Galactic X-ray Sources

Follow up of ART-XC detected sources with RTT 150

Emrah Kalemci
Sabancı University

Mehtap Ozbey Arabacı
Erzurum Ataturk University
Classification of X-ray Binaries (in a nutshell....)

High-mass X-ray binaries (wind-fed X-ray sources)

- Supergiant HMXBs
- Be/X-ray binaries (Mehtap...)

Intermediate-mass X-ray binaries

Low-mass X-ray binaries (disk-fed X-ray sources)
Close binaries with accreting compact objects

LMXBs
- Roche lobe overflow.
- Very compact systems.
- Rapid NS rotation.
- Produce mPSRs.

IMXBs
- Very rare.
- Roche lobe overflow.
- Produce LMXBs(?)

HMXBs
- Accretion from the stellar wind.
- Mainly Be/X-ray.
- Wide systems.
- Long NS spin periods.
Low mass X-ray binaries

**NSs as accretors**
- X-ray pulsars
- Millisecond X-ray pulsars
- Bursters
- Atoll sources
- Z-type sources

**WDs as accretors**
- Cataclysmic variables
  - Novae
  - Dwarf novae
  - Polars
  - Intermediate polars
  - Supersoft sources (SSS)

**BHs as accretors**
- X-ray novae
- Microquasars
- Massive X-ray binaries

Şölen...
LMXBs with NSs or BHs

The latest large catalogue (Li et al. arXiv: 0707.0544) includes 187 galactic and Magellanic Clouds LMXBs with NSs and BHs as accreting components. Donors can be WDs, or normal low-mass stars (main sequence or sub-giants). Many sources are found in globular clusters. Also there are more and more LMXBs found in more distant galaxies.

In optics the emission is dominated by an accretion disc around a compact object. Clear classification is based on optical data or on mass function derived from X-ray observations. If a source is unidentified in optics, but exhibits Type I X-ray bursts, or just has a small (<0.5 days) orbital period, then it can be classified as a LMXB with a NS. In addition, spectral similarities with known LMXBs can result in classification.

Sidenote: A lot of LMXBs are TRANSIENT systems, and can be found through all sky monitor type detectors. ART-XC can be used to look into quiescence properties.
LMXBs luminosity function

LMXB galactic luminosity function (Grimm et al. 2002)

LMXB luminosity function for NGC 1316 (Kim and Fabbiano 2003)
Isolated neutron star systems

The new zoo of neutron stars

Mostly eRosita territory

During last >10 years it became clear that neutron stars can be born very different. In particular, absolutely non-similar to the Crab pulsar.

- Compact central X-ray sources in supernova remnants.
- Anomalous X-ray pulsars
- Soft gamma repeaters
- The Magnificent Seven
- Unidentified EGRET sources
- Transient radio sources (RRATs)
- Calvera....
Chromospherically active stars!

This is also possibly eRosita territory rather than ART-XC, as the X-ray emission is soft.
ART XC window to Galactic X-ray sources

Figure 6. Samples of PSF of the module number 1. These PSF were obtained by averaging the PSF measured at four azimuth angles for different offset angles. The size of each image is 400” × 560”. The color scale is logarithmic. The measurements of PSF are performed at the 7 mm defocusing position.
ART-XC targets for Galactic sources

- Survey of galactic black holes and neutron stars with low luminosity
- Study heavily obscured galactic X-ray binary systems
- Study broad band spectra of Galactic objects (including binary systems, anomalous pulsars, SNRs) up to 30 keV, spectroscopy and timing of point sources
- Study of cyclotron lines features of X-ray pulsars with energy resolution 1.5 keV up to 30 keV
Unidentified INTEGRAL Sources as a Proxy

- Masetti gang and others (like us) looked into identifying INTEGRAL sources with optical follow up observations (using RTT 150 as well)
- According to Masetti 2013, among 204 new sources:
  - 125 (61.2%) are AGNs (skipping sub classification)
  - 51 (25.0%) are X–ray binaries
    - %78 HMXB
    - %22 LMXB
  - 25 (12.3%) are CVs
    - %80 dwarf novae (possibly magnetic)
    - %20 symbiotic stars
  - 3 cases (1.5%) possibly belong to the class of active stars.
- Side note - SWIFT/BAT Palermo survey found 90% AGN and remaining 6 mostly CVs (Parisi 2014)
XMM Serendipitous Source Catalog

Hardest Galactic sources

aPsr (accretion)
rPsr (rotation)
CV
Art of optical follow up I

- Main problem - for both Swift BAT and INTEGRAL instruments is the angular resolution of several arcminutes! ART-XC HPD is <40” which helps but there will still be many likely counterparts in the source position error circle! That’s on axis!!!

Need help from high resolution X-ray telescopes
Chandra would be best
Swift XRT would still be very useful....
eRosita would help as well.

NuStar?

MOS WILL BE GREAT!

Ozbey Arabaci 2012
Art of optical follow up II

- Get optical spectra of possible sources....
- Identify all absorption and emission features, line ratios
- Determine if the source is main sequence or evolved star
- Is the continuum blue, or red
- Interpret based on additional information coming from the X-ray data (hardness, spectrum, timing, etc)

Masetti 2013
X-ray binaries with Halpha emission
Photometry, Color / color diagrams

• An additional tool could be photometric observations, light curves, color/color diagrams and comparison with population studies.

Use survey or observation data and compare with the general behavior.

Hardness from ART-XC + Chandra or Swift could help as well.
Conclusions

• While most of the sources will be AGN, mostly obscured AGN, we should receive coordinates with Galactic X-ray sources.

• Cygnus and Scutum arms could be a good target for groups working on Galactic sources. HMXBs are likely sources to be found.

• Chandra/Swift follow up programs would be useful.

• MOS capability will help.

• Finally, what about a NuStar legacy program (if NuStar or a follow-up observatory is still active?)
ART-X bandında ne bekliyoruz
A Low Mass X-Ray Binary: 4U 1820–30

- Earth
- White Dwarf
- Neutron Star
- Accretion Disk
- X-Rays

- X-Ray Emission: BURSTS

- 130,000 km
- 1,200 km/sec

SUN
Toplanti notlari

• Tolga SRG calismalari:
  • 3-30 keV
  • 8 veri aktarimi. En az 200 kaynak, + 200 ortak arastirmalar.
  • L2, 7.5 yil
  • RTT - %20 Turkish, %15 joint
  • 2019 mart
  • 2021 de anca.
Irek

• %20 - 25-30 açık gece, 200 kaynak 10 yıllık is!!!!
• Kuzey ruslarla ilişi daha ayrintılı
• Transient olacak