Exploring the SMC to the faintest X-ray fluxes: First results from a Chandra survey

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Introduction and description of the observations

The Small Magellanic Cloud is a prime target for studies of young X-ray source populations. Previous observations with ROSAT (e.g. Haberl et al, 2000), ASCA (Yokogawa etal, 2003), RXTE (Laycock etal, 2005), XMM-Newton (e.g. Sasaki etal, 2002) and Chandra have revealed a rich population of X-ray binary pulsars (XBPs).
In addition, its proximity and well studied stellar populations allow us to identify and classify the optical counterparts of the X-ray sources.
We obtained 100 ksec exposures of two fields in the SMC selected for their high X-ray pulsar content. The observations are performed with the *Chandra* ACIS-I detector because of its large field of view.

The main goals of these observations are :

- (a) Study the X-ray binary populations of the SMC down to the levels of quiescent sources (~10^{32} erg/s).
- (b) Search for low-mass X-ray binaries in the SMC
- (c) Study the coronal emission from stars in a low-metallicity galaxy
- (d) Study in detail two bright supernova remnants.

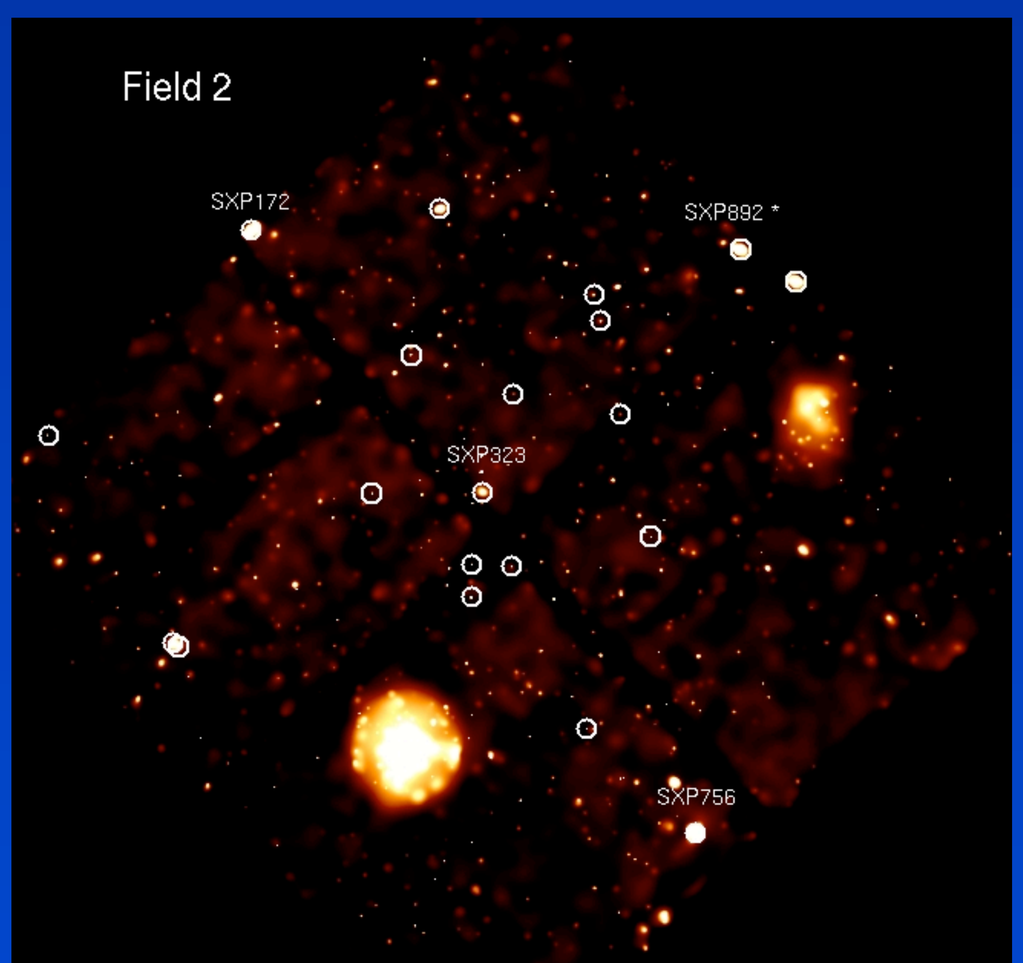

Fig.1b: Same as Fig 1a, but for Field 2 (one new pulsar is located on the ACIS-S CCD which is not shown here).

Data analysis

The data for the individual and coadded exposures for each field were processed with the *Champ*-Plane pipeline (Hong etal, 2005). In Fig. 1 we show adaptively smoothed X-ray images of the two fields. After the initial processing of the event-files we searched for discrete sources using *wavdetect* (Freeman etal, 2002). We detect 211 and 191 sources in Field-1 and 2 respectively.

In order to identify the sources associated with High-mass X-ray binaries (HMXBs) we cross-correlated the X-ray sources with stars from the OGLE-II (Udalski etal, 1998) and the MCPS (Zaritsky etal, 2002) catalogs. We find that 41 X-ray sources have optical counterparts consistent with early-type stars (OB sp. types). Fifteen of these sources were also detected in the shallow (10 ksec) *Chandra* observations of the same fields.

