

Soft X-ray sources in the 2XMM catalogue

Joana Rodrigues¹, Sean Farrell, Natalie Webb & Didier Barret

Centre d'Etude Spatiale des Rayonnements, Toulouse, France

Abstract: We have mined the 2XMM serendipitous source catalogue for soft X-ray sources with the aim of identifying new candidate stellar mass compact objects such as Isolated Neutron Stars (INS), Cataclysmic Variables (CV) and Super-Soft Sources (SSS). We present the results of these studies along with spectral and timing analyses of the most promising candidates. We report on the results obtained and discuss the possible nature of these sources.

Introduction

- Soft spectrum X-ray sources are objects of great interest as they permit us to:
 - understand the end points of stellar evolution,
 - deduce the age of the Universe,
 - study matter under extreme conditions (ρ , T, B, g),
 - understand accretion (jets, outbursts, etc.),
 - study particle acceleration,
 - test the theory of general relativity,
 - study the exotics states of matter,
 - understand high magnetic fields in late-type stars.

Data reduction

- Filtering criteria**
 - Selected sources which had:
 - EPIC 0.2-1keV flux > 60% of the total flux,
 - been flagged as good or potentially good sources (SUM_FLAG=0 or 1).
- Reduction and analysis**
 - 775 sources were selected and screened by manually inspecting spectra, light curves and images.
 - we investigated the nature of all the sources by cross-correlating source positions with SIMBAD and searching through the literature.
 - we extracted the spectra (and light curves, for the variable sources) with version 7.1 of SAS and analysed them with ftools package (version 6.05), for the 10 most promising sources which could be INS, CV, or SSS.

Results

- Table 1 shows the preliminary identification for all 775 sources investigated.
 - approximately 57% of the sources had not been previously identified,
 - approximately 32% of the sources were stars.
- In Figure 1 we can see that the distribution, in Galactic coordinates, of our sample of sources is approximately isotropic.
- Figure 2 shows the 752 real sources plotted on a soft vs hard colour-colour diagram. We can see that below the dashed line all the identified sources are compact objects. The 6 unknown objects that fall in this region may also therefore be compact objects.
- From the analysis of the most promising sources, we found the following candidates:
 - 2 stars,
 - 3 X-ray neutron star binary,
 - 2 neutron star (isolated or in a quiescent binary system),
 - 1 Cataclysmic Variable (CV),
 - 1 possible Isolated Neutron Star (INS),
 - 1 possible Ultra-Luminous X-ray source (ULX).

Examples:

- CV candidate:**
 - Best fit is a ($\chi^2/\text{dof}=0.94/29$) blackbody plus absorption models with $KT=0.08 \pm 0.01$ keV, (it could not be fitted with a neutron star atmosphere model; Fig. 3.1),
 - optical image (Fig. 3.2) shows a very faint object.
- INS candidate:**
 - Best fit is a ($\chi^2/\text{dof}=0.96/26$) neutron star atmosphere with absorption models (Fig.4.1),
 - no optical counterpart (Fig.4.2) (neither in the 2MASS survey).
- ULX candidate:**
 - Best fit is a ($\chi^2/\text{dof}=0.87/27$) power law model (Fig 5.1)
 - optical image (Fig. 5.2) shows an object outside the centre of a galaxy ($8''$ away).
 - calculated luminosity is equal to 2.95×10^{41} erg s^{-1} cm^{-2} (assuming distance of $z=0.02$ to known galaxy).

source type	number of sources (%)
Isolated Neutron Star	<1
X-Ray Binary	<1
Pulsar	<1
Planetary Nebula	<1
Super-Soft Source	<1
Supernova Remnant	<1
Cataclysmic Variable	1.8
AGN	4.0
star	31.6
unknown	56.5
spurious	3.0
total	100

Table 1: Statistics obtained for the 775 sources investigated.

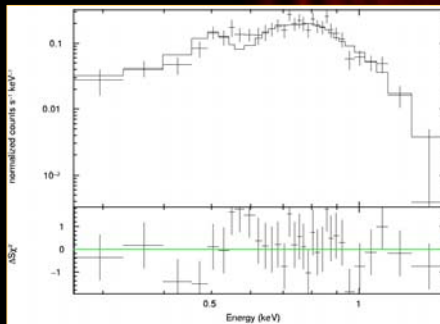


Fig 3.1: PN spectrum for the CV candidate, fitted with black body plus absorption models (solid line).

