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The Small Magellanic Cloud in the eROSITA survey

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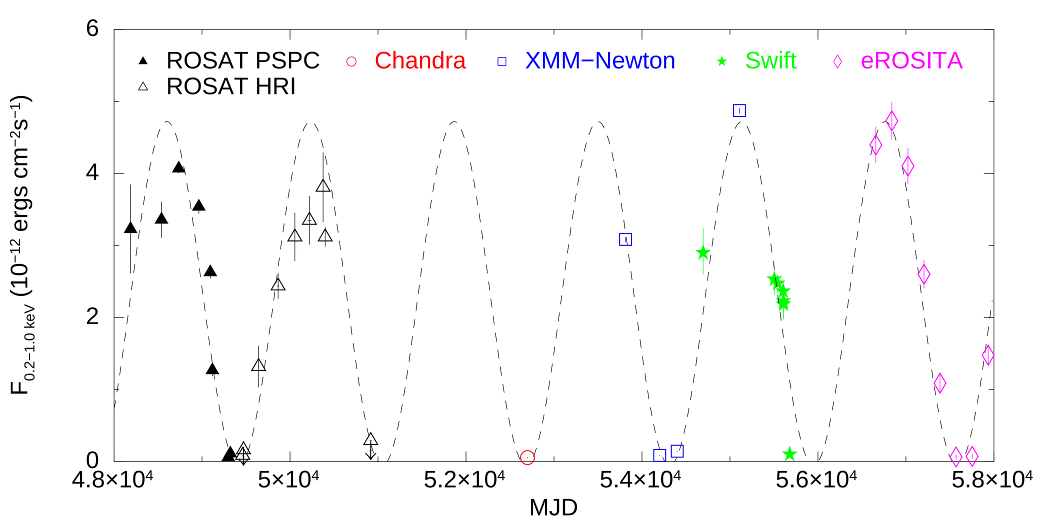
Summary

The X-ray source population of the Small Magellanic Cloud (SMC) offers a large sample of Be/X-ray binaries (BeXRBs) and supersoft X-ray sources (SSSs). All are at a close distance of 60 kpc, in a low metallicity environment and have a low Galactic foreground absorption. This is contrary to the Galaxy, where most sources are obscured by large amounts of absorbing gas and where uncertainties in distances complicate the determination of luminosities, or to more distant galaxies, where spatial confusion of individual X-ray sources becomes complicated and only the brightest X-ray sources can be detected. Both BeXRBs and SSSs can show high variability, reaching luminosities of 10^{37} erg s^{-1}. The repeated coverage of the SMC during the eROSITA survey every six months enables to monitor the Be/X-ray binary population and to discover new systems already in moderate outbursts with luminosities $\gtrsim 10^{35}$ erg s^{-1}. The detection of these systems in outburst can be used to trigger follow-up X-ray observations. Light curves of SSSs can be measured and new systems might be discovered in the outer parts of the SMC.

Light curves

The long term evolution of some SMC BeXRBs was studied with XMM-Newton [7]. In the eROSITA survey, light curves for the complete BeXRB population can be analysed. This will allow to discriminate between persistent and transient BeXRBs.



For variable SSSs, light curves can be used to constrain the nature of the X-ray emission. The diagram above gives the light curve of SMC3 [4] as observed since discovery in the ROSAT all sky survey. eROSITA fluxes are estimated from a sine function and a random flux variation of 10%. The simulated data points are separated by 6 months, starting at 2014 January 1.

Transient sources in the SMC

Be/X-ray binaries (BeXRBs)

Due to high recent star formation and low metalicity, the SMC hosts a remarkably high population of ~90 known BeXRBs, concentrated in the SMC bar. BeXRBs can e.g. be used to trace the recent star formation history [1] or estimate SN kick velocities[2]. These systems consist of a neutron star (NS), and an early type Be star, which ejects matter into a decretion disc in the equatorial plane. During periastron or due to disc instabilities, the NS can accrete matter, which causes an X-ray outburst.

