2DF-XMM WIDE ANGLE SERENDIPITOUS SURVEY

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ABSTRACT

The XMM-Newton Survey Science Centre (SSC) is carrying out an identification and follow-up programme of serendipitous sources discovered in XMM-Newton observations. The goals of this survey include the detailed characterisation of the dominant X-ray source populations, e.g. AGN luminosity functions, absorption distribution and evolution, and the relationship between optical emission line and X-ray spectral properties. In addition to our ongoing core XID spectroscopic identification programme, we have now targetted over 3000 sources, spread evenly over 3 decades in X-ray flux, with the 2dF multi-fibre spectroscope on the AAT in 27 pointings, including the LSS survey fields. Critically we have now identified over 1000 sources with $F_{0.5-4.5keV} \geq 10^{-14}$ ergs^{-1}cm^{-2} over a very large area > 15 deg^2 which is an unsurpassed resource with which to investigate the AGN population around the break in the X-ray source counts. We highlight the discovery of new and rare classes of sources such as BAL QSOs not seen in either the ROSAT wide area survey or current pencil beam X-ray surveys.

Key words: Surveys; X-rays.

1. SSC XID PROGRAMME

The SSC XID programme aims to provide statistical identifications for the whole of the XMM-Newton serendipitous catalogue (Watson et al. 2003). To achieve this we have undertaken a core programme to obtain spectroscopic IDs for ∼1000 sources in a high b medium sample (∼10^{-14} ergs^{-1}cm^{-2}) in the North (AXIS, e.g. Barcons et al. 2002) and this 2dF sample in the South to identify the bulk of objects contributing to the X-ray background. A high b bright sample ∼10^{-13} ergs^{-1}cm^{-2} has been completed by Della Ceca et al. (2004) and a Galactic Plane Sample (∼7 x 10^{-15} ergs^{-1}cm^{-2}) is also underway (PI Motch). Deep optical imaging programmes are also being undertaken with the INT WFC (Yuan et al. 2003) and the ESO WFI (Dietrich et al. 2005) to provide photometric identifications

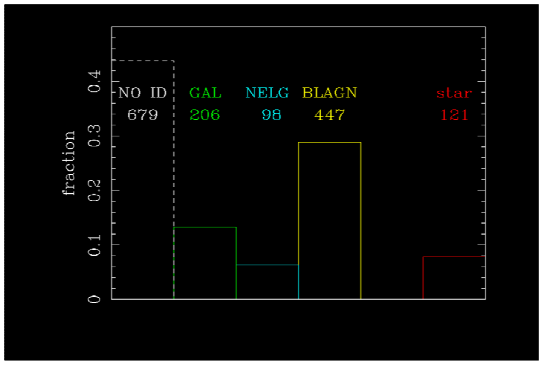

Figure 1. Provisional histogram of 2dF optical identifications.

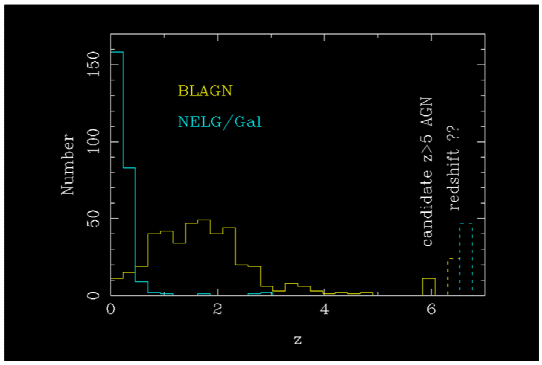

Figure 2. Provisional 2dF redshift distribution by optical class.

and redshifts for a much larger number of XMM-Newton fields and this includes $\frac{1}{2}$ of the 2dF sample to date.