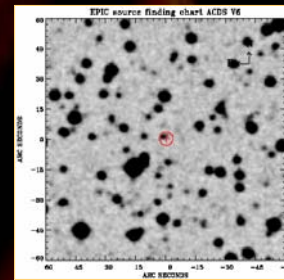


Fig 3.2: 2XMM catalogue finding chart optical image for the CV candidate (cross shows the source position within the 2XMM error circle).

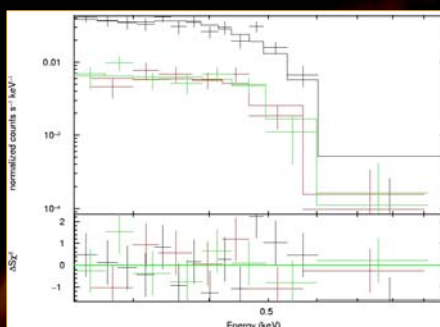


Fig 4.1: PN, MOS 1 and MOS 2 spectra of the INS candidate, fitted with neutron star plus absorption modes (solid line).

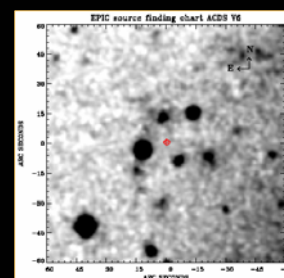


Fig 4.2: 2XMM catalogue finding chart optical image of the (I)NS candidate (cross shows the source position within the 2XMM error circle).

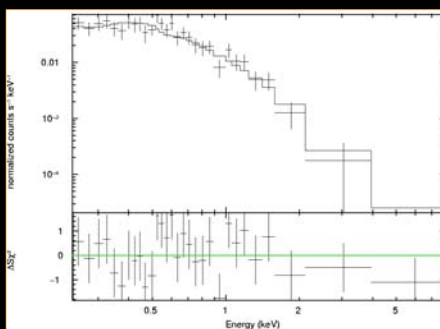


Fig 5.1: PN spectrum for the ULX candidate, fitted with a power law (solid line).

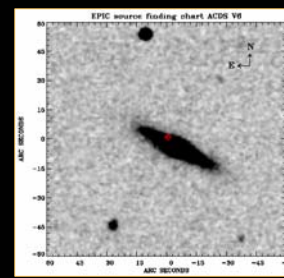


Fig 5.2: 2XMM catalogue finding chart optical image of the ULX candidate (cross shows the source position within the 2XMM error circle).

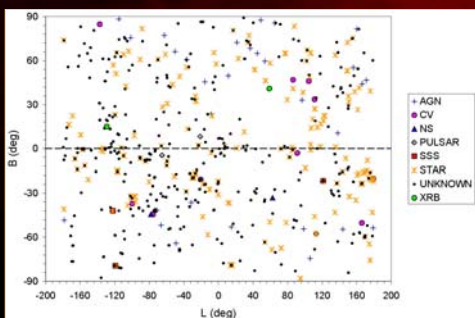


Fig 1: Distribution of 752 sources studied in Galactic coordinates (dashed line represents the Galactic plane).

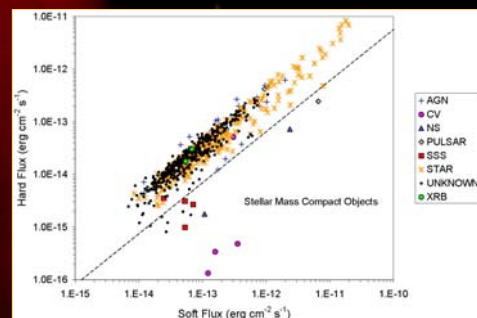


Fig 2: Comparison between the soft flux (0.2-2keV) and hard flux (1-12keV) detected for 752 studied sources (all identified sources below dashed line are compact objects).

Conclusions:

- This studied population of soft X-ray sources in 2XMM are mostly unidentified,
- from the identified sources, a small proportion are stellar mass compact objects and the majority are stars,
- a number of very interesting new objects were identified including a CV, an INS and a ULX.
- follow-up multi-wavelength studies are needed to confirm the nature of these objects,
- 2XMM catalogue is a fantastic resource for population studies.