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SEYFERT GALAXIES WITH CIRCUMNUCLEAR/NUCLEAR STARBURSTS

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RESUMEN

En este artículo, presentamos nuestros resultados preliminares de galaxias Seyfert con *starburst* circumnuclear/nuclear. Hemos buscado la literatura reciente y hemos encontrado 76 galaxias activas con evidencia de actividad starburst nuclear, de las cuales 16 son Seyfert 1, 51 Seyfert 2, y 9 LINERs. Después de estudiar las 51 Seyfert 2, encontramos que aquellas Seyfert 2 con núcleo Seyfert 1 oculto, tienen propiedades infrarrojo-radio similares a las galaxias Seyfert 1, y son diferentes de las Seyfert 2 "verdaderas" sin núcleo Seyfert 1 oculto. Estas últimas son similares a las galaxias starburst.

ABSTRACT

In this paper, we present our preliminary results on Seyfert galaxies with circumnuclear/nuclear starburst(SB) activity. We have searched the recent available literature and found 76 active galaxies with clear evidence of nuclear SB activity, among which 16 are Seyfert 1s, 51 Seyfert 2s, and 9 LINERs. After studying the 51 Seyfert 2s, we find that those Seyfert 2s with hidden Seyfert 1 nuclei, have similar Infrared-Radio properties as Seyfert 1 galaxies, and are different from "real" Seyfert 2s without a hidden Seyfert 1 nucleus. The later are similar to starburst galaxies.

Key Words: **GALAXIES : ACTIVE — GALAXIES : SEYFERT — GALAXIES : STARBURST — GALAXIES : STATISTICS**

1. INTRODUCTION

The connection between starburst(SB) activity and AGNs is one of the most important and hotly debated issues in the study of active galaxies. On the theoretical side, Norman & Scoville (1988) have suggested that the circumnuclear star-forming activity could drive gas into the innermost nuclear region to feed the central black hole. However, Terlevich (1992) and Terlevich et al. (1992) have proposed that Seyfert 2s and LINERs could be well reproduced by violent star formation in a metal-rich environment, such as in the nuclei of early-type galaxies, which has been well known as the Starburst model for AGN (see e.g. the recent review by Cid Fernandes 1997 and references therein). In a series of papers(Dultzin-Hacyan 1995, Dultzin-Hacyan & Ruano 1996, and Dultzin-Hacyan et al. 1999), it has been shown that there are several lines of evidence against the simplest formulation of a "Unified Scheme" for Seyfert galaxies, according to which, *all* Seyfert 2s have a hidden Sy 1 nucleus. In this paper, we add new evidence to the existence of two kinds of Sy 2s: The hidden Sy 1, and the "real" or "pure" Sy 2. According to these authors the difference between Sy 1 and "real" Sy 2 is relative decrease in the accretion power in the first versus a relative increase of nuclear/circumnuclear SB activity in the second.

On the other hand, more and more high-quality observations from HST and large telescopes on ground, support the presence of active star formation activity around the nuclei in dozens of Seyfert galaxies. For example, in NGC 1068, a prototype of Seyfert 2 galaxy, the circumnuclear starburst accounts for at least 50% of the whole bolometric luminosity, 81% at far UV($\sim$ 1500 Å), and 83 % at near UV ($\sim$ 2500 Å) bands(Gonzalez Delgado et al. 1997). And Heckman et al. (1997) and Gonzalez Delgado et al. (1998) have presented high resolution UV images of 4 Seyfert 2 galaxies, and found compact nuclear starburst in all of them. In Seyfert

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2 galaxies with nuclear starburst, the observed UV fluxes, as suggested by Colina et al. (1997), are dominated not by AGN, but by the young massive stars in the nuclear region.

There are several ways to detect star-forming activities in Seyfert galaxies (Wilson 1987). Narrow-band Hα imaging (Evans et al. 1996, Gonzalez Delgado et al. 1997), high-resolution radio continuum mapping(Forbes & Norris 1998), high S/N spectroscopy on central region and using stellar population synthesis technique (Schmitt et al. 1999, Boisson et al. 2000, and Jimenez-Benito et al. 2000), the shape of the IRAS spectra, and infrared(IR) spectroscopics searching for absorption lines from red supergiants (Terlevich et al. 1990, Oliva et al. 1995).

In order to study the role of starburst in Seyfert galaxies and the connection between starburst and AGNs, we collect all active galaxies with circumnuclear and/or nuclear starburst as completely as possible from the recent literature, which are listed in Table 1.