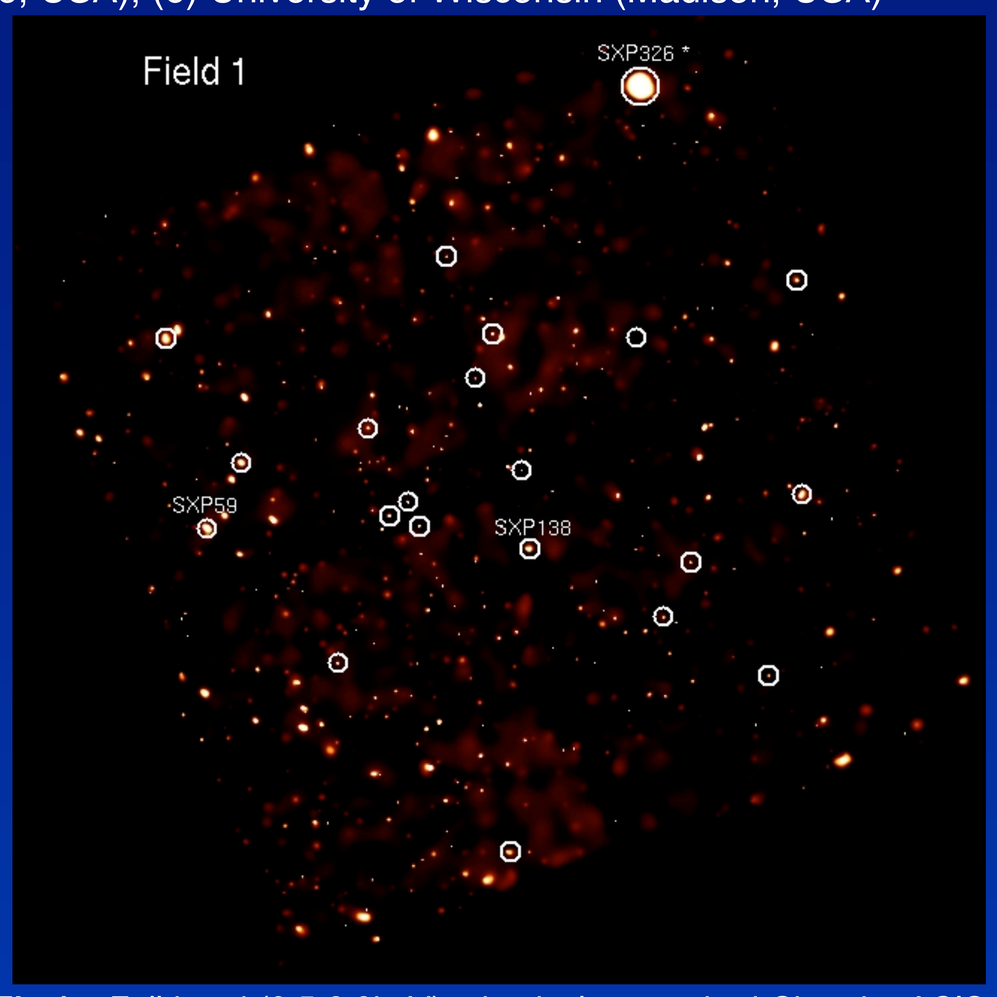

Fig.1a: Full band (0.5-8.0keV) adaptively smoothed Chandra ACIS-I images of Field-1 The sources associated with early-type stars are marked with circles. For the detected X-ray pulsars we also give their pulse-periods (new pulsars are marked with asterisks).

New X-ray pulsars and the XLF of HMXBs in the SMC

We searched for X-ray pulsars by using Lomb-Scargle periodograms. We find three new X-ray pulsars with periods between 6.3s to 892s, and X-ray luminosities between 2×10^{34}erg/s to 7.7×10^{35}erg/s. All three new pulsars are associated with early-type stars. In addition we detect 9 known pulsars, while we do not detect pulsations from 2 known X-ray pulsars.

