Observations of the LMC X-ray sources with the 
Ariel V Sky Survey Instrument

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Received 1977 May 16; in original form 1977 April 4

Summary. Long-term X-ray light curves are presented for the X-ray sources in the Large Magellanic Cloud, as obtained by the Leicester University Sky Survey Instrument on board the Ariel V spacecraft. The five previously known sources have all been detected. Evidence is presented for a sixth source possibly associated with the LMC.

All sources are variable but no regular periodic behaviour has been observed. LMC X-1 and X-2 vary a factor of 2 or 3, LMC X-3 and X-4 were observed to vary by a factor of at least 7, and LMC X-5 and X-6 varied from just above to below our threshold of detectability.

1 Introduction

Because the distance is known, the absolute X-ray luminosity, $L_X$, of the LMC X-ray sources is also known. For sources in the LMC $L_X = 1-2 \times 10^{38}$ erg/s which is about the maximum $L_X$ estimated for any galactic source. It has been proposed that these sources are operating close to the Eddington limit and that they represent a distinct class of sources (Margon & Ostriker 1973; Seward et al. 1972; Ryter 1970).

Since the high-luminosity sources in our galaxy are clustered about the centre, they are heavily obscured, and there is little chance of finding and studying the corresponding optical object. The best place to search for an optical object associated with this class is in the LMC. However, because of the large distance, even the best position measurements will include a large number of optical candidates. Source variability might be the only way of establishing a positive identification. Thus, the variability of the LMC X-ray sources is especially interesting.

Three of the sources LMC X-1, X-2 and X-3 have been consistently seen by all observers (Leong et al. 1971; Giacconi et al. 1972; Rapley & Tuohy 1974; Tuohy & Rapley 1975; Markert & Clark 1975). There has been uncertainty over the existence of X-4, and the present results explain this in terms of source variability. Epstein et al. (1977) have also observed the luminosity of this source to vary strongly and have discovered X-ray flares

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of ~20-s duration. The most precise positions for X-1 to 4 have been obtained with the rotation modulation collimator on SAS-3 (Delvaille 1976) and the Ariel positions agree completely with these measurements. X-5 was discovered by Markert & Clark (1975) using the OSO-7 satellite and our results confirm the existence of this source.

We have searched the Ariel SSI data for long-term source variability. The sources are not bright so it is necessary to integrate many orbits of data to measure the source strength well. The data points we present are averages over ~10 orbits or ~15 hr. Observations taken from MJD 42772–78 and from MJD 42934–44 separated the sources particularly well.

Table 1. Measured flux LMC sources (Uhuru counts, ~2–10 keV). (18 counts = $L_X = 1.0 \times 10^{38}$ erg/s.)

<table>
<thead>
<tr>
<th>LMC</th>
<th>X-1</th>
<th>X-2</th>
<th>X-3</th>
<th>X-4</th>
<th>X-5</th>
<th>X-6?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uhuru</td>
<td>19 ± 1</td>
<td>15 ± 1</td>
<td>21 ± 1</td>
<td>9 ± 2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Copernicus</td>
<td>7–31</td>
<td>24 ± 5</td>
<td>7–38</td>
<td>&lt;4</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>OSO-7</td>
<td>23 ± 3</td>
<td>21 ± 3</td>
<td>18–44</td>
<td>&lt;4</td>
<td>7 ± 1</td>
<td>–</td>
</tr>
<tr>
<td>SAS-3 RMC</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>13–58</td>
<td>&lt;2</td>
<td>–</td>
</tr>
<tr>
<td>Ariel (counts x 2.7)</td>
<td>11–30</td>
<td>14–24</td>
<td>4–30</td>
<td>1.5–15</td>
<td>1–2</td>
<td>1–2</td>
</tr>
</tbody>
</table>

Figure 1(a)

Figure 1(b)

Figure 1. (a–d) The long-term X-ray light curves of LMC X-1 to LMC X-5, plotted as 10-orbit (0.7) sums. The dashed lines show gaps in the observation. Data spanned by the letter 'C' means that the source was confused with other LMC sources and the data can be regarded strictly as upper limits.
Figure 2. SSI azimuthal data, summed over ~25 orbits in each of the upper and lower halves, indicating the presence of a sixth variable possibly associated with the LMC, at a sector position between LMC X-3 and X-4 in the upper data set.
2 Observations

Variability of the LMC sources has been reported by most observers. The measured intensity levels have been summarized in Table 1. All data have been converted to a common set of units. For our data the conversion factor is: 1 Ariel V SSI count = 2.7 Uhuru counts. For other data we have used 1 Uhuru count = $1.7 \times 10^{-11}$ erg cm$^{-2}$ in the range 2–10 keV. The Ariel V SSI observations, summed over approximately 10 orbits (0$^d$.7), are shown in Fig. 1(a–d).

We find, during our observation, that X-3 was the strongest and perhaps the most variable of the LMC sources. At the other extreme, our observations usually show X-2 to be steady at a level of ~6 SSI counts/s. The data from X-1, X-2 and X-3 were folded modulo periods from 1.5 to 15 days. No regular periodicities were found.

X-4 was clearly detected on two occasions. The variability was large, as for X-3. X-5 was observed once near the limit of detectability in an 82-orbit sum centred on MJD 42941. The single line-of-position for this sum partially overlaps the OSO-7 error box (Fig. 6), but since there is no other line-of-position for this source, the identification with the OSO-7 source is not conclusive.

**LMC X-6?**

A previously unreported source was intermittently observed between LMC X-3 and X-4 on scans which clearly separated the latter. LMC X-4 is clearly observed in the data in the

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**Figure 3.** A polar projection of the LMC region, showing Ariel V SSI error boxes (rectangles) for all observed sources; including a line-of-position for LMC X-5. The circle is the OSO-7 position for LMC X-5 (Markert & Clark 1975), and the small dots represent the 1 arcmin error circles obtained by SAS-3 for LMC X-1 to 4 (Delvaile 1976). For a summary of Uhuru and Copernicus positions, see Markert & Clark (1975).
lower half of Fig. 2, but the upper histogram shows evidence for another source closer to LMC X-3. The error box for this new source (A0501−66) is shown in Fig. 3 along with the Ariel V 90 per cent confidence contours for LMC X-1 to 4. Since the source is weak, it is not certain that it is associated with the LMC.

3 Conclusions

Long-term X-ray light curves obtained with the Ariel V Sky Survey Instrument show variability in all of the LMC sources but do not show any evidence for regular periodic changes. The light curves generally resemble those of some of the Galactic Centre sources.

LMC X-1 and X-2 vary a factor of ~3 in intensity. LMC X-3 and X-4 are more strongly variable showing changes of ~10 in intensity. LMC X-5 (and perhaps X-6) are considerably weaker. A more sensitive observation is needed to study the variability of these weaker sources. Such an observation will probably see many more LMC sources if the source distribution as a function of $L_x$ is the same as for sources in our galaxy.

Acknowledgments

The authors thank the SRC for financial support and Dr C. G. Page, Dr M. J. Ricketts and M. G. Watson for the use of computer programs and for many helpful discussions during the data analysis.

References