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UNABSORBED SEYFERT 2 TYPE GALAXIES - WITH AND WITHOUT HIDDEN AGN SOURCE

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Abstract. We have compiled a sample of 27 nearby unabsorbed Seyfert 2 type galaxies to investigate them whether there is hidden or non – hidden AGN source. This question in some way coincides with the presence of hidden broad line region (HBLR) and non–HBLR in Seyfert 2.

Our sample contains Seyfert 2 type galaxies which are X–ray unabsorbed and their measured column densities are $N_H < 10^{22}$ cm^{-2}. For all objects we have $F_{[OIII]}$ flux's measurements in the emission line [OIII] λ 5007 Å.

We have derived the ratio $(N_{ph} / N_{ion})_{h\nu > 55 \text{ eV}}$ of the number of N_{ph} traced by the [OIII] λ 5007 Å emission line to the number N_{ion} of high ionizing photons hν > 55 eV emitted by the central AGN source for all sample's objects. This ratio is a probe of the collimation hypothesis of the Unified model. In the anisotropic case the ratio $(N_{ph} / N_{ion})_{h\nu > 55 \text{ eV}}$ is considerably larger than 1. Following our results a fraction of our sample's unabsorbed Seyfert 2 possess a hidden AGN source .

On the other hand, we have calculated the Eddington ratio L_{Bol} / L_{Edd} for some of the objects. There is a critical value of the Eddington ratio, 10^{-3}, below which there is no HBLR, but when this ratio is ≥ 0.2 – 3 the broad lines also disappear.

Finally, we have investigated the objects in our Seyfert 2 sample with hidden AGN engine ($(N_{ph} / N_{ion})_{h\nu > 55 \text{ eV}} > 1$) for HBLR and non–HBLR. Four objects of our sample are HBLR galaxies and these have hidden AGN source.

1. INTRODUCTION

The standard theory for active galaxies is based on the idea for accretion disk around a massive black hole. This theory predicts the presence of hard X-ray continuum from central engine, that is strong enough to photoionize the Broad Line Region (BLR – closer to the source) and the Narrow Line Region (NLR – at < 100 pc from the nuclear engine).

Seyfert galaxies are divided into types 1 and 2 in the Unified model, which is orientation-based unification scheme. According to this model, the two types Seyferts are actually the same objects but they differ only because of their orientation.

Seyfert 2 type galaxies possess a BLR, but it is obscured by a molecular torus and because of this it is unobservable.

In fact, there are some exceptions from this Unified model. Some Seyfert 2 type galaxies don't harbour a BLR, so they are the "true" Seyfert 2 galaxies – non–HBLR (Tran 2001, 2003).

Not all Seyfert 2 galaxies have a BLR in polarized light, and not all Seyfert 2 galaxies have column densities higher than 10^{22} cm^{-2}. Normally the column density of neutral hydrogen N_H for X–ray radiation in type 2 Seyferts is significantly higher than this in type 1 objects, because of the torus around the nucleus, which is on the line of sight. But there are some Seyfert 2 galaxies, which are X–ray unabsorbed and their measured column densities are $N_H < 10^{22}$ cm^{-2} (Panessa and Bassani 2002).

In this paper we have used a sample of 27 nearby unabsorbed Seyfert 2 type galaxies to investigate them whether there is hidden or non – hidden AGN source and probe them for a HBLR.

2. DATA AND RESULTS

Our sample contains 27 nearby Seyfert galaxies and most of them are classified by NED as Seyfert 2 type, but other as type 1.8 – 1.9. For simplicity we generally call them Seyfert 2. In this paper we adopt the cosmological constant $H_0 = 75$ km s^{-1} Mpc^{-1}.

In *Table 1* N_{ph}/N_{ion} is calculated from:

$$N_{ion} = \int_{55eV}^{\infty} \frac{F_\nu^{nt}}{h\nu} d\nu = 4\pi R_G^2 \frac{F_{h\nu=55eV}^{nt}}{h\alpha}, \quad F_\nu^{nt} = F_{\nu_0}(\nu_0/\nu)^\alpha,$$

where N_{ion} is the number of ionizing photons with $h\nu > 55$ eV provided by the central AGN source, R_G is the distance to the galaxy,

$$N_{ph} = \frac{\alpha_G(O^{+2}, T_e) L^{corr}([O^{+2}]\lambda 5007) CF^{-1}}{\alpha_{5007}^{eff}(n_e, T_e) h\nu_{5007}};$$

N_{ph} is the total number of ionizing photons that must be available to produce the observed [OIII] λ5007 emission, $L^{corr}([O^{+2}]\lambda 5007)$ is the luminosity corrected for extinction, $\alpha_G(O^{+2}, T_e) = 5.1 \times 10^{-12}$ cm^3 s^{-1} is the recombination coefficient at $T_e \approx 10^4$ K, $\alpha_{5007}^{eff}(n_e, T_e) = 0.7 \times 10^{-9}$ cm^3 s^{-1} is the effective recombination coefficient at $n_e = 3 \times 10^5$ cm^{-3} and $T_e = 10^4$ K. The covering factor CF = 0.07 (Yankulova et al. 2007).

