

## MEDIUM-DEEP OBSERVATIONS OF QSOS/AGNS IN THE FIELD OF SA 57

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### ABSTRACT

The Selected Area 57 is one of the best studied fields of the sky at all wavelengths and AGN samples have been selected with different techniques, including optical variability. We present preliminary analysis of a medium-deep XMM-Newton observation of the field, yielding 140 X-ray sources, 90 of which are identified in the optical band.

Key words: Active Galactic Nuclei; X-ray surveys.

### 1. INTRODUCTION

In recent years consensus has grown on a fast increase in cosmic time of the number density of QSOs, down to  $z \sim 3$ , followed by a slower decline of the luminosity function (LF), which can be described by a QSO luminosity evolution. The quantification of this behavior is currently based on the 2QZ survey (Croom et al. 2001) for  $z < 2$ , on Warren et al. (1994) and Schmidt et al. (1995) surveys for  $z > 3$  and, most recently, on SDSS data (Fan et al. 2001) for  $z > 4$ . None of the above surveys adequately covers the redshift region  $z \sim 2 - 3$  where the maximum of QSOs density is located. Moreover, higher redshift data are restricted to the bright end of QSO LF and even low redshift data do not sample the evolution of objects fainter than  $M_B \sim -23$ . While the evolution of the number density of *high luminosity, X-ray selected*, AGNs resembles that of optically selected quasars (Fiore et al. 2003), little is known about the evolution of *low luminosity, optically selected* AGNs, because *standard color techniques cannot be used when the nuclear luminosity becomes smaller than the host galaxy luminosity*. The most accurate location to date of the time of maximum QSO number density is provided by Wolf et al. 2003, through a color-selected sample which extends down to  $M_B > -21.5$ . Fainter AGNs in the field of SA 57 were selected by Bershadsky, Trevese, & Kron (1998) (BTK) searching for *variable galaxies*, i.e. active nuclei

comparable or fainter than their host galaxy, monitored in  $\sim 15$  years of observations at Kitt Peak National Observatory (KPNO) 4m telescope, reaching so far a limit of  $M_B < -19$ , after the spectroscopical confirmation of the 5 brightest objects of the sample. While hard X-ray selected samples are, confirming the predictions of standard AGN synthesis models for the CXB (e.g. Comastri et al. 2001) somewhat surprising results are also emerging: 1) the sources making the CXB peak at a redshift ( $z \sim 1$ ) lower than predicted by synthesis models (e.g. Hasinger 2003); 2) there is evidence that low luminosity sources peak at later cosmic time (Hasinger 2003, Fiore et al. 2003). Understanding the evolution of faint AGN, particularly around the epoch of maximum density, requires the analysis of a field where deep AGN samples *selected in both optical and X-ray bands* are present, to allow an accurate break down in classes of object like QSOs, different types of Seyfert galaxies, star-burst galaxies, LINERs and possibly obscured *quasar-2* type objects.

### 2. THE SELECTED AREA 57

The Selected Area 57 is one of the best studied fields of the sky at all wavelengths: radio FIRST Survey (Becker et al. 1995), IR deep ISOPHOT Survey (Lynden-Vornle et al. 2000), soft X-ray ROSAT HRI (Miyaji et al. 1997). A field of  $\sim 35$  arcmin in diameter has been repeatedly observed since 1975 in the  $U$ ,  $B_J$ ,  $R_F$ ,  $I_N$  bands. In a series of papers (Koo, Kron & Cudworth 1996 ; Koo & Kron 1988 ; Trevese et al. 1989, 1994; Bershadsky et al. 1998 (BTK)) a number of search techniques for QSOs/AGNs detection to faint limits ( $B=22.5$ ) has been elaborated, including non-stellar color, absence of proper motion, and variability. In January 2005 we observed the field of SA 57 for 65 ks with XMM-Newton. We present preliminary results concerning the optical identification and classification of the detected sources. We detected a total of 140 sources on four images obtained in the 0.5-10, 0.5-2, 2-10, 5-10 keV bands by combining MOS1, MOS2 and PN data. The flux limit in the 2-10 keV band is approximately  $4 \cdot 10^{-15}$  erg cm<sup>-2</sup> s<sup>-1</sup> at  $S/N \sim 3$ . The

