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EXPLORING (EXTREMELY) OBSCURED ACCRETION

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RESUMEN

Se piensa que la mayor parte de la acreción en el Universo ocurre en entornos oscurecidos. Se han usado muchas técnicas para seleccionar Núcleos Galácticos Activos (AGN) oscurecidos. Aquí presentamos los resultados de una selección de AGN oscurecidos utilizando su cociente de flujos de rayos X y ópticos. A pesar de tomar un flujo límite en rayos X relativamente alto, la mayor parte de las fuentes sólo son identificables usando espectroscopía en telescopios de 10 m. Hemos identificado 22 fuentes (18 utilizando GTC). Entre las fuentes identificadas hay AGN con líneas de emisión anchas (BLAGN), galaxias con líneas de emisión estrechas y "galaxias normales". 11 de esas 17 fuentes son AGN altamente luminosos y oscurecidos (los llamados QSO2). Los dos BLAGN de mayor luminosidad son fuentes super-Eddington, mientras que el tercero parece ser un objeto de transición entre un tipo 2 y un tipo 1. Nuestro método de selección parece ser bastante eficiente seleccionando QSO2, pero no fuentes más fuertemente oscurecidas, como los largamente buscados AGN ópticamente gruesos.

ABSTRACT

Most accretion in the Universe is thought to occur in obscured enviroments. Many different techniques are used to select obscured AGN. We present here the results of a selection of obscured AGN using their X-ray to optical flux ratio. Despite choosing a relatively high X-ray flux limit, most sources turn out to be only identifiable through 10 m-class spectroscopy. We have identified 22 sources (18 using GTC). Among the identified sources there are broad-line AGN (BLAGN), narrow emission line galaxies, and "normal galaxies". 11 of those 17 turn out to be high-luminosity highly-absorbed AGN (the so-called QSO2). The two highest luminosity BLAGN are super-Eddington sources, while the third one appears to be a transition object between a type 2 and a type 1. This method appears to be quite efficient in selecting QSO2, but not more highly obscured sources, such as the long-sought Compton-Thick AGN.

Key Words: galaxies: active — surveys — X-rays: galaxies

1. GENERAL

The X-ray Background (XRB) is a fossil of all the radiation emitted by accretion on to Supermassive Black Holes (SMBH) in Active Galactic Nuclei (AGN) through the history of the Universe. The "flat" shape of the XRB spectrum compared to that of the spectra of unabsorbed AGN immediately reveals that most accretion in the Universe occurs in obscured environments (Fabian & Iwasawa 1999).

Many methods to detect these obscured AGN have been proposed, involving observations in wavelengths less affected by absorption (MIR, X-ray...) than the optical/UV, or recur to radiation from places thought to have a direct view to the central region ([O III],[Ne V...). Each of these methods rely on a different aspect of the AGN phenomenon, and therefore may reveal different AGN populations.

In this work we take advantage of the penetrating power of X-rays, by selecting X-ray-detected sources with a high X-ray-to-optical flux ratio (X/O). X-ray radiation is thought to come from the inner nuclear regions and hence a bright 2–10 keV observed flux is often hailed as the "smoking gun" evidence for the presence of an AGN, a distinct advantage over other methods using radiation in other wavebands even more immune to absorption, but coming from re-processed radiation farther away from the SMBH.

Unabsorbed AGN (also called broad-line AGN –BLAGN– or type 1 AGN) and moderately absorbed AGN (often appearing as Narrow Emission Line Galaxies – NELGs or type 2 AGN) in X-ray surves show $-1 \leq \log(X/O) \leq 1$. For example, out of the 315 sources in the *XMM-Newton* Medium Survey (XMS: Barcons et al. 2007), 257 had X/O in that interval, and only 18 had $\log(X/O)>1.2$.

We have investigated here the nature of the high X/O sources. We have first scanned several X-ray surveys to select a large sample of this objects (§ 2).

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Then we have identified several subsamples of them (with different degrees of completeness § 3) using 10 m-class spectroscopy. We are currently analyzing the identifications in the framework of the different surveys, showing here a few highlights (§ 4). We finish with some insights as to the nature of this sources in § 5.