"T" ratio is the other parameter similar to the N_{ph}/N_{ion} ratio:

$T = (F_{2-10keV} / F_{[OIII]})$.

Table 1. Observed and calculated data for 27 unabsorbed Seyfert 2 galaxies

Name	z	Log N_H	Γ	$F_{2-10keV}$	$F_{[OIII]}$	N_{ph}/N_{ion}	T
MRK 273x	0.458000	21.15	1.66	0.01	0.00014	0.15	71.43
MRK 334	0.021945	20.64	2.00	1.366	0.2	–	6.83
IRAS F01475-0740	0.017666	21.59	2.06	0.075	0.0625	2.65	1.2
IRAS 20051-1117	0.031498	< 21.60	1.92	0.24	0.0152	0.31	15.79
ESO 540-G001	0.026845	20.28	1.99	0.08	0.024	1.15	3.33
CGCG 303-017	0.037132	21.56	1.71	0.215	0.0126	0.55	17.06
CGCG 551-008	0.023616	< 20.60	2.09	0.031	0.0047	0.41	6.60
MCG 03-05-007	0.019927	< 20.48	1.85	0.069	0.0102	0.91	6.76
UGC 03134	0.028710	21.23	1.34	0.019	0.0065	8.11	2.92
IC 1631	0.030841	< 21.50	2.10	1.00	0.052	0.14	19.23
NGC 2992	0.007710	21.95	1.70	7.4	0.680	0.90	10.88
NGC 3147	0.009407	< 20.46	1.94	0.22	0.009	0.19	24.44
NGC 3660	0.012285	20.26	1.83	0.236	0.0593	1.72	3.98
NGC 3941	0.003095	≤ 21.00	2.1	0.004	0.00329	2.28	1.22
NGC 4472	0.003326	21.48	1.61	0.038	0.0003	0.11	126.67

Table 1 – continued

Name	z	Log N_H	Γ	$F_{2\text{–}10keV}$	$F_{[OIII]}$	N_{ph}/N_{ion}	T
NGC 4501	0.007609	21.30	1.5	0.011	0.0054	10.08	2.04
NGC 4565	0.004103	20.11	1.7	0.02	0.006	2.95	3.33
NGC 4579	0.005067	20.39	1.88	0.52	0.009	0.10	57.78
NGC 4594	0.003416	21.23	1.5	0.16	0.007	0.75	22.86
NGC 4698	0.003342	20.91	1.91	0.10	0.0024	0.12	41.67
NGC 5033	0.002919	20.76	1.7	0.28	0.017	0.60	16.47
NGC 5929	0.008312	20.76	1.7	0.135	0.0408	2.98	3.31
NGC 5995	0.025194	21.94	1.81	2.89	0.66	2.00	4.38
NGC 6221	0.004999	22.04	1.9	1.4	0.00214	0.01	654.21
NGC 6251	0.024710	21.88	1.83	0.14	0.057	2.66	2.46
NGC 7590	0.005255	< 20.96	2.29	0.12	0.017	0.19	7.06
NGC 7679	0.017139	20.34	1.75	0.60	0.1083	1.52	5.54

Note. In the columns are presented: the name of the galaxy; redshift z as reported in NED; N_H is in units of cm^{-2} (from other articles – see references at the end of this paper); photon index Γ (from other references); observed hard X-ray (2-10 keV) flux in units of 10^{-11} ergs s^{-1} cm^{-2} (from other references); the extinction-corrected flux of [OIII] λ5007 emission in units of 10^{-11} ergs s^{-1} cm^{-2} (observed $F_{[OIII]}$ is from other references); N_{ph}/N_{ion} ratio; "T" ratio.

The data in this table is taken from: Bassani et al. (1999), Bian and Gu (2006), Cappi et al. (2006), Dadina (2007), Gu and Huang (2002), Gu et al. (2006), Lumsden and Alexander (2001), Moran et al. (1996), Mulchaey et al. (1994), Panessa and Bassani (2002), Panessa et al. (2007), Polletta et al. (1996), Shu et al. (2006), Tran (2003), Wang and Zhang (2007).

We have used from Wang and Zhang (2007) the empirical relation $M_{BH} - \sigma$ to estimate the mass of the central massive black hole:

$$M_{BH} = 1.35 \times 10^8\, M_\odot\, (\sigma / 200 \text{ km s}^{-1})^{4.02},$$

and Eddington ratio

$$(L_{Bol}/L_{Edd}) = 0.1 \left(\frac{L_{Bol}}{1.4\times10^{44}\,\text{erg.s}^{-1}}\right)\left(\frac{M_{BH}}{10^7\,M_\odot}\right)^{-1},$$

where bolometric luminosity is $L_{Bol} = 30\, L_{2\text{–}10keV}$ (Panessa et al. 2006); see *Table 2*.

