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The Role of Wide Field X-ray Surveys in Astronomy

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Abstract. We review the history of X-ray sky surveys from the early experiments to the catalogues of 10^5 sources produced by ROSAT, Chandra and XMM-Newton. At bright fluxes the X-ray sky is shared between stars, accreting binaries and extragalactic sources while deeper surveys are dominated by AGN and clusters of galaxies. The X-ray background, found by the earliest missions, has been largely resolved into discrete sources at soft (0.3-2 keV) energies but at higher energies an important fraction still escapes detection. The possible identification of the missing flux with Compton-thick AGN has been probed in recent years by Swift and Integral.

Variability seen in objects observed at different epochs has proved to be an excellent discriminator for rare classes of objects. The comparison of ROSAT All Sky Survey (RASS) and ROSAT pointed observations identified several Novae and high variability AGN as well as initiating the observational study of Tidal Disruption events. More recently the XMM-Newton slew survey, in conjunction with archival RASS data, has detected further examples of flaring objects which have been followed-up in near-real time at other wavelengths.

Keywords. X-rays: general, surveys

1. Introduction

In common with other wavelengths, X-ray surveys have two broad goals (i) to construct large samples to understand the global properties of a class of objects (ii) to find rare objects which help to fill in the details. X-ray astronomy started in 1962 with the launch of an experiment aboard an Aerobee 150 sounding rocket (Giacconi *et al.* (1962)). The discovery of strong emission from a point source (SCO X-1) and the cosmic X-ray background (CXB), by this mission, were highly influential in shaping the goals of future missions. Subsequent high-energy surveys of the galactic plane (e.g. by Integral (Winkler *et al.* (2003)) or MAXI (Matsuoka *et al.* (2009))) have now found ∼100 Low-Mass X-ray binaries (LMXB), of which SCO X-1 is the brightest member, which can vary their output by two orders of magnitude in a matter of weeks. The CXB was later shown to be a summation of extragalactic point sources (e.g. Setti & Woltjer (1973)). Many missions have investigated their properties; ASCA, Beppo-Sax and Einstein resolved 25-30%, ROSAT resolved 75% in soft X-rays while deep surveys by XMM-Newton and Chandra increased this to 80-90% (Brandt & Hasinger (2005) and references therein). At soft X-ray energies the sky is dominated by unobscured AGN while at higher energies the contribution from the more numerous self-absorbed AGN becomes increasingly important. Synthesis models fitting the CXB can be used to constrain the evolution of AGN and predict a significant fraction of highly absorbed (Compton-thick) objects (e.g. Gilli, Comastri & Hasinger (2007)). Deep surveys revealed a luminosity-dependent evolution of number density, with high-luminosity QSO peaking at z=2-3 while lower luminosity Seyfert galaxies are more prevalent at $z< 1$ (La Franca *et al.* (2005), Hasinger, Miyaji &

Schmidt (2005)). The elusive Compton thick population has begun to be revealed in the Swift BAT (Burlon *et al.* (2011)).

2. Rare objects

Large surveys allow rare objects to be found from their X-ray colours, time signatures or celestial location. Seven isolated neutron stars were identified from their soft X-ray spectrum and faint optical companion in the RASS (Voges *et al.* 1999). All belong to the Gould belt at a distance of 100–500 pc (Haberl (2006)). Transient events in Galactic nuclei led to the discovery by ROSAT of Tidal Disruption events (see Komossa 2002 for a review) which have also been found in small numbers in the XMM-Newton slew survey (Esquej *et al.* (2007), Saxton *et al.* (2012)). Ultra Luminous X-ray sources (ULX) with $L_X > 10^{39}$ ergs s^{-1} have been found in the outskirts of a few hundred galaxies in the XMM-Newton serendipitous survey (2XMM; Watson *et al.* (2009)). A selection of these which may harbour intermediate mass black holes ($10^2 < M_{BH} < 10^5 M_\odot$) have been proposed by Walton *et al.* (2011). The most extreme of these, HLX-1, with $L_X = 10^{42}$ ergs s^{-1}, appears to have $M_{BH} \sim 10^3 M_\odot$ (Farrell *et al.* (2009)). Coming from the other end, a small number of AGN with $10^4 < M_{BH} < 10^5 M_\odot$ have also been found with XMM-Newton from their very soft X-ray spectra (e.g. Terashima *et al.* (2012)).

3. Future prospects

eRosita (Predehl *et al.* (2010)), has the potential to revolutionise wide-field X-ray surveys in the same way that ROSAT did in the 1990s. It is expected to see more than 10^6 AGN and 10^5 clusters of galaxies. Tight constraints on cosmological and dark energy parameters may be available from cluster counts. In addition, transient detection will likely open up new research areas. For example, the mission should detect ~ 1 tidal disruption event each week. At higher energies, NuSTAR (Harrison *et al.* (2010)) and HXMT will provide new constraints on highly absorbed AGN.

References

Brandt, W. & Hasinger, G. 2005, *Annu. Rev. of Astron. and Astroph.* 43, 827
Burlon, D., Ajello, M., Greiner, J., Comastri, A., Merloni, A., & Gehrels, N. 2011, *ApJ* 728, 58
Esquej, P., Saxton, R., Freyberg, M., *et al.* 2007, *A&A* 462, 49
Farrell, S., *et al.* 2009, *Nat.* 460, 73
Giacconi, R., & Gursky, H., Paolini, F., & Rossi, B. 1962, *Phys. Rev. Lett.* 9, 439
Gilli, R., Comastri, A., & Hasinger, G. 2007, *A&A* 463, 79
Haberl, F. 2006 *Space Sci.* 308, 181
Harrison, F., *et al.* 2010, *SPIE* 7732, 27
Hasinger, G., Miyaji, T., & Schmidt, M. 2005, *A&A* 441, 417
Komossa, S. 2002, *RvMA* 15, 27
La Franca, F. 2005, *ApJ* 635, 864
Matsuoka, M., *et al.* 2009 *PASJ* 61, 999
Predehl, P., Boehringer, H., Brunner, H., *et al.* 2010 *SPIE* 7732, 23
Saxton, R., Read, A., Esquej, P., *et al.* 2012, *A&A* 541, 106
Setti, G. & Woltjer, L. 1973, *IAU Symposium No. 55* 208
Terashima, Y., Kamizasa, N., Awaki, H., Kubota, A., & Ueda, Y 2012, *ApJ* 752, 154
Voges, W., Aschenbach, B., Boller, T., *et al.* 1999, *A&A* 349, 389
Walton, D., Roberts, T., Mateos, S., & Heard, V. 2011, *MNRAS* 416, 1844
Watson, M., *et al.* 2009, *A&A* 493, 339
Winkler, C., Courvoisier, T., Di Cocco, G., *et al.* 2003 *A&A* 411, L1

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