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Type 2 Quasars at the heart of dust-obscured galaxies (DOGs) at high z

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Abstract. Dust-obscured galaxies (DOGs) represent a recently-discovered, intriguing class of mid-IR luminous sources at high redshifts. Evidence is mounting that DOGs (selected on the basis of extreme optical/mid-IR color cut and high mid-IR flux level) may represent systems caught in the process of host galaxy formation and intense SMBH growth. Here we report the results of an X-ray spectroscopic survey aimed at studying the X-ray properties of these sources and establishing the fraction of Type 2 quasars among them.

Keywords: Galaxies:active – Galaxies:nuclei – Infrared:galaxies – X-ray:galaxies
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According to many models of joint formation and co-evolution of quasars and their massive spheroidal host galaxies distant dust-enshrouded quasars might represent an early phase in quasar evolution [1, 2]. However, this evolutionary phase has been rarely observed, and a population of heavily obscured (possibly Compton Thick, CT hereafter) X-ray quasars is only loosely constrained to date. Even the deepest X-ray surveys detected directly only a handful of CT AGNs [3]. In the recent years many works have used the mid-IR (MIR) emission or combinations of MIR and optical/radio data to successfully select a population of highly obscured AGNs at $z \gtrsim 1$ [4]. In particular, [5, 6, 7] found a very efficient approach in collect sources with AGN luminosities in the MIR and faint optical or near-IR emission (i.e. $F_{24\mu m}/F_{R} \gtrsim 1000$ and $F_{24\mu m} \gtrsim 1$ mJy), the so-called dust-obscured galaxies (DOGs), e.g. [8]. All these studies indicate that the majority of the bright 24 μm sources with faint optical counterparts are highly obscured quasars at $z \gtrsim 1$.

We have performed an X-ray spectroscopic survey of DOGs aimed at studying the largely unexplored X-ray properties of these high-z systems [9]. To this purpose, we have collected all available *Spitzer*, optical and X-ray data of five fields from the SWIRE survey, since this survey, covering with medium-deep *Spitzer* MIPS and IRAC photometry about 30 deg^2 of the sky, provides a unique opportunity to build up a large sample of DOGs. We selected only those sources falling in a region of $\sim$6 deg^2 covered by X-ray observations available in the *XMM–Newton* and *Chandra* archives. The final sample includes 44 DOGs. The vast majority of spectroscopic (available for 7 sources) and photometric redshifts are in the range $0.7 < z < 2.5$, with an average $\langle z \rangle = 1.2$. Unfortunately, as the X-ray coverage of the SWIRE fields is highly inhomogeneous, we derived the

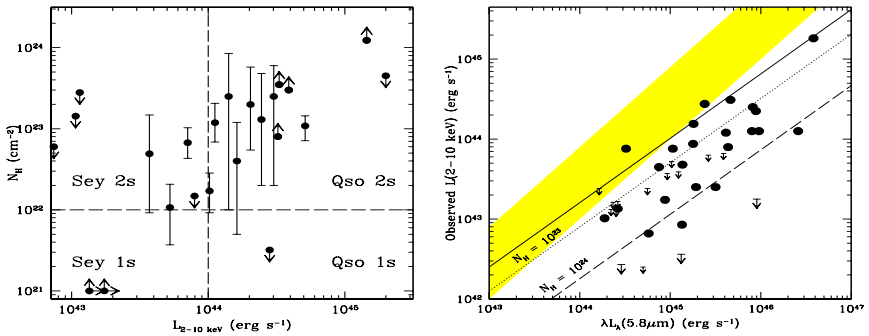

FIGURE 1. Left (a): N_H vs L_{2-10} for the X-ray detected DOGs in [9]. Right (b): $L_{5.8\mu m}$ vs *observed* L_{2-10}^{Obs}. Downward-pointing arrows indicate the 3σ upper limit on L_{2-10}^{Obs} for the X–ray undetected sources. The solid line represents the relationship between L_{2-10} and $L_{5.8\mu m}$ obtained for the X–ray sample, while the dotted(dashed) line represents the $L_{2-10}/L_{5.8\mu m}$ ratio expected for an absorption with N_H=10^{23}(10^{24}) cm^{-2}. The shaded area indicates the range of L_{2-10}-$L_{5.8\mu m}$ found for AGNs in the local Universe [10].

X-ray spectral properties for only 23 out of 44 sources (e.g. Fig 1a), while 21 sources remain undetected in X-rays. The main results of our work can be summarized as follows: (1) all these sources have a 2-10 keV luminosity $L_{2-10} \gtrsim 10^{43}$ erg s^{-1}, whereby they fall well within the AGN X-ray luminosity range, (2) 70% of the sources show a column density $N_H > 10^{22}$ cm^{-2}, (3) 50% of them can be classified as quasar 2 on the basis of their $N_H > 10^{22}$ cm^{-2} and $L_{2-10} > 10^{44}$ erg s^{-1}, and (4) at least four DOGs at $z > 1.4$ were found to be very likely CT quasar 2 candidates. These results have definitively established the AGN-dominated nature of the X-ray emission in DOGs with $F_{24\mu m} \gtrsim 1$ mJy. We were also able to provide a rough estimate of the N_H for the 15 X-ray undetected DOGs showing MIR colors typical of AGN-dominated sources, e.g. Fig 1b (see [9] for details), one third of which is consistent with being CT.

The present results, together with the high dust content, redshift distribution and huge bolometric luminosities inferred for these sources (i.e., $10^{12} < L_{Bol} < 10^{14}$ $L_\odot$), lead further support to the idea that the DOG phenomenon is linked to the early stages of quasars evolution.

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