This paper is organized as follows. In Section 2, we present the basic information of our sample of 76 active galaxies with circumnuclear/nuclear starburst, and the IR and radio properties of 51 Seyfert 2 galaxies are presented and discussed in Section 3. Finally, Section 4 summarizes our main results.

2. THE SAMPLE OF ACTIVE GALAXIES

From the recent literature, we collect the active galaxies with the clear evidence of nuclear and/or circumnuclear starburst activities, such as nuclear star-forming rings, spectroscopic signature (high order Balmer absorption lines, Wolf-Rayet features) of young massive stars, etc, and find 76 such active galaxies, which are presented in Table 1.

Table 1 contains the list of all 76 active galaxies with increasing right ascension, which includes: galaxy name (column 1); 2000 right ascension and declination (columns 2 and 3); redshift (4) and activity type (5) from NASA/IPAC Extragalactic Database(NED); distance (6), for nearby galaxies (z $<$ 0.01), it is taken from the database of the CfA redshift survey, and for those with z $>$ 0.01, it is calculated by $V_{\rm GSR}/h_0$, where h_0 is equal to 75 km/s/Mpc; B magnitude (7) and the recessional velocities corrected to the Galactic Center ($V_{\rm GSR}$)(8) from RC3 (de Vaucouleurs et al. 1991), and finally references to evidence of starburst in column 9.

Among these 76 active galaxies, the activity types of NGC 2681 and NGC 6574 in NED are given to be "Sy", so we assign NGC 2681 to be LINER as in Veron & Veron (2000), and NGC 6574, "Sy2", as in Kotilainen et al. (2000). Following Maiolino & Rieke (1995), we take Seyfert 1 + 1.2 + 1.5 as Seyfert 1 galaxies, and Seyfert 1.8 + 1.9 + 2.0 as Seyfert 2s, so we get 16 Seyfert 1s, 51 Seyfert 2s, and 9 LINERs. Though our sample cannot be considered complete in any way, and there exists an observational bias (it is difficult to detect the nuclear starburst in Seyfert 1s), our results confirm that nuclear starburst activities are more common in Seyfert 2s than in Seyfert 1s (Gonzalez Delgado et al. 1997, Maiolino et al. 1997, and Dultzin-Hacyan et al. 1999).

In Table 2, we summarize the IRAS fluxes and 1.49 GHz radio emission from the NRAO/VLA Sky Survey (NVSS)(Condon et al. 1998), and T, the numerical index of Hubble type, incl, the inclination angle, and W20, 21-cm HI line width at 20 percent of the peak, are taken from the Lyon-Meudon Extragalactic Database (LEDA).

In the following text, we define "SS" for Seyfert 2 galaxies with Starbursting activity and "PA" for Seyfert 2s with Pure AGN activity in order to avoid confusion.

3. RESULTS

3.1. *Two types of Seyfert 2s ?*

The discovery of broad polarized Balmer lines in some Seyfert 2 galaxies (Antonucci & Miller 1985, Miller & Goodrich 1990, and Tran 1995a,b,c), leads to the now well-known standard unified model for Seyfert galaxies, where Seyfert 1 and 2 galaxies are intrinsically the same, the observed differences are just the result of varying orientation relative to the line of sight, and the broad-line region in Seyfert 2s is hidden by an obscuring dusty molecular torus whose size is around a few pc. If it were the case, there would be no statistical difference between their host galaxies. However, recent studies have indicated that the host galaxies of Seyfert 1 are different from those of Seyfert 2s, including (1) the Hubble type, Seyfert 1's is earlier than Seyfert 2's (Malkan et al. 1998, Hunt & Malkan 1999); (2) the environment, the relative densities of Seyfert 2s are 1.6 to 2.7 times higher than those of Seyfert 1s (Laurikainen & Salo 1995, Dultzin-Hacyan et al. 1999); (3) the circumnuclear

Fig. 1. Distribution of Seyfert 2 galaxies with nuclear starburst in the IR diagram. Open circle represents Seyfert 2 galaxy without hidden Seyfert 1 nucleus, and filled circle for Seyfert 2 with hidden Seyfert 1 nucleus.

star-forming activity, there is more starburst activity in Seyfert 2s than in Seyfert 1s (Maiolino et al. 1997, Ohsuga & Umemura 1999); and (4) the bar percentage in Seyfert 2s is also higher than that in Seyfert 1s (Pogge 1989, Maiolino et al. 1997). All these evidence can't be explained by this simplified unified model.