By combining the HMXBs detected in the deep and shallow Chandra surveys of the SMC we can construct their X-ray luminosity function (XLF; fig 2). Since all HMXBs from the shallow observations of these two fields were also detected in the deep observations, we only use their luminosity from the latter data for this XLF.

We find that the XLF is well described by a broken power-law with a break-point at ~4×10^{34}erg/s and cumulative slopes of ~0.2 and ~0.8 below and above the break respectively. This is consistent with expectations from the onset of the propeller effect at low luminosities (e.g. Shtykovskiy & Gilfanov 2005). However, we do not see an upturn at low luminosities suggestive of an increasing population of quiescent sources.

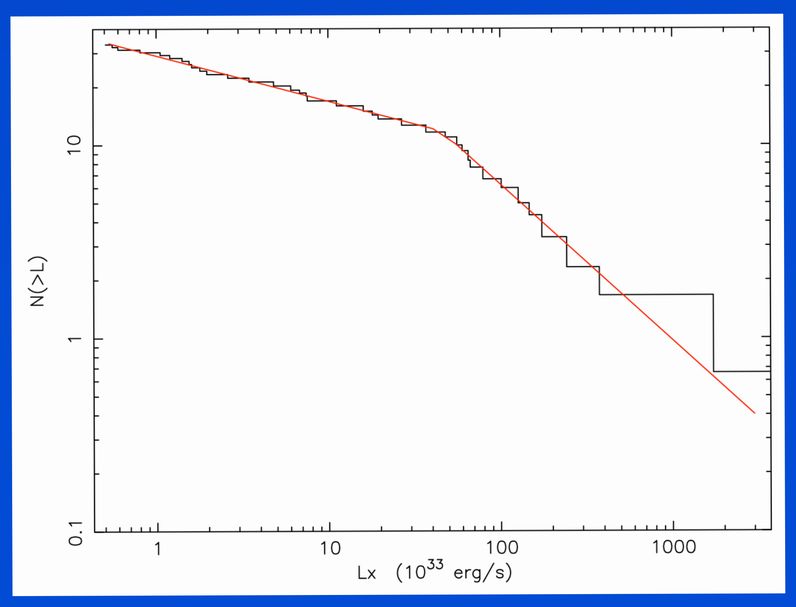

Fig 2: The X-ray luminosity function of the X-ray sources sources detected in both the shallow and deep surveys.