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Cumulative Luminosity Functions of M31 X-ray Point Sources

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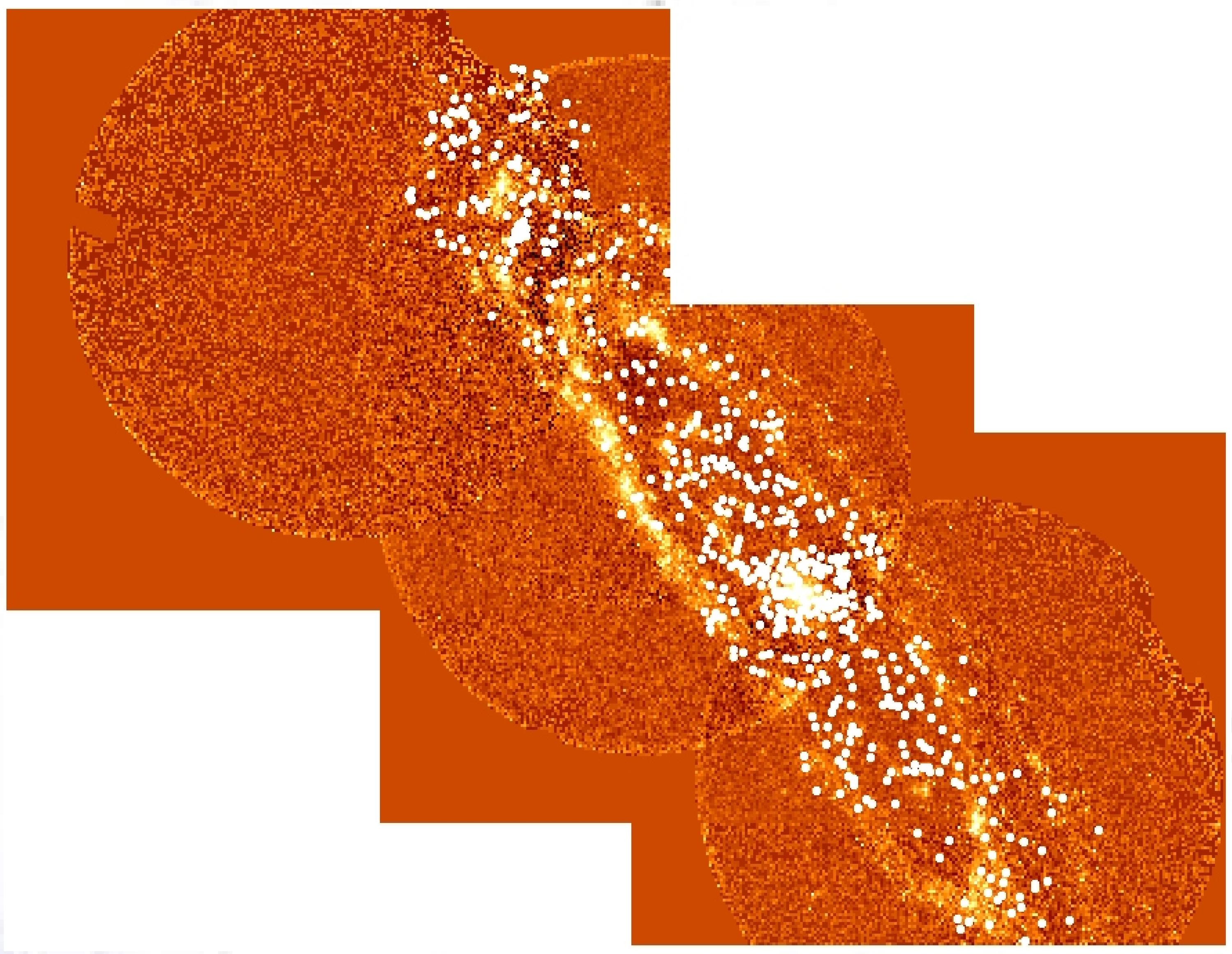


1. Introduction

We present selected results from a large XMM-Newton survey of the X-ray point sources in M31. At a distance of 760 kpc (Van den Bergh 2000), M31 is the closest spiral galaxy to our own and the ideal host galaxy for the study of the X-ray content of normal galaxies. The X-ray point sources in M31 are expected to be mostly X-ray binary stars (XBs) where a neutron star or black hole accretes matter from a companion star. In high mass XBs (HMXBs) the mass donor is a high mass star (5 M_{SUN}) while in low mass XBs (LMXBs) it is a low mass donor (5 M_{SUN}). HMXBs have a faster evolution than LMXBs because their companion stars are more massive; this makes them a good tracer of recent star formation episodes (Grimm et al 2003). LMXBs evolve on longer timescales and are connected with the total stellar mass of a galaxy (Gilfanov 2004). HMXBs are predominantly found in the spiral arms of galaxies while LMXBs are concentrated in the core. The determination of the physical nature of X-ray sources in external galaxies represents a major challange; information from the X-ray emission alone is rarely sufficient for an unambiguous classification. In this survey we analyse the energy spectral and power density spectrum of each M31 X-ray point source with a flux in excess of $\sim 10^{34}$ ergs cm $^{-2}$ s^{-1} to aid the classification of XBs following the method of Barnard, Kolb & Osborne 2006.