Table 2. Black hole masses and Eddington ratios for galaxies with meaured stellar velocity dispersions

Name	σ [km s^{-1}]	M_{BH} [$M_\odot$]	Log (L_{Bol}/L_{Edd})
NGC 2992	166.1	6.39851×10^7	-2.18
NGC 3147	261.3	3.95452×10^8	-3.65
NGC 3660	95	6.77083×10^6	-1.67
NGC 3941	168.7	6.81076×10^7	-5.63
NGC 4472	291.1	6.1044×10^8	-5.54
NGC 4501	160.9	5.63052×10^7	-4.33
NGC 4565	136.0	2.86431×10^7	-4.81
NGC 4579	154.4	4.77041×10^7	-3.12
NGC 4594	241.1	2.86171×10^8	-4.27
NGC 4698	132.7	2.59498×10^7	-3.58
NGC 5033	131.4	2.49429×10^7	-3.03
NGC 5929	120.6	1.76689×10^7	-2.67
NGC 6251	310.7	7.93241×10^8	-4.44

Note. In this table are listed: the name of the galaxy; σ – the stellar velocity dispersion of the galaxies (from data archive LEDA); M_{BH} – the black hole mass; the Eddington ratios (L_{Bol}/L_{Edd}).

The unabsorbed Seyfert 2 galaxies are divided into two sub-classes: unabsorbed non–HBLR Seyfert 2 and HBLR Seyfert 2 galaxies. There is a critical value of the Eddington ratio 10^{-3} (the thin line on the *Fig. 1*), below which there is no HBLR (Nicastro et al. 2003). But when the Eddington ratio is $\geq 0.2 - 3$, the broad lines also disappear.

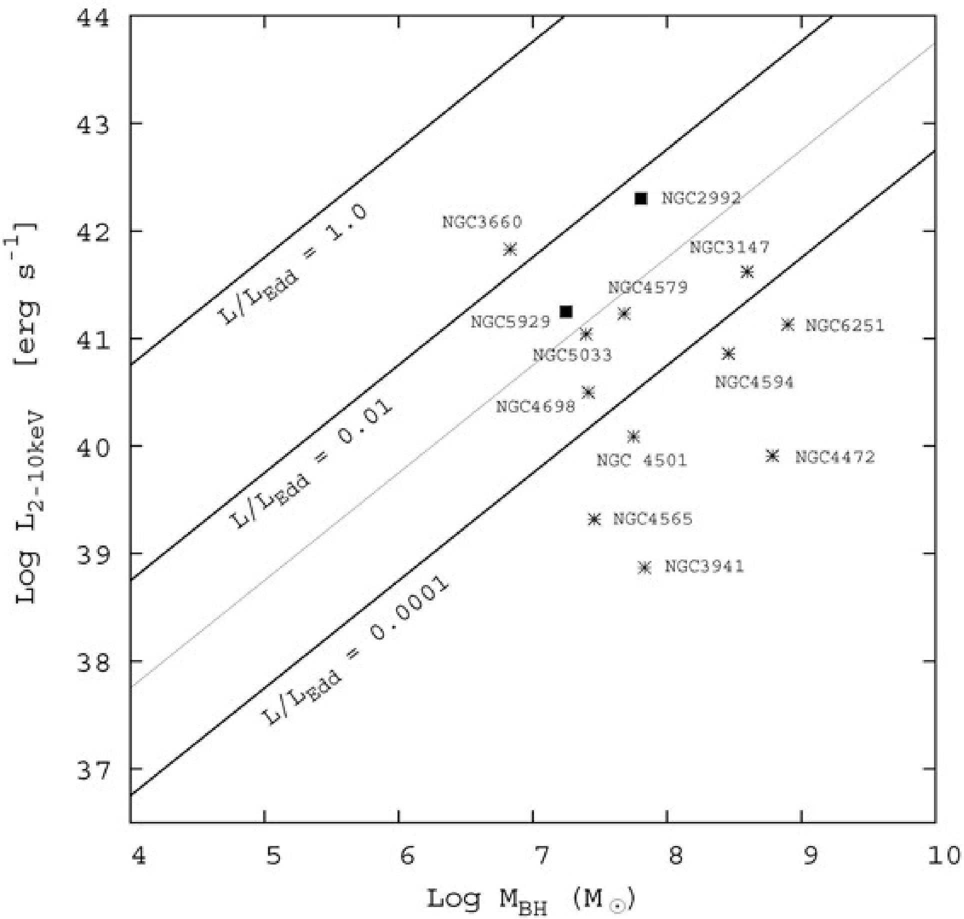

Figure 1: The relation between the mass of the central massive black hole and luminosity $L_{2–10keV}$. The objects which have polarized broad lines are marked with squares on the figure and they are between the two critical values of the Eddington ratio.