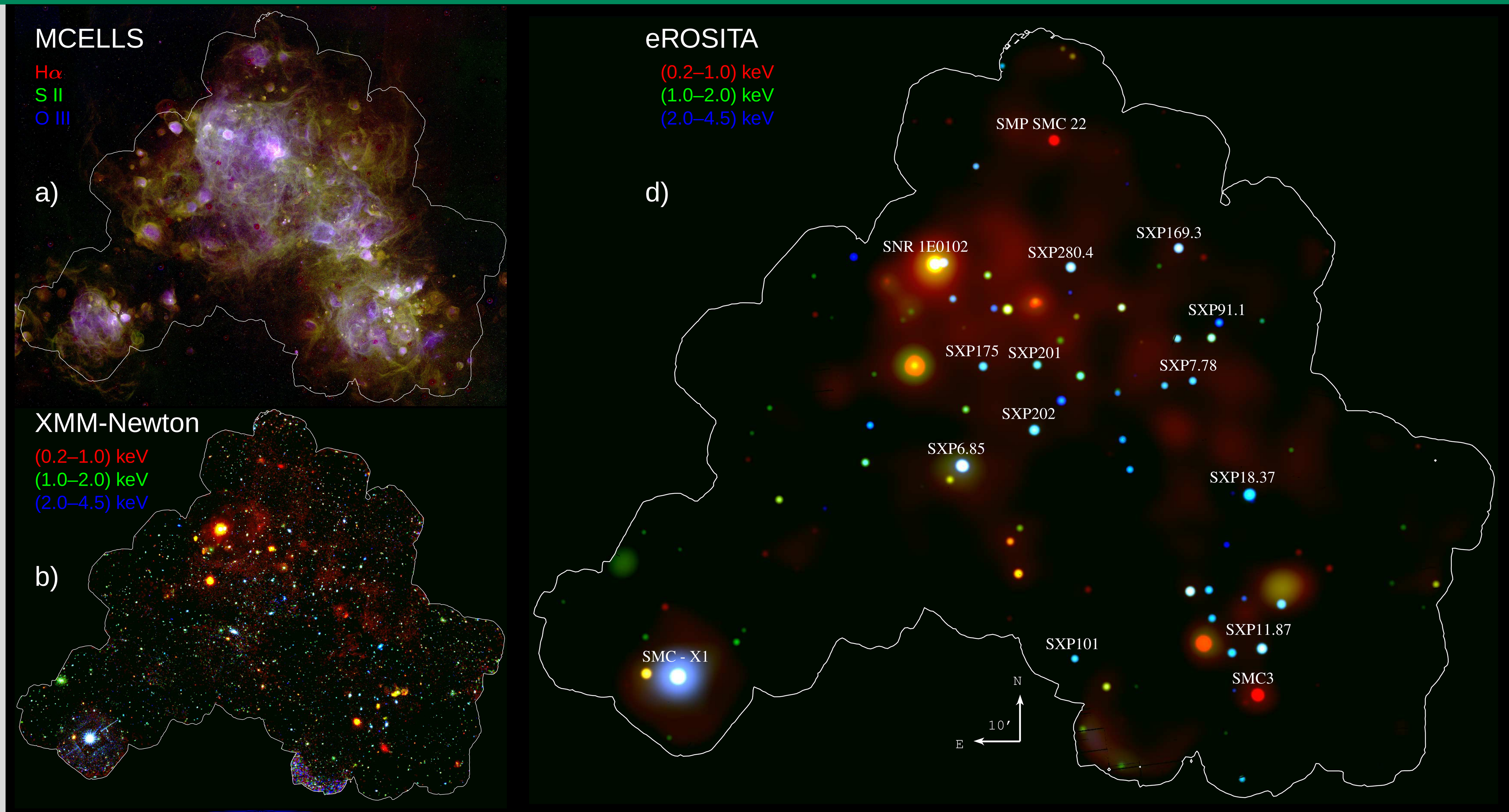
- Type I: Accretion during periastron, $L_X = 10^{36-37}$ erg s^{-1} for some days
- Type II: Accretion during disc instabilities, $L_X > 10^{37}$ erg s^{-1} for some weeks
- quiescent: Accretion from stallar wind, $L_X \lesssim 10^{33}$ erg s^{-1}