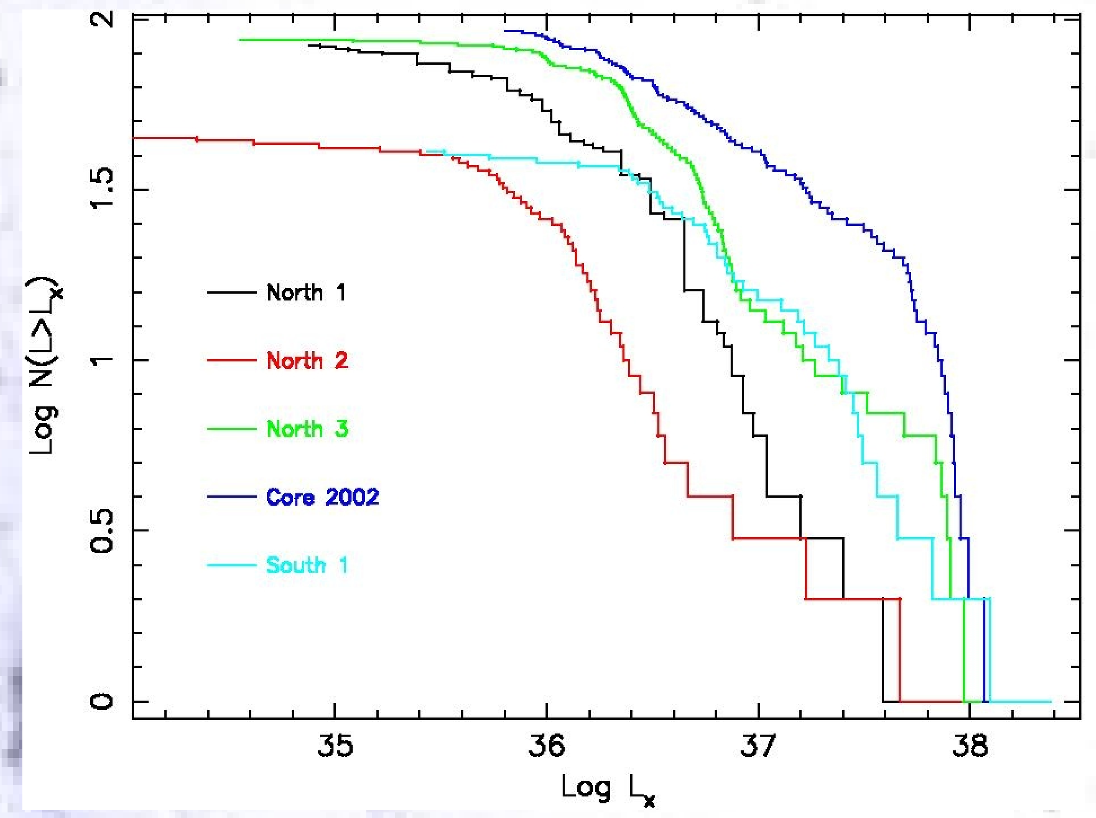
2. Comparison with previous luminosity function studies