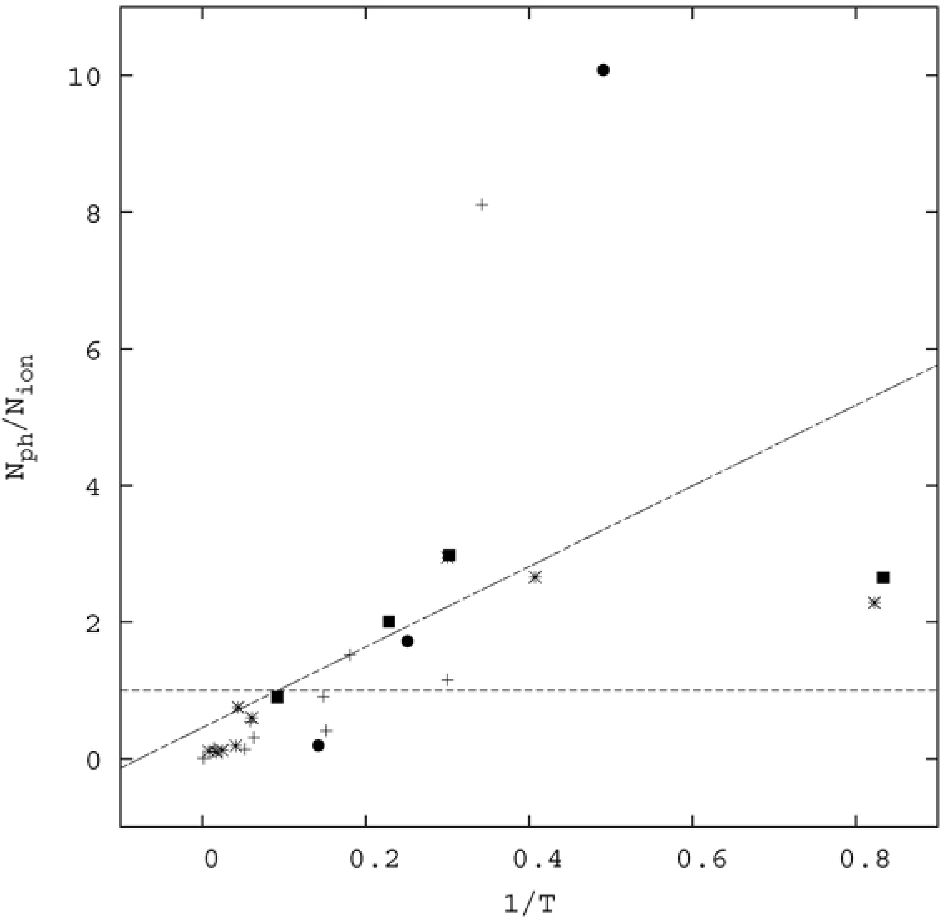

Figure 2: The relation between "T" ratio (as a good indicator of nuclear obscuration) and N_{ph}/N_{ion} ratio. The two indicators have similar properties. The slanted line is a linear approximation between them. The horizontal line ($N_{ph}/N_{ion} = 1$) shows the boundary between the objects with hidden AGN source ($N_{ph}/N_{ion} > 1$) and these with non – hidden AGN source ($N_{ph}/N_{ion} < 1$). N_{ph}/N_{ion} is an anisotropy parameter. The objects which have polarized broad lines are marked with squares on the figure; these without polarized broad lines are shown with circles; asterisks denote the galaxies, which are non–HBLR Seyfert 2, because they are beyond the two boundaries for the Eddington ratio; the unabsorbed galaxies, which are unspecified about existence of a HBLR are marked with pluses.

The mean value of the log T are –0.087±0.145 and –0.342±0.217 for Seyfert 2 galaxies with and without HBLR, respectively (Shu et al. 2006).

3. CONCLUSIONS

Our sample of 27 nearby unabsorbed Seyfert 2 galaxies contains only 4 HBLR objects. These four objects have polarized broad lines. In *Fig. 2* they have N_{ph}/N_{ion} > 1, therefore they possess a hidden AGN source.

On the other hand, the Eddington ratio L_{Bol}/L_{Edd} is a good criterion for presence of a HBLR. We have estimated the Eddington ratios for two of these four objects (for which the velocity dispersions are available) and they occupied the area with $0.001 < (L_{Bol}/L_{Edd}) \leq 0.2$. The other objects shown in the *Fig. 1*, are without HBLR, according to the theory.

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