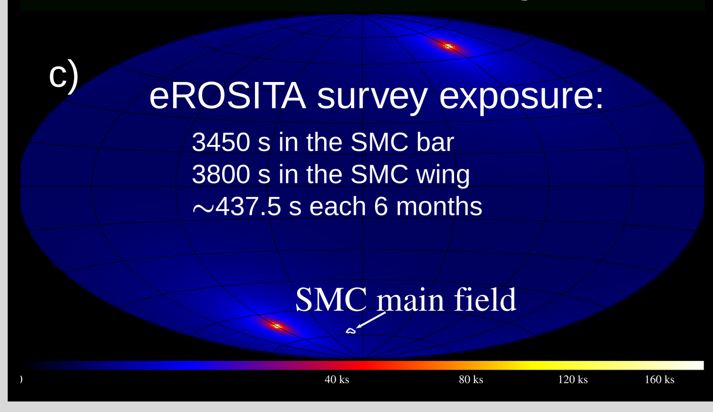
Supersoft X-ray Sources (SSSs)

In the outer parts of the SMC, ~5 SSSs are known, mainly from ROSAT. The low foreground absorption ($N_H < 6 \times 10^{20}$ cm^{-2}) enables the study of these sources in the SMC. SSSs are explained by thermonuclear burning on the surface of an accreting white dwarf. They are associated with cataclysmic variables, post-outburst novae, planetary nebulae and symbiotic stars. As progenitors for Type Ia supernova, they are of high interest. SSS can show a transient or variable behaviour reaching luminosities of $L_X = 10^{36-38}$ erg s^{-1}.

- constant: e.g. SMP SMC 22 [3]
- regular variability: e.g. SMC3 [4]
- irregular variability: e.g. CAL 83 (in the LMC) [5]
- transient: e.g. Nova LMC 1995 [6]

The SMC in X-rays





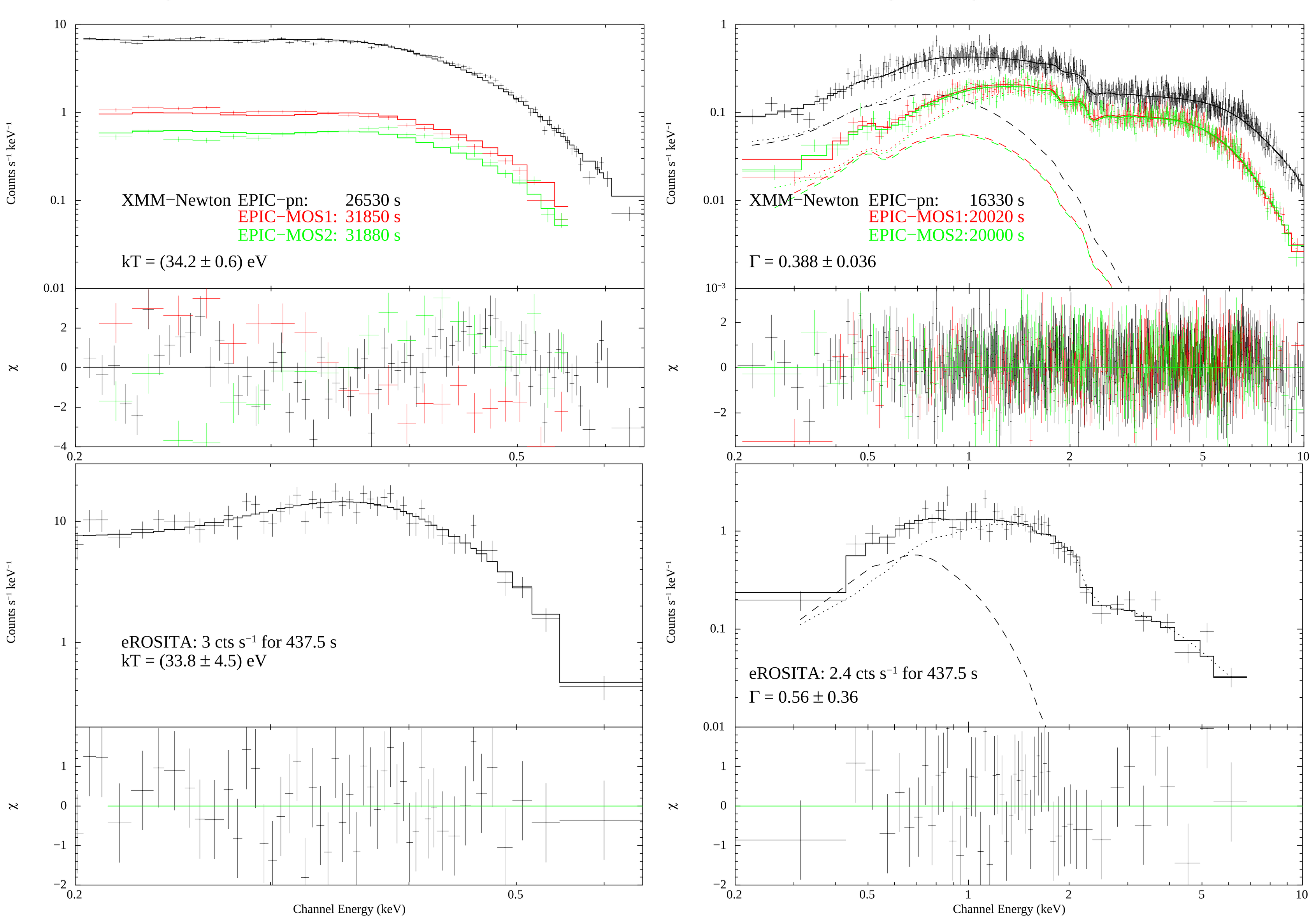
a) MCELLS image of the SMC, Credit: F. Winkler/Middlebury College, the MCELS Team, and NOAO/AURA/NSF. b) XMM-Newton background subtracted mosaic image from the SMC survey [8]. The image has an average exposure of 10–30 ks and reveals ~3000 X-ray sources. c) eRosita exposure map (for a sun-pointing scanning axis).

