Chandra Detection of Intra-cluster X-ray sources in Fornax

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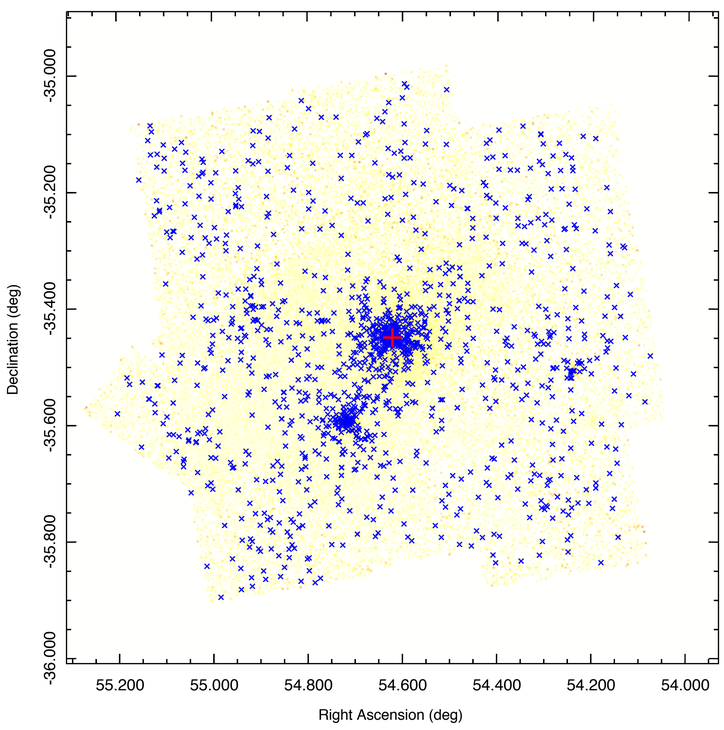
Introduction

Galaxy clusters are observed to have large amount of intra-cluster medium (ICL). Due to their large stellar mass, large number of low mass X-ray binaries (LMXBs) are expected (Gilfanov, 2004). In Virgo cluster, a significant number of excess LMXBs has been observed which are neither coincident with globular clusters or stellar component of the galaxies (Hou+ 2017). Based on that, we aim to find whether those excess LMXBs can be found in the second nearest cluster-Fornax Cluster, and investigate the possible connection between the excess sources and ICL. We select 29 archived Chandra observations within 30 arcmin (~180 kpc) of the central galaxy of Fornax Cluster-NGC 1399, with total exposure time **1.3 Ms**.

Source detection

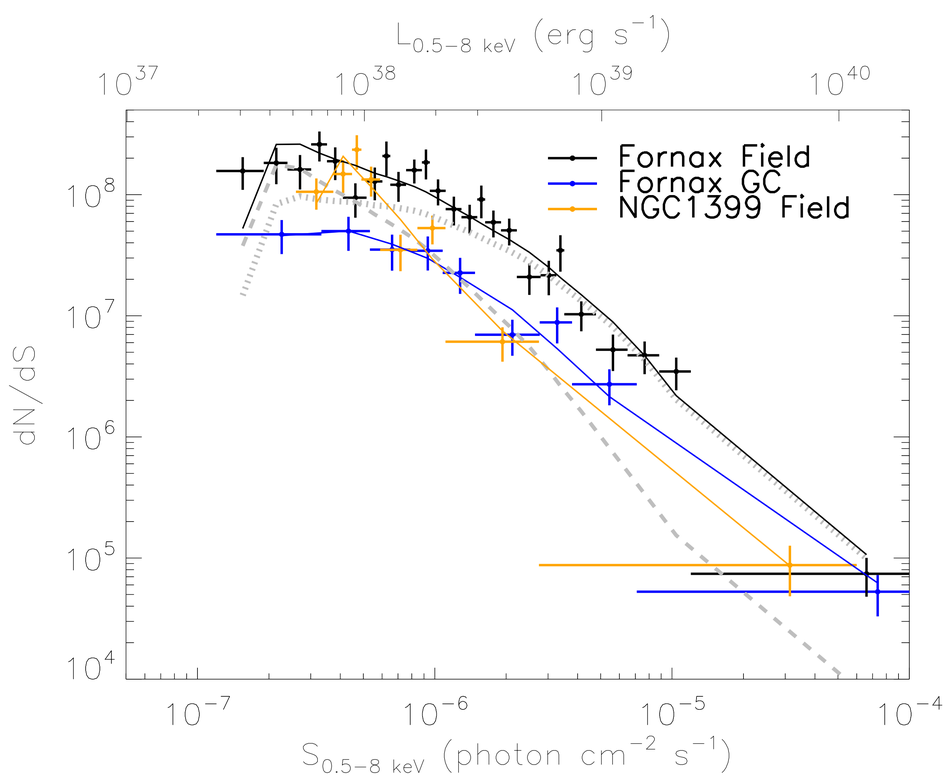
We stack all the observations together, and perform the source detection. 1177 X-ray sources in 0.5-8 keV band are detected within the field of view (FoV), down to a limiting luminosity 3×10^{37} erg s^{-1}, and 270 of them are spatially coincident with globular clusters (GCs) within 1 arcsec.



