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DETECTION OF X-RAYS FROM THE LARGE MAGELLANIC CLOUD

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ABSTRACT

A source of low-energy X-rays approximately 12° wide has been detected at the position of the Large Magellanic Cloud. Between 1.5 and 10.5 keV the spectrum is slightly softer than that of the isotropic background. The observed flux corresponds to an emission rate of about 4×10^{38} ergs sec^{-1}.

A rocket carrying proportional counters was launched from Johnston Atoll at 1132 U.T. on October 29, 1968. The detectors were filled with 90 per cent argon and 10 per cent methane and had 1-mil aluminized Mylar windows with an area of 323 cm^2 each. Collimating slats restricted the field of view to $\pm 2\overset{\circ}{.}5$ to cutoff in the roll plane of the rocket and $\pm 75°$ to cutoff in the pitch plane. Apogee of the flight was 335 km, and only data taken at altitudes above 200 km have been used.

The rocket was equipped with an attitude-control system programmed to scan the Magellanic Clouds with one set of detectors while another set, mounted back to back with the first, scanned the Cygnus and Cassiopeia region. Roll scans were performed for 4 min in the plane of the horizon at an average rate of $1\overset{\circ}{.}5$ sec^{-1}. The zenith was at right ascension 2^h45^m, declination +17°. Then the rocket and the scan plane were tipped 45° and the scanning continued for 1.5 min, so that any ambiguity in location of the detected sources was removed.

Figures 1 and 2 show the count rate observed as a function of azimuth during the first 4 min of the flight. Data from the second portion of the flight are similar. Count-rate increases larger than statistical fluctuations are observed at the locations of Cyg XR-1/Cyg XR-2, the Large Magellanic Cloud, and perhaps Cas A. Increased count rates during the second portion of the flight are consistent with the identifications included in Figures 1 and 2. In addition, Cyg XR-2 was detected separately from Cyg XR-1.

The flux detected from Cyg XR-1 was 2.0 ± 0.2 photons cm^{-2} sec^{-1}, with energies between 1.5 and 15 keV. This is consistent with previous measurements (Bowyer *et al.* 1966; Grader *et al.* 1966; Chodil *et al.* 1967; Chodil *et al.* 1968). If the increased count rate at 328°–336° is from discrete sources, it represents 0.2 count cm^{-2} sec^{-1} between 1.5 and 15 keV (uncorrected for counter efficiency). This is consistent with observations of Cas A and Cep XR-2 by Friedman, Byram, and Chubb (1967).

The source identified as the Large Magellanic Cloud (LMC) extends over about 12°. This is consistent with the visible character of the Cloud. Its X-ray spectrum between 1.5 and 10.5 keV is probably slightly softer than that of the isotropic background. The low count rate made it impossible to determine this spectrum with certainty. If we assume that the photon spectrum can be represented by a power law with a spectral index of −1.6 (i.e., the same as that for background measured by Seward *et al.* 1967), then this observation represents a flux of 0.2 photon cm^{-2} sec^{-1} or 1.5×10^{-9} erg cm^{-2} sec^{-1} between 1.5 and 10.5 keV. If the distance to the LMC is taken as 50 kpc, the emission rate is 4×10^{38} ergs sec^{-1} in this spectral region. If the assumed spectral shape is correct, these values of flux and intensity are accurate to ±25 per cent. This intensity inferred for the LMC corresponds to 25–30 X-ray objects having the same source strength as Tau XR-1.

Friedman *et al.* (1967) have estimated the X-ray luminosity of our Galaxy as $\sim 7 \times 10^{39}$ ergs sec^{-1}. This is an estimate of the total emission of discrete sources in the photon energy range 1–10 keV, which is 17 times the LMC luminosity measured in this experiment. The mass of the LMC is generally estimated to be of the order of one-tenth of that of our Galaxy. Thus, within the large uncertainties in this observation and in Friedman's estimate, the relative populations of X-ray sources are apparently the same in our Galaxy and in the LMC.

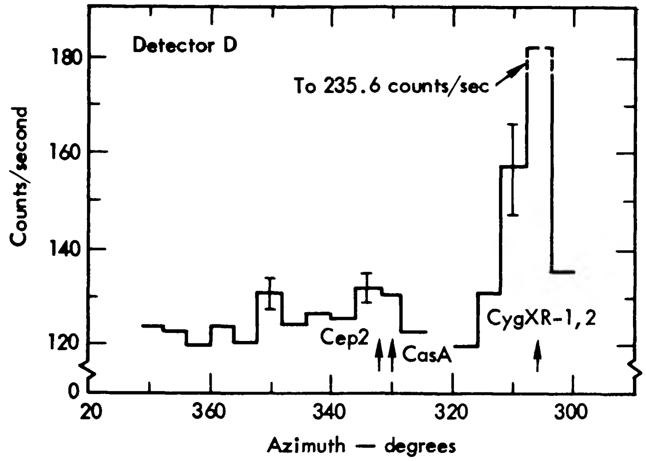

FIG. 1.—Count rate observed as a function of azimuth by north-pointing detector during first 4 min of flight. This detector was sensitive to X-rays between 1.5 and 25 keV. Error bars represent 1 standard deviation of the data. Break in data at 322° is where attitude-control system starts its slow-scanning mode. This break indicates that count rate is not known even though azimuth is well determined. Data between 300° and 320° were taken for shorter time, hence counting uncertainties are larger.

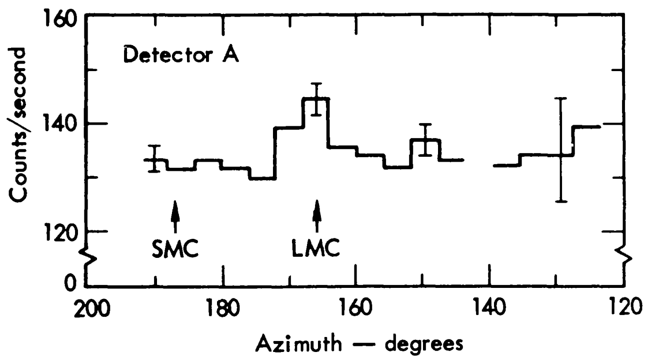

FIG. 2.—Data similar to those of Fig. 1, taken with south-pointing detector during first 4 min. This detector and the north-pointing detector of Fig. 1 were identical. All comments in Fig. 1 pertain, except that here the break is at 142°.

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REFERENCES

Bowyer, S., Byram, E. T., Chubb, T. A., and Friedman, H. 1966, *Science*, **152**, 66.
Chodil, G., Mark, H., Rodrigues, R. M., Seward, F. D., and Swift, C. D. 1967, *Ap. J.*, **150**, 57.
Chodil, G., Mark, H., Rodrigues, R. M., and Swift, C. D. 1968, *Ap. J.* (*Letters*), **151**, L1.
Friedman, H., Byram, E. T., and Chubb, T. A. 1967, *Science*, **156**, 374.
Grader, R. J., Hill, R. W., Seward, F. D., and Toor, A. 1966, *Science*, **152**, 1499.
Seward, F. D., Chodil, G., Mark, H., Swift, C. D., and Toor, A. 1967, *Ap. J.*, **150**, 845.