d) Simulated eROSITA image of the full survey, created from the XMM-Newton image. Emission above and below 2.5×10^{-4} cts s^{-1} arcsec^{-2} was smoothed to 25″and 150″, respectively. From the XMM-Newton SMC point source catalogue [9], we expect ~100 source in the SMC main field with $> 6.5 \times 10^{-14}$ erg cm^{-2} s^{-1}.

Spectral capability

The symbiotic nova SMC3

The Be/X-ray binary SXP6.85



Simulation of two X-ray spectra as observed with XMM-Newton for one scan in the eROSITA survey. The upper diagrams show the super-soft spectra of the symbiotic nova SMC3 (left) and the BeXRB SXP6.85 (right) during bright states. The SMC3 spectrum was modelled with absorbed black-body emission, the spectrum of SXP6.85 with absorbed power-law (dotted line) and a multi-temperature thermal disc model (dashed line). In the lower diagrams, the simulated eROSITA spectra of both sources are presented.

- Upper limits for detection by demanding 15 counts: $5.2 \times 10^{-13} \frac{\text{erg}}{\text{cm}^2\text{s}}$ (SXP6.85) $5.0 \times 10^{-14} \frac{\text{erg}}{\text{cm}^2\text{s}}$ (SMC3)
- Classification of BeXRB easily possible from photon index and source variability.
- Temperature determination for SSSs feasible.

Prospects with eROSITA

- Monitor the BeXRB population of a complete galaxy.
- Light curves of SSSs can provide important clues to the physics of the individual systems.
- Discover new BeXRBs: Each year, ~3 new BeXRBs are discovered, mainly in the SMC bar. We expect new transients during the survey.
- Discover new SSS, which were in off-state during the ROSAT all-sky survey and are in the outer fields, not covered by modern X-ray observatories.
- Trigger follow-up observations: E.g. a serendipitous detection of the BeXRB IGR J05414-6858 in the LMC in outburst with Swift [10] allowed to trigger a XMM-Newton ToO observation to determine the spin period and measure the spectrum.

References

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[2] Coe 2005, MNRAS 357, 1379
[3] Mereghetti 2010, A&A 519, 42
[4] Sturm et al. 2011, A&A 529, 152
[5] Greiner & DiStefano 2002, A&A 387, 944
[6] Orio & Greiner 1999, A&A 344L, 130
[7] Eger & Haberl 2008, A&A 491, 841
[8] Haberl et al. 2012, in preparation
[9] Sturm et al. 2012, in preparation
[10] Sturm et al. 2011, ATel #3537

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