# A COSMIC X-RAY SURVEY IN THE SOUTHERN HEMISPHERE

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## 1. Introduction

An unstabilised Skylark rocket (SL 118) was launched from Woomera, South Australia at 20:20 local time on April 10, 1967. The rocket carried a large-area proportional counter to perform a high-sensitivity survey for cosmic X-ray sources in the Southern sky. The flight was successful and during the period of observation with the rocket above the absorbing atmosphere, from 80 to 350 sec after launch, a total of 50 scans across the sky were obtained. In addition to the predominant roll motion of the rocket, a slow precession about a flat (70° half angle) cone provided at least two separate looks at every part of the celestial hemisphere. At the time of the flight, the Milky Way was almost perpendicular to the horizon and a region around the Galactic equator from Scorpius to Taurus via Centaurus, Carina, Puppis and Orion was visible.

The proportional counter had an effective photon collection area of 295 $cm^2$ and the energy band from 0·9 to 5 keV was analysed in flight into five discrete energy bands. The counter window of 6 $\mu$m melinex and gas-absorption path of 5 cm-atmos argon-methane ensured a high photon-detection efficiency over this waveband. Geometric collimation of 30° by 30°, being purposefully rather broad to ensure observation of all the available sky, was provided by an aluminum egg-box array mounted before the counter. An interesting aspect of the electronics was the first flight of a new method of discrimination against particle background (Mathieson and Sanford, 1963), in which pulses due to particles were rejected by sensing their relatively long rise-time in comparison with those resulting from the X-ray photon absorptions.

## 2. Flight Data

The flight data showed a remarkably clear discrimination between the Earth and sky observations on each pass, the count rate changing by a factor of about 20 on crossing the horizon. The initial examination of the data has provided information on the sky background and on several discrete sources and these results are summarised below.

*Perek (ed.), Highlights of Astronomy,* 188–191. 

### A. DIFFUSE BACKGROUND

On each of the 50 separate rocket scans, some period or periods without significant discrete X-ray sources are seen. Normally, with such a broad collimation, the most reliable diffuse background fluxes will be obtained in the high galactic latitude regions which are relatively free of strong, discrete sources. From an average of many passes at high latitude, the following background figure is thus obtained:

$$\text{Diffuse X-ray intensity (2–5 keV)} = 2{\cdot}1 \times 10^{-8} \text{ erg/cm}^2\text{-sec-ster}.$$

This figure is in good agreement with other values (Gould, 1967), some of which have been derived after making appreciable corrections for the particle contribution to be subtracted from the measured count rates. It is clearly not possible with the present data to distinguish between a truly diffuse, isotropic background, and an isotropic distribution of small, discrete X-ray sources.

### B. SCORPIUS X-1

This well-known source was observed during a number of passes near rocket apogee (165 km). At this altitude the source, lying 5° below the horizontal, was some 7° above the X-ray horizon. The corresponding line-of-sight air path, of $10^{-4}$ gm/cm$^2$, requires a small correction at the low-energy end of the spectrum to account for terrestrial absorption. Taking this into account the observation gives:

$$\text{Sco X-1 intensity (2–5 keV)} = 1{\cdot}3 \times 10^{-7} \text{ erg/cm}^2\text{-sec}.$$

This figure may be compared with values of $2{\cdot}6 \times 10^{-7}$ erg/cm$^2$-sec obtained by the LRL group in October, 1965 (Grader *et al.*, 1966) and $1{\cdot}3 \times 10^{-7}$ erg/cm$^2$-sec by the same group in May 1967 (Chodil *et al.*, 1967). The agreement between the Leicester and most recent LRL measurements is interesting and, since instruments from the same group are involved, the differences observed from the earlier LRL flight may well be real.

### C. TAURUS X-1

The Taurus X-ray source was observed on three separate occasions during the flight, with the source well above the Earth's horizon. The observed flux was essentially unchanged on each occasion, with a mean value of:

$$\text{Tau-X-1 intensity (2–5 keV)} = 1{\cdot}9 \times 10^{-8} \text{ erg/cm}^2\text{-sec}.$$

This value is in good agreement with other measurements (Gould, 1967).

### D. CENTAURUS X-2

The most outstanding observation of the flight was of a very strong source in

Centaurus. This has been called Centaurus X-2 because of a previous identification of a much weaker source in the same constellation by NRL. Almost certainly Centaurus X-2 is the same source as that seen in the flight from Woomera one week earlier and named Crux X-1 (Harries *et al.*, 1967). The source was observed on several occasions throughout the flight of Skylark 118 and the best source position obtained is:

$$\text{Right Ascension} = 200^\circ$$
$$\text{Declination} = -60^\circ.$$

The maximum error in position does not exceed 2°. However, it may be considered as doubtful whether this precision will be sufficient to warrant an optical search, since the source is located in a dense region of the Milky Way. The observed intensity of Centaurus X-2 on April 10, was:

$$\text{Cen X-2 intensity (2–5 keV)} = 1{\cdot}6 \times 10^{-7} \text{ erg/cm}^2\text{-sec}.$$

This may now be compared with a more recent observation by the LRL group (Chodil *et al.*, 1967), which, for the same energy band, gives an intensity of only $2{\cdot}6 \times 10^{-8}$ erg/cm$^2$-sec. Though the LRL measurement was made with the source very close to the horizon, the possibility of significant atmospheric absorption seems to be ruled out by the appearance of the published LRL spectrum. Thus, it may be concluded that the Centaurus X-2 source decreased in intensity by a factor of 6 in a 6-week period. This probably represents the clearest indication yet of the variability of a cosmic X-ray source. A study of the spectrum of Centaurus X-2 shows that this is a significantly steeper function of energy than Scorpius X-1 and, moreover, on April 10 Centaurus X-2 was the strongest source in the sky at an energy below 3 keV.

### E. CARINA AND ORION REGIONS

The galactic plane between Centaurus X-2 and Taurus X-1 was scanned many times during the experiment. No definite source observations were made in this region. The highest count rate occurred in the direction of Carina-Vela, with a value some 10% above the background measured at high galactic latitudes. With 95% confidence it is possible, therefore, to place an upper limit of 0·5 photons/cm$^2$-sec to the total flux of X-rays (2–5 keV) received from any sources in the Carina-Vela direction, and slightly lower limits to fluxes from the galactic plane between Puppis and Orion. The interest in this measurement derives from the fact that the extension of the local spiral arm is believed to lie in the direction of Carina or Orion. Clearly the population of X-ray sources is here considerably lower than in the Cygnus extension of the same spiral arm. The total (2–5 keV) flux previously observed from the Cygnus direction is roughly 1·5 photons/cm$^2$-sec (Gursky *et al.*, 1967) and this would have been readily detected by the present instrument.

### F. LARGE MAGELLANIC CLOUD

Several scans across the LMC revealed no significant X-ray flux from this direction and, with 95% confidence, an upper limit of 0·5 ph/cm$^2$-sec in the 2–5 keV band can be placed on this possible source.

## References

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