0.5-8 keV flux map in our whole FoV. The central galaxy NGC 1399 is marked by a red +. Detected sources are shown in blue crosses.

Luminosity Function

We analyze the luminosity functions (LFs) of field sources in NGC 1399 (R<4′) and all sources in Fornax region (4′<R<15′). LFs of NGC 1399 field sources and Fornax GC coincident sources are fitted with power-laws. The LF of Fornax field sources is fitted with a power-law plus the empirical CXB model.

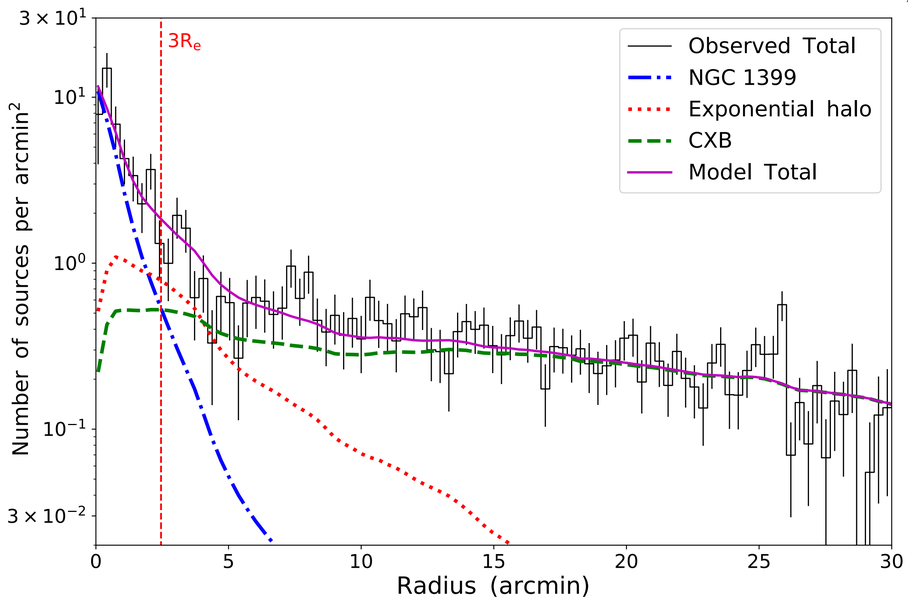


LFs of NGC 1399 field, Fornax GC and Fornax field sources. The best-fitted power-law models of NGC 1399 Field and Fornax GC are shown in corresponding colours. The best-fitted LF of the Fornax Field are shown in the black, including a power-law (grey dash) and a CXB model (grey dotted).

