AGNS AMONG ROSAT BLANK FIELD SOURCES

I. CAGNONI\textsuperscript{1}, M. ELVIS\textsuperscript{2}, D.-W. KIM\textsuperscript{2}, J.-S. HUANG\textsuperscript{2}, A. CELOTTI\textsuperscript{3} and F. NICASTRO\textsuperscript{2}

\textsuperscript{1} Dipartimento di Scienze, Università dell’Insubria, Via Valleggio 11, 22100, Como, Italy (E-mail:ilaria.cagnoni@uninsubria.it)
\textsuperscript{2} Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA
\textsuperscript{3} SISSA-ISAS, Via Beirut 4, 34014, Trieste, Italy

We selected a sample of sources with high X-ray over optical flux ratio from the ROSAT PSPC archives. Out of the 16 sources in our sample, one is a (possibly extreme) BL Lac and two are AGNs. Six more sources are tentatively classified as AGNs on the basis of their X-ray properties and of our optical-IR imaging. For one of the AGNs and for the AGN-like blanks we find a discrepancy between the lack of absorption indicated by the X-ray spectra and the presence of red counterparts in their error circles. We discuss various possibilities to reconcile the X-ray and optical information.

1 \textit{ROSAT} blank field sources

We have found a class of ‘blank field sources’ or ‘blanks’ (Cagnoni et al. 2002). These are X-ray sources with $f_X/f_V > 10$ and so are extremely X-ray loud. We selected our sample from the bright ($f_X > 10^{-13}$ erg cm$^{-2}$ s$^{-1}$) high latitude ($|b| > 20$) ROSAT sources in WGACAT (1995 version, White Giommi & Angelini 1984) with no optical optical counterpart on the POSS (McMahon & Irwin 1992). While our sample contains only 16 blanks many more may exist, given our demanding search criteria (e.g. no optical counterpart within 39", 99\% radius). Blanks are a varied population. We have previously shown (Cagnoni et al. 2001) that this is an efficient method of finding high redshift ($z > 0.6$) clusters of galaxies. Here we highlight the peculiar AGNs among the blanks. (We will use the term AGN in the text meaning unbeamed AGNs, i.e. excluding the blazar class).

2 AGNs expected among \textit{ROSAT} blanks

Some “normal” BL Lacs are expected to contaminate our sample for $f_X/f_V < 35$ (e.g. Maccacaro et al. 1988), but blanks reach $f_X/f_V$ up to a factor of 10 higher. An obvious possibility is that we are selecting the most extreme representatives of the BL Lacertae class, i.e. extremely variable (a factor of $\geq 10$) and/or BL Lacs with SED peaking at energies higher than the \textit{ROSAT} band. This peak could be either the low energy (synchrotron, and some of
these objects, which also proved to be extremely variable, were recently found by Costamante et al. 2001) or the high energy (inverse Compton, no such BL Lacs have been found so far) one shifted appropriately.

Normal type 1 AGNs with \( f_X > 10^{-13} \text{ erg cm}^{-2} \text{ s}^{-1} \) have \( O \sim 18 \) and could be selected as blanks only if their optical counterpart is obscured in the O-band by \( A_O > 3.5 \text{ mag} \), which corresponds to a local \( N_H > 4 \times 10^{21} \text{ cm}^{-2} \), or if their optical emission is intrinsically highly suppressed. Not all obscured AGNs could still be visible with \( f_X > 10^{-13} \text{ erg cm}^{-2} \text{ s}^{-1} \) in the ROSAT PSPC. AGNs can reach such X-ray fluxes despite the obscuring material only if they are intrinsically bright, as quasars or QSOs, or if their spectrum is dominated by a conspicuous soft X-ray excess, as Narrow Line Seyfert galaxies (NLSy).

QSO-2s and NLSy2 galaxies are the “missing links” of the unifying models of AGN (Urry & Padovani 1995) and their number density and importance for the X-ray background are still debated (e.g. Comastri et al. 2001). The other possibility for AGNs to be selected as blanks is when their optical emission, which is dominated by the big blue bump (BBB) component from the accretion disk (Elvis et al. 1994), is highly suppressed. This can happen in AGNs powered by radiatively inefficient mechanisms for accretion, e.g. advection dominated accretion flows (ADAFs, e.g. Narayan & Yi, 1994), where most of the energy is stored in the gas and advected toward the hole and only a small fraction is radiated.

### 3 AGNs and AGN candidates found among blanks

The main observational properties of the AGN and AGN-candidates in our sample are summarized in Table 1. While we were progressing our investigation one of the blanks, 1WGA J1340.1+2743, was classified as a BL Lac for the lack of features in its optical spectrum (Lamer, Brunner & Staubert (1997). The source is one of the most extreme in our sample and both its \( f_X/f_V \) (\( \sim 250 \)) and its broad-band radio indices \( (\alpha_{\nu_R} = 0.62 \) and \( \alpha_{\nu_X} = 0.61 \) for a NVSS counterpart of 4.6 mJy) are not compatible with normal BL Lacs. 1WGA J1340.1+2743 properties can be explained if this source is an extreme synchrotron dominated BL Lac such as those in Costamante et al. (2001) or if the source was flaring during the WGACAT observation. *Chandra* follow-up caught the source 10 times fainter than in WGACAT, suggesting that the source could indeed be an extreme and/or extremely variable BL Lac.

