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Type-2 QSOs in the CDFS

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ABSTRACT

We have analyzed using XSPEC the X-ray spectra of 188 hard X-ray selected, 2-10 keV, sources in the Chandra Deep Field South (CDF-S). We identify 15 type-2 QSOs, defined as luminous ($Lx>10^{44}$ erg s^{-1}) and highly absorbed, (column density $NH>10^{22}$ cm^{-2}) sources. 7 of these show Narrow Line, 3 Broad Line optical spectra while for 5 there are only photometric redshifts available. We find 7 more unabsorbed QSOs yielding a ratio of absorbed to unabsorbed sources R=2:1 at these high luminosities. The X-ray spectra suggest very high, Compton thick column densities in 3 out of the 15 type-2 QSOs. IRAC Spitzer observations provide additional constraints on the amount of obscuration in these sources.

The Sample

We analyse the CDF-S as there is complete redshift information for **all** the 243 hard X-ray selected sources (in contrast to the 2 Ms CDF-N where a large number of sources remains unidentified). We have selected only the hard X-ray selected 2-10 keV sources in the list of Giaconni et al. 2002 which lie in the central CDF-S region, i.e. in all the 11 separate pointings which comprise the total 1Msec exposure. In this way we maximise the observed counts. Our selection yields 188 sources.
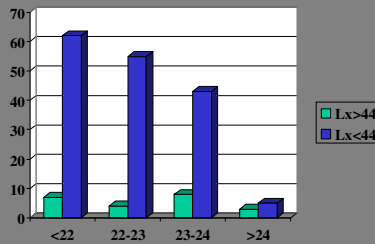

FIG. 1 THE LUMINOSITY DISTRIBUTION

The column density distribution for the luminous (Lx>44) and Less luminous AGN. Note that the fraction of absorbed (NH>22) and unabsorbed (NH<22) sources remains roughly the constant with luminosity: 15/7 against 103/62 for Lx>44 and Lx<44 respectively.

Type-2 QSO

NAME	NH (x10^{22}) cm-2	z	R-K	logLx	class
76	20	2.39	4.64	44.4	NL
72	7.0	1.99	-	44.2	-
68	3.5	2.73	2.11	44.4	BL
62	23.	2.81	2.58	44.4	BL
61	1.1	2.02	5.80	44.3	-
57	18	2.56	3.23	44.2	NL
600	744.	1.33	5.22	44.5	NL
54	18	2.56	-	44.1	NL
610	983.	2.04	-	44.3	-
45	12.	2.29	5.12	44.1	NL
202	36.	3.70	3.37	44.1	NL
605	>1000.	4.29	-	45.7	-
27	47	3.06	4.76	44.6	NL
24	3.4	3.61	3.59	44.4	BL
159	11.	3.30	-	44.7	-

The type-2 QSOs

We define as type-2 QSOs those having a high luminosity (Lx>44) and a high absorbing column density. There are 15 type-2 in our sample Moreover there are 7 type-1 (unabsorbed) QSOs i.e. we observe a ratio R~2:1 of obscured to unobscured QSOs. The type-2 QSOs consist of 7 Narrow Line (NL), 3 Broad Line (BL) and 5 sources which are Spectroscopically unidentified and have only photometric redshifts available as they are fainter than R=24. The redshifts of the type-2 QSOs range from 1.3 to 4.29. Our analysis using the X-ray spectra improves on previous work by Padovani et al.

The Compton thick sources

3 type-2 QSOs (600, 610, 605) appear to be Compton thick ie have column densities higher than 10^{24} cm^{-2}. The DIRECT measurement of the NH has been possible due to the large redshift of the sources z>1.3 which shifts the cut-off spectral energy in the Chandra passband. An FeK line cannot be detected due to poor photon statistics. Note that source #600 is an ERO as it has R-K=5.22. The other two sources have not been observed in the K-band. None of the 3 Compton thick QSOs presents an X-ray to optical flux ratio log(fx/fo)>1.
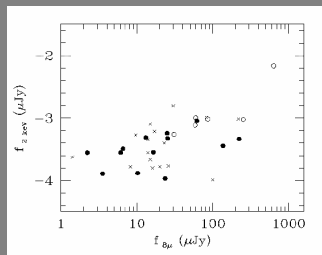

FIG. 2 X-RAY vs. SPITZER fluxes

The monochromatic observed X-ray (2 keV) against the Spitzer IRAC 8µm fluxes for the type-2 (filled symbols) type-1 (open) as well as the CDFS optically unidentified sources presented in Rigby et al. (2005). The most heavily absorbed sources lie on the bottom right side of the diagram having a deficit of X-ray emission at their IR luminosity.
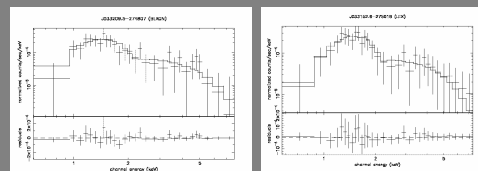

FIG 3. THE X-RAY SPECTRA

Example spectra of two type-2 sources (62 and 76) together with the best fit models and residuals (lower panel) The spectra were fit using the C-statistic (Cash 1979) using no binning. However, for illustrative purposes the spectra here have been binned to give a signal to noise ratio of 30.