2. SAMPLE SELECTION

Given the rarity of the high X/O objects we need to combine several large-area surveys in order to assemble a sample as large as possible. Furthermore, we further select sources with a relatively high X-ray flux, to ensure good quality X-ray spectra to be able to study in more detail its direct emission and to constrain the presence of Compton Thick (CT) sources.

Our parent samples include the *XMM-Newton* Bright Serendipitous Survey (Della Ceca et al. 2004; Caccianiga et al. 2007), the Bright Ultra-hard XMM-Newton Survey (Mateos et al. 2012, in preparation), selected from 2XMMi-DR3 sources selected in 5–10 keV and two surveys explicitely designed to pick up high X/O sources: a cross-correlation of the 2XMMp catalogue with SDSS DR5 (del Moro et al. 2009, 2012 in preparation) and a cross-correlation of 2XMMi-DR2 with SDSS DR7 (Della Ceca et al. 2012, in preparation).

Our full sample includes 41 sources with log(X/O)$\geq$1.2 (up to log(X/O)$\sim$3) and 2–10 keV X-ray flux $\geq 10^{-13}$ cgs. Despite this high X-ray flux limits, these objects had $R/r' \sim 21-25$, and some of them are extended, so they are only amenable to spectroscopy using 10 m-class telescopes.

3. IDENTIFICATIONS

We have identified 22 of those 41 objects using GTC/OSIRIS (18 identifications), VLT/FORS2 (1) and Subaru/MOIRCS (3), finding 10 BLAGN, 11 NELG, and one "normal" absorption line galaxy (Gal). Three further objects had clear featureless continua and evidence for radio emission, so they are probably BL Lac objects. The X-ray flux of the latter objects is probably beamed, boosting them into our selection space.

We have defined a "complete sample" including all the 17 objects in our sample with X-ray flux $\geq 1.5\times10^{-13}$ cgs and log(X/O)$\geq$1.2, all of which have been identified: 6 BLAGN, 7 NELG, 1 Gal and 3 BL Lacs.

Given the somewhat heterogeneous origin of our full sample, we have also defined a statistically complete subsample coming only from the (Della Ceca et al. 2012, in prep.) survey, including 7 sources from the "complete sample": 1 BLAGN, 4 NELG and 2 BL Lacs, all with X-ray flux $\geq 1.6\times10^{-13}$ cgs and log(X/O)$\geq$1.7.

4. HIGHLIGHTS

X-ray spectral analysis of 22 sources reveal significant ($>2\sigma$) absorption in 14 sources (3BLAGN, 10 NELGs, 1BL Lac), 11 of which (1 BLAGN, 9 NELGs) are within the "X-ray type 2 QSO zone" (X-ray luminosity $>10^{44}$ cgs and $\log(N_{\rm H}/{\rm cm}^{-2}) > 22$). All NELGs and BLAGN in the statistically complete subsample are among these type 2 QSO. Only one of them might be a CT source from its flat X-ray spectrum (del Moro et al. 2009).

The presence such a large fraction of BLAGN among our identified sources is unexpected, since they are normally unobscured and should fit within the "standard" X/O limits. Therefore we have concentrated in this type of sources.

The statistically complete sample still includes 1 BLAGN, this is doubly surprising because it would be classified as a type 2 QSO. Its high Eddington ratio (>100) and narrow broad emission lines reveal that it is a Narrow Line Sy1, but its high X-ray absorption remains unexplained.

The second most luminous BLAGN also shows a very high Eddington ratio $\sim$100, but not strongly significant intrinsic X-ray absorption. The next BLAGN going down in luminosity shows an EW in its [O II] line ($\sim$86 Å) intermediate between that of type 1 (<10 Å) and 2 ($\sim$200 Å) Sy galaxies, so perhaps it is a transition objects between those two types, despite its lack of significant intrinsic X-ray absorption.

5. SUMMARY

Exploring the brightest sources with high X-ray-to-optical ratio appears to be a good method to detect BL Lacs, high X-ray luminosity obscured sources (type 2 QSO), and peculiar BLAGN, but does not seem to pick up many Compton Thick sources, perhaps because their X-ray flux is strongly suppressed. A thorough statistical treatment within the individual surveys will further our knowledge of the objects with extreme X-ray to optical flux ratio.

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