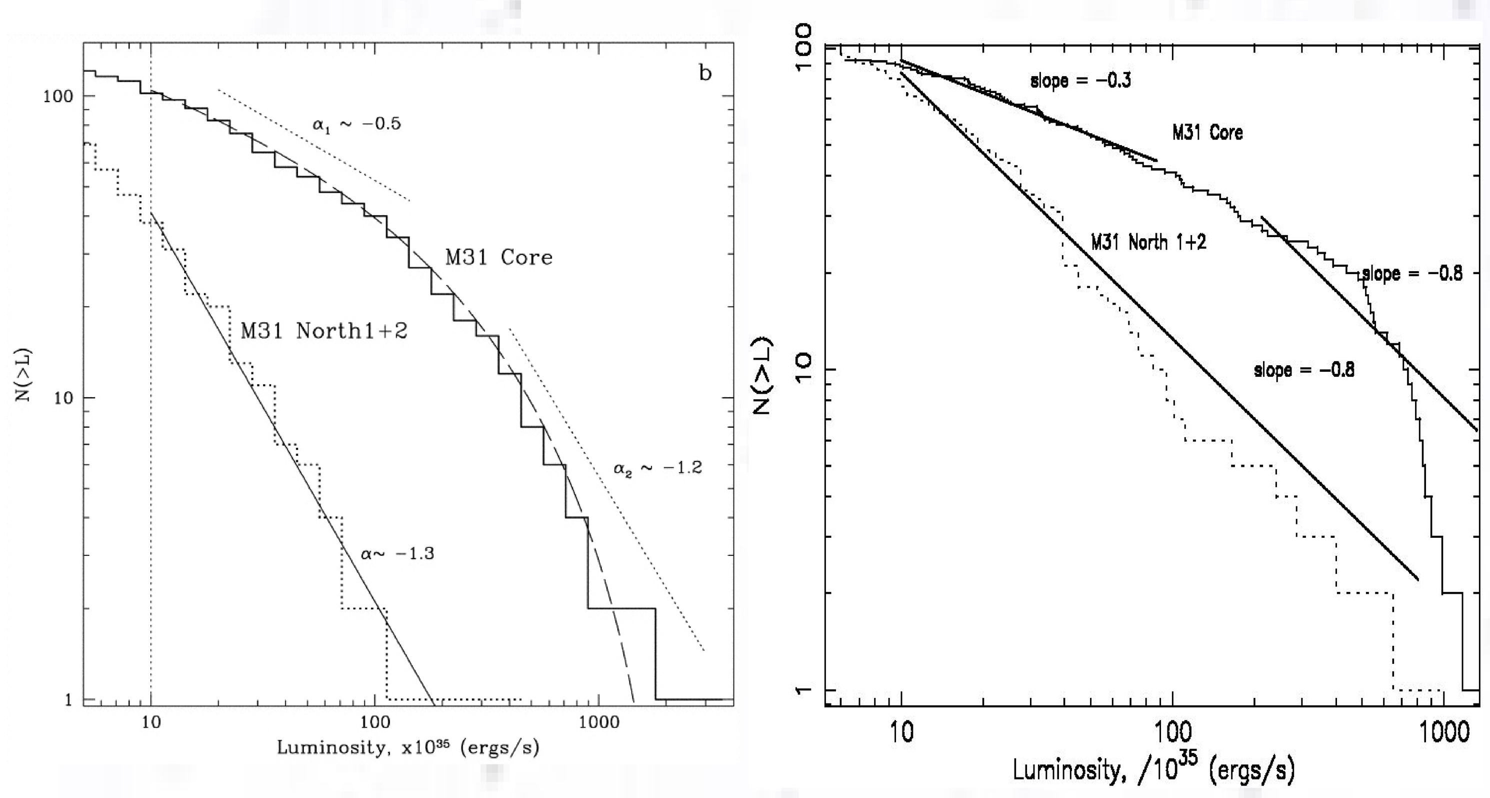
Trudolyubov et al (2002) created luminosity functions of part of the northern disc and of the Core region of M31 from this large M31 survey. For faint sources they estimated the luminosity using an absorbed power law spectral shape with a photon index of 1.5 and n_H of 7 x 10^{20} cm^{-2}, while analytical fits to the energy spectra were carried out on the bright sources. They found that the cumulative luminosity function for the northern disc had a slope of -1.3 0.2, which flattened to -1.1 for luminosities above $\sim 10^{36}$ ergs s^{-1} when corrections for background objects are performed. The core was fit with two power law distributions above and below 1.5 x 10^{37} ergs s^{-1}. For slopes between 10^{36} and 1.5 x 10^{37} ergs s^{-1} they obtain the slope of -0.5 0.1, for higher luminosities the slope was -1.2$^{+0.2}_{-0.4}$.

Our results have been plotted below on the same scales and with these slopes plotted against our data. We have not assumed a single spectral model for our faint sources, all sources have analytical fits. We have also identified more point sources in the northern disc.

3. Source Detection

The image above shows a mosaic of GALEX images of M31 (Thilker et al 2005) with the point sources, as detected by the edetect_chain in SAS 6.0.0, overlaid. The minimum likelihood threshold was set to 10 and detected regions that overlapped with a radius of 20" were excluded. Light curves, energy spectra and power density spectra were then extracted for each source region, and an automatically selected appropriate background region of the same size, and analysed to determine source properties. Spectra were fit with power law, bremsstrahlung, black body and neutron star atmosphere models in xspec 11.3.1 with free parameters to determine the flux of the source and to determine which fit was best for each source. The unabsorbed luminosity of each source was calculated assuming a distance to M31 of 760 kpc (Van den Bergh 2000).





4. Results so far

These are the first cumulative luminosity distributions of M31 fields to be created using individual fits for each source spectrum to obtain the unabsorbed luminosity for each source. We have so far studied 225 sources over 5 fields.

The Core and South 1 fields have not yet been fully surveyed down to the same luminosity limits as the North fields and so the luminosity cut-off for these fields is higher than in the North fields. The cut off is currently 3.5 x 10^{36} erg s^{-1} for the Core while it is about 2.5 x 10^{36} erg s^{-1} for South 1 and 3.5 x 10^{34} erg s^{-1} for the North fields. These luminosity functions are currently not corrected for incompleteness.

Our survey is continuing by looking at the unstudied sources we have detected in M31 and also with a study of Galactic sources. The PDS type and luminosity of these sources will allow us to distinguish between types of X-ray binary. We will study the differential behaviour of the luminosity function with distance from the centre of M31.

5. References:

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Background image modified from a GLAEX image http://galex.stsci.edu/GR1/

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