Two blanks (1WGA J1412.3+4355 and 1WGA J1415.2+4403) were spectroscopically identified in the RIXOS survey (Mason et al. 2000) as AGNs at \( z \sim 0.5 - 0.6 \). 1WGA J1415.2+4403 could be a normal type 1 AGN because its WGACAT flux was \( \sim 50\% \) overestimated due to the steep nature of it
spectrum. 1WGA J1412.3+4355 presents an unexpected red POSS counterpart while looks only moderately red in our optical-IR follow-up. Another 6 sources (see Tab. 1) are likely to be AGNs. 1WGA J0951.4+3916 shows signs of absorption in the X-ray band ($N_H \sim 2^{+3}_{-1} \times 10^{21}$ cm$^{-2}$) and has a red counterpart (POSS and our imaging). One more source, 1WGA J1420.0+0625, differs from the AGN-like ones for the lack of a red counterpart. Could we be seeing the reflected component of an intrinsically bright obscured AGN?

### 3.1 Perverse AGNs: Dusty, yet Unobscured in X-rays

The remaining 5 AGN-like sources seem to share the same peculiar combination of characteristics: type 1 AGNs X-ray spectra with low absorbing column densities (consistent with the Galactic values) but red counterparts ($O - E > 2$ in the POSS and $R - K > 4$ in our imaging). For a local AGN type 1, $O - E > 2$ implies $A_V > 4$ (e.g. Risaliti et al. 2001) and thus strong obscuration ($N_H > 2 \times 10^{21}$ cm$^{-2}$ for a dust to gas ratio typical of the ISM in our Galaxy), in contrast to the results of the X-ray data.

There are some possibilities to reconcile the optical and X-ray data: (1) the AGNs have $z \geq 3.5$ (e.g. Fig. 7 of Risaliti et al. 2001). This is excluded for 1WGA 1415.2+4403, but it is still possible for the other RIXOS AGN (1WGA J1412.3+4355) whose the redshift measurement is based on only 1 optical line; (2) a dust to gas ratio $\sim 40 - 60$ times higher than the Galactic value; (3) a modified dust grain size distribution with respect to the Galactic ISM; (4) the presence of dust within a warm absorber (e.g. Komossa & Bade 1998); (5) a highly suppressed BBB emission (see § 3).

The planned optical spectroscopic follow-up is needed to investigate the nature of the AGN-like blanks.

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"With the exception of 1WGA J1535.0+2336, red in the POSS, but only moderately red in our imaging; of 1WGA J1220.6+3347 red in our imaging but not in the POSS"
Table 1: Properties of the AGN blanks.

| Source name Identification (1WGA J) | Identification | $F_X$ (0.3-3.5 keV) | $F_X$ | $R$ | $E_o$ | $O_o$ | $K$ | $O-E_o$ | R-K |
|------------------------------------|----------------|---------------------|-------|-----|-------|-------|-----|---------|-----|
| 1340.1+2743 BL Lac               | 2.35           | 8.94                | 21.3  | -   | -     | 15.8 ± 1.2 | -   | 5.5     |
| 1412.3+4355 AGN(z=0.59)          | 1.76           | 0.97                | 19.9  | 18.73 | -     | 16.7 ± 0.4 | > 2.77 | 3.2     |
| 1415.2+4403 AGN(z=0.56)          | 2.97           | 0.64                | 20.7  | -   | -     | 16.0 ± 0.4 | -   | 4.7     |
| 0951.4+3916 AGN?                 | 2.62           | 1.39                | 20.1  | 19.1 | -     | 16.2 ± 0.4 | > 2.4  | 3.9     |
| 1220.3+0641 AGN?                 | 1.95           | 8.22                | 17.6  | 18.58 | 21.81 | 13.6 ± 0.4 | 3.23  | 4.0     |
| 1416.2+1136 AGN?                 | 2.98           | 0.59                | 19.9  | 19.5 | 22.22 | 14.9 ± 0.4 | 2.72  | 5.0     |
| 1535.0+2336 AGN?                 | 0.70           | 0.83                | 19.9  | 19.6 | 21.8  | 16.5 ± 0.4 | 2.2   | 3.4     |
| 1233.3+6910 AGN?                 | 2.43           | 4.11                | ∼ 22  | -   | -     | 16.1 ± 1.2 | -   | 5.9     |
| 1220.6+3347 AGN?                 | 2.31           | 1.30                | 19.9  | 20.9 | 21.7  | 15.6 ± 0.6 | 0.8   | 4.3     |
| 1420.0+0625 Unknown              | 2.21           | 1.68                | 20.0  | -   | -     | 16.6 ± 0.4 | -   | 3.4     |

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