported X-ray sources; *dots*, some optical objects near Cyg X-6 location.

68 percent at 0.74 keV. We note that the following interpretation of the Cyg X-6 spectrum cannot be subject to either gross errors in the atmospheric model or improper counter operation. This is because a few seconds later at a zenith angle of 92° and altitude of 140 km, we detected the Cygnus Loop, a soft X-ray source. Within the limited statistical precision of our data (~90 counts net due to the Loop), our data are consistent with the interpretation of the Loop's X-ray spectrum as low-temperature bremsstrahlung with line emission near 0.6 keV (Cox 1972; Gorenstein *et al.* 1971; Tucker 1971). Our counting rates correspond to an integrated flux above the Earth's atmosphere of $\sim 10^{-8}$ ergs $(\text{cm}^2\ \text{s})^{-1}$ between 0.1 and 1 keV from the Loop.

In Figure 2 we present the polycarbonate pulse-height spectrum for Cyg X-6 along with the calculated counter response to three different model source spectra. The data are consistent with a line or lines of energy 1.0 ± 0.05 keV and an on-axis flux of ~0.5 photon $(\text{cm}^2\ \text{s})^{-1}$ for a line at 1.0 keV (above the Earth's atmosphere). The data are also consistent with several simple bremsstrahlung models, $dN/dE \sim \exp(-E/E_0)E$, with significant interstellar absorption (Brown and Gould 1970). These range from $E_0 \sim 0.12$ keV, $N_{\text{H}} \sim 1.2 \times 10^{22}$ H atoms cm^{-2}, to $E_0 \sim 0.03$ keV, $N_{\text{H}} \sim 7 \times 10^{22}$ H atoms cm^{-2}. (These extreme cases are shown in Fig. 2.) The optimum fit to the data corresponds to $E_0 = kT = 0.06$ keV ($T = 7 \times 10^5$ ° K), $N_{\text{H}} = 3 \times 10^{22}$ H atoms cm^{-2}; and the integrated flux above the atmosphere between 0.5 and 1.4 keV is ~0.4 keV $(\text{cm}^2\ \text{s})^{-1}$.[1]

IV. DISCUSSION

While the sky near Cyg X-6 is very congested, several interesting objects exist within our error box including the nova V407 and parts of the extended supernova remnant

[1] The 1.5σ signal in our (less efficient) Mylar window counter is consistent with all the above results.

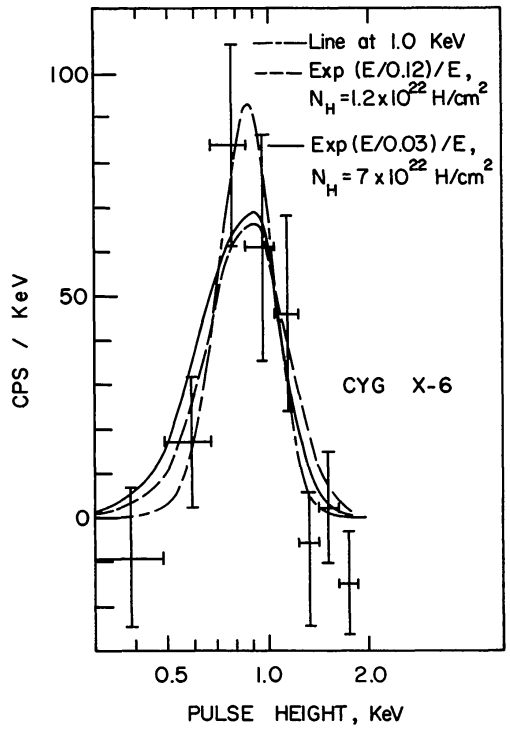

FIG. 2.—Spectral fits for Cyg X-6. Data points are observed rates per keV (with background removed) versus pulse height in keV. Curves are calculated counter responses including counter efficiencies and resolution. The Cyg X-6 data are from the polycarbonate counter.

HB 21. Miller (1971) has suggested that the planetary nebula NGC 7027 might be a thermal-bremsstrahlung source at a temperature of 7×10^5 ° K or higher. However, this nebula (at $l^{II} = 84\overset{\circ}{.}5$, $b^{II} = -3\overset{\circ}{.}4$) is outside our error box. If it is an X-ray source, it must be considerably weaker than the source that we have observed. While our error box for Cyg X-6 overlaps that of Cyg XR-4 as seen by NRL in 1965 (Friedman, Byram, and Chubb 1967), the small area, thick Mylar window counters, and high scan rate used in the NRL flight make it unlikely that the two sources are the same.

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