2. 2DF OBSERVATIONS

We have obtained 2dF optical multi fibre spectroscopy in 27 pointings at the AAT (South) covering 68 XMM fields and including the LSS survey fields. Exposures were typically 1 hour and any X-ray source with an optical counterpart that could be allocated a fibre was ob-

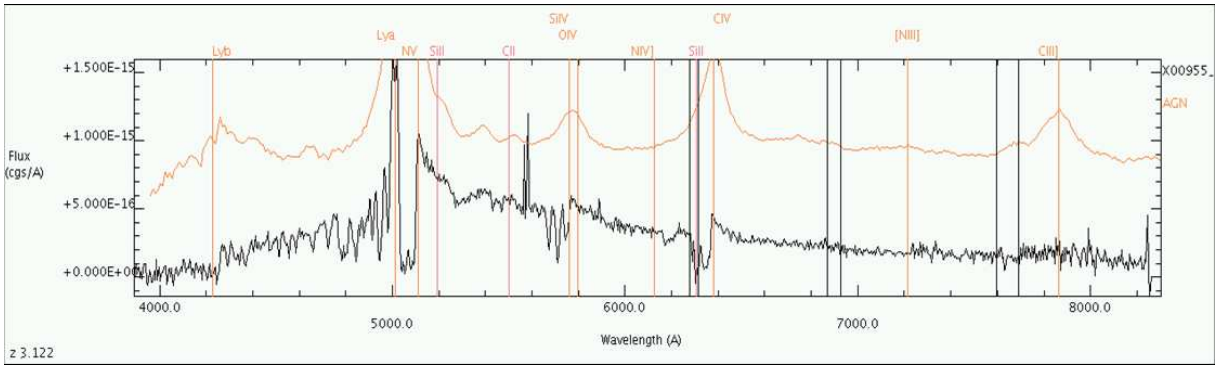

Figure 3. 2dF spectrum of a rare z=3.122 X-ray selected BAL QSO.

served, prioritised according to X-ray to optical offset on the sky. The identification stage is complete and we have beaten the barrier of 1000 sources brighter than $F_{0.5-4.5keV} \geq 10^{-14}$ ergs^{-1}cm^{-2}. In total $\geq$3000 X-ray sources have been observed and reduced. This opens up unique areas of parameter space.

3. PROVISIONAL 2DF ID STATISTICS

Figure 1 shows provisional indentification statistics for $\sim$50% of the final sample covering an area of $\sim$8deg^2. The identification rate is $\geq$50% having definite or probable IDs. Identification classes are simply based on optical properties alone, i.e. broad line AGN (BLAGN), absorption line galaxies (GAL), narrow emission line galaxies (NELG) and stars. Figure 2 shows the distribution of redshifts and highlights the outstanding feature of this survey which is that our wide coverage and large sample size gives us many more of the statistically rare objects at higher redshift than the pencil beam deep surveys.

4. UNIQUE SCIENCE EXAMPLE: SERENDIPITOUS BAL QSOS

Broad absorption line QSOs were virtually absent in previous X-ray surveys because of absorption. Indeed none were found in ROSAT surveys! We have already identified $\leq$20 BALQSOs in $\sim$1000 QSOs which is $\sim$2% of the X-ray QSO population and $\frac{1}{3}$ of the fraction found in past optical surveys. This is suprisingly large but is consistent with more recent SDSS results in which $\sim$15% of the optical QSO population, 1.7$\leq$z$\leq$3.5, are BALQSOs (Reichard et al. 2003). Figure 3 is an example 2dF spectrum of an X-ray detected, z=3.122 BAL QSO. X-ray selected objects will have the lowest X-ray absorption of the BALQSO population so we will study e.g. if their optical absorption lines are typical of the optically selected population and measure X-ray column densities.

5. X-RAY HR AND STACKING ANALYSIS

We have reprocessed over 100 XMM exposures for the 2dF fields using a test 2XMM catalogue pipeline and have made a catalogue which allows selection of objects by e.g. X-ray Hardness Ratio (HR). We can also select 2dF subsamples such as TyI or TyII QSOs by optical type and stack their X-ray spectra. There are $\geq$150 BLAGN having total EPIC counts $\geq$200 and we will present a stacked and rebinned spectrum (z-corrected 0.1keV bins) and hence determine mean power law continuum fits and resolve the presence of any residual Fe lines.

6. F_X-F_{OPT} CORRELATIONS

We have correlated our X-ray catalogue to Supercosmos R,B mags and the XID WFC/WFI multiband imaging will probe up to 2 mags deeper than SDSS to i$\leq$23 for $\frac{1}{2}$ of the 2dF sample to date. Initial studies suggest we may obtain photometric identifications and redshifts for up to $\sim$80% of the final sample in this way. We want to explore the space density of z$\sim$4 QSOs in X-ray surveys - do they decline at z$\geq$2 in the same way that optical QSOs do? Finally this sample provides an excellent statistical ID training sample so that most XMM catalogue objects can in future be identified statistically based on their X-ray properties alone.

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