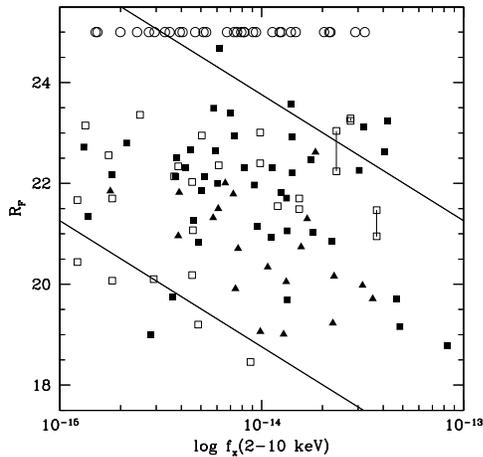


Figure 1. The optical  $R_F$  magnitude versus X-ray (2-10 keV) flux. Filled symbols: secure identifications, open symbols: less secure identifications; triangles: QSOs, squares: other identified objects; connected points: ambiguous identifications; open circles: optically unidentified.

photographic survey of SA57 has been conducted with the prime focus camera at KPNO since 1974 and is described in and Koo (1986). A photometric catalogue of about 8000 objects in a field of  $\sim 0.3 \text{ deg}^2$ , complete to  $B_J \sim 23$  was used for optical identifications of the X-ray detected sources. Six sources not identified within the above list were identified with NGPFG objects (Infante et al. 1995). A total of 99 objects has been identified with optical sources. Of these, 74 are the most secure identifications (single optical sources within 5 arcsec from the X-ray position), 25 are less secure or ambiguous and 41 are not identified. Of the 74 most secure identifications 24 are confirmed QSOs/AGNs and 1 is the extended source corresponding to the galaxy cluster II Zw 1305.4+2941 at  $z = 0.24$ . The surface density of all X-ray sources is about  $700 \text{ deg}^{-2}$ , of which  $290 \text{ deg}^{-2}$  are detected in the 2-10 keV band. For comparison with previous studies (Mignoli et al. 2004), we report in Figure 1 the  $R_F$  magnitude versus the 2-10 keV flux. Most of the objects not detected in optical images, and reported as upper limits  $R_F > 25 \text{ mag}$ , have an X-ray to optical ratio  $X/O > 30$  and are good *quasar-2* candidates, according to Fiore et al. (2003). An analysis of the X-ray spectra is in progress. Of the 42 confirmed QSOs/AGNs of the optical SA 57 survey (40 from Trevese et al. 2001), 29 fall within the X-ray field: 26 point-like objects, and 3 variable galaxies belonging to the BTK sample. Of the 26 point-like QSOs in the XMM field, 25 are detected as X-ray sources, i.e. 96%. Of the 3 variable extended BTK sources only 2 are detected in X-ray band. The third, BTK 512, has a secure redshift  $z = 0.215$  and observed variability of the optical spectrum. Other 3 non confirmed BTK objects are detected in X-rays, supporting their AGN character.

### 3. CONCLUSIONS

- The large amount of data available in the field of SA 57 allows to detect and classify at once a large fraction of the X-ray detected objects.
- The present X-ray survey, with 58 objects detected in the hard 2-10 keV band in  $\sim 0.2 \text{ deg}^2$ , is slightly deeper than the HELLAS2XMM 1dF survey (Fiore et al. 2003) which contains 122 sources in  $0.9 \text{ deg}^2$ .
- The distribution of the sources in the  $R_F$  vs  $F_x(2-10 \text{ keV})$  plane, shows the existence of  $\sim 20$  *quasar-2* candidates with high X/O ratio.
- Virtually all the point-like AGNs in the field are detected in X-rays.
- We detect altogether 9 objects found through variability (extended (BTK), or point-like (Trevese et al. 1989)) and not detected by colors or other techniques.
- Deep K-band images ( $K \sim 24$ ) of this field are highly desirable to further investigate the possible *quasar-2* character of the high X/O sources.
- Spectroscopy of the unconfirmed variable galaxies, as well as of the remaining optically identified X-ray sources, is needed to constrain the cosmic evolution of the faint AGNs in both optical and X-ray bands.

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