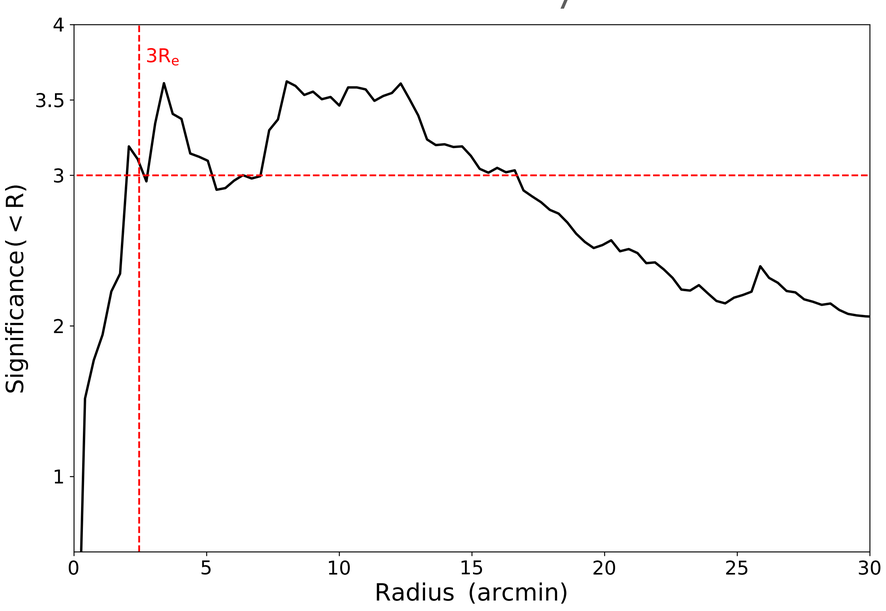
We find the power-law LFs of NGC 1399 Field and Fornax Field have statistically consistent slopes. The LF of Fornax GC is significantly flatter than the other two LFs.

Radial distribution

We study the spatial distribution of detected sources, excluding GC-LMXBs, foreground stars and sources related with Fornax galaxies except NGC 1399. By using the scaling relation between the number of LMXBs and stellar mass, we calculate the expected radial distribution of LMXBs of NGC 1399 and the exponential halo. We also calculate the expected cosmic X-ray background (CXB) sources radial distribution within the FoV based on empirical CXB relation (Georgakakis+ 2008).



Our observed and predicted radial distributions are generally consistent. We find there is a significant excess (Observed Total-NGC 1399-CXB) ~ 183 sources. We study the radial distribution of significance of the cumulative excess sources.



We find the significance of excess sources reach 3σ over $3' < R < 15'$. When considering the contribution from the exponential halo, there is still an excess ~ 74 sources.

Possible origins of the excess sources

We propose several scenarios for the excess sources (~74):

(1) Supernova-kicked LMXBs: Neutron stars got kicked from the host galaxies and transferred to the intra-cluster medium when supernovae exploded. We find the Fornax galaxies in our FoV can contribute ≲ 34 supernova-kicked LMXBs (Zhang+ 2013).

(2) Diffuse ICL-LMXBs: Iodice+ 2017 detect a diffusive ICL in the core of Fornax Cluster with a total luminosity ~ 8.3×10^{9} $L_{\odot}$, which can result in ~ 20 LMXBs.

(3) Unidentified GC-LMXBs: Some GCs might be too faint to be identified. However, generally bright GCs have higher probability to host LMXBs. We therefore only expect ≲ 20 unidentified GC-LMXBs (Cantiello+2018).

(4) Ultra-compact Dwarfs (UCD) X-ray sources: UCDs, which are believed to be tidally stripped nucleated galaxies, can also have an X-ray counterpart. We identify 15 X-ray sources among 144 known UCDs in Fornax. But 13 of 15 X-ray incident UCDs have been identified as GCs due to the ambiguous classification.

References

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[2] Georgakakis+ 2008, MNRAS, 388,1205
[3] Gilfanov+ 2004, MNRAS, 349, 146
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[5] Iodice + 2017, ApJ, 851, 75
[6] Zhang+ 2013, A&A, 556, A9

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