On the other hand, Hutchings & Neff (1991) and Neff & Hutchings(1992) even earlier have suggested that there are two distinct types of Seyfert 2s, those with hidden Seyfert 1 nuclei and those without. During studying the origin of the ultraviolet(UV)continuum in Seyfert 2 galaxies, Heckman et al. (1995) have also suggested the possibility of two entirely different kinds of type 2 Seyfert galaxies(see also Antonucci 1993).

Among these 51 Sy 2s, there are 9 PA galaxies as indicated in Veron & Veron (2000) and 42 SS galaxies, where 8 sources with upper limits of 25 μm fluxes, so we need to use the survival analysis methods (ASURV Rev 1.2, Isobe, Feigelson & Nelson 1986) for the following statistical study. We find that the probability for these two samples (PA and SS) to be extracted from the same parent population is less than 0.0001 %, and the mean values of $s_{25\mu m}/s_{60\mu m}$ are 0.484±0.082 and 0.170±0.018 for PA and SS, respectively.

Following Hutchings & Neff (1991), we plot these 51 Seyfert 2s in Fig 1, where we show the distribution of 60 μm luminosity vs. the flux ratio of 25 μm to 60 μm. As predicted, most of them are located in the SS region. We find that there are 12 sources located in the PA region, eight of them (NGC 262, NGC 1068, NGC 1275, NGC 4507, NGC 5506, IC 3639, Mark 477 and Mark 1210) have been detected polarized broad emission lines, except IC 4995, Mark 607, NGC 5347 and NGC 7672. It is very interesting to notice that the 60 μm luminosities of these four sources are all less than 6.3 $\times 10^9$ $L_\odot$, and also less than that of those with detectable hidden BLRs, which indicate that there might also exist hidden BLRs, but too faint to be detected (David Alexander, 2000, private communication). It is consistent for NGC 7672 that according to Miller & Goodrich (1990), NGC 7672 might have hidden BLRs, but at a flux level below the detection threshold. For NGC 5347, Gonzalez Delgado & Perez (1996) have observed very-high-excitation lines, such as [Ne V], He II, [Fe VII] and [Fe X], which are photoionized by a hard AGN-like continuum. For the other two sources, IC 4995 and Mark 607, there are no spectropolarimetric observations yet. Thus, our results confirm that there might exist two distinct Seyfert 2s: one is the "pure" Seyfert 2 and the other is the hidden Seyfert 1.

3.2. *IR and Radio properties*

In order to find out the differences between PA and SS galaxies, we study their radio and IR properties. It is well known that there exists a tight relation between radio and far infrared (FIR) emission for normal, starburst and Seyfert galaxies (the later with more scatter). We define q to be the ratio of FIR to 1.49 GHz emission as in Helou et al. (1985), which is :

$$q = \log \frac{\mathrm{FIR}/3.75 \times 10^{12}\mathrm{Hz}}{S_\nu(1.4GHz)} \quad (1)$$

Where FIR $= 1.26 \times 10^{-14}(2.58 \times \mathrm{s}_{60\mu\mathrm{m}} + \mathrm{s}_{100\mu\mathrm{m}})$, $\mathrm{s}_{60\mu m}$ and $\mathrm{s}_{100\mu m}$ are IRAS fluxes at 60 μm and 100 μm, respectively. Since IRAS was taken with a fixed aperture (at 60 μm, its resolution is 1.5' × 4.75', Neugebauer et al. 1984), in general, for the most nearby galaxies, the circumnuclear starburst rings could lie outside the aperture. However, introspection of our sample shows that for the three closest galaxies in our sample: Circinus (4.2 Mpc), NGC 4945 (3.7 Mpc), and NGC 5128 (4.9 Mpc), their star-forming rings are located at about 10, 5.6 and 50 arcseconds, respectively (Marconi et al. 1994, Marconi et al. 2000a,b), which are far smaller than the IRAS aperture. And for the rest of galaxies, the distance is more than 10 Mpc, and 1.5' corresponds to larger than 4.36 Kpc. So the IRAS aperture is not a problem for our sample of galaxies.

For (radio-loud) AGN, q is less than 2.0 (Sopp & Alexander 1991), while in starburst it is around 2.21

Fig. 2. Distribution of Seyfert 2 galaxies with nuclear starburst in the diagram of ratio of FIR to radio (q) vs. the IR spectral index. The symbols have the same meaning as in Fig. 1.

(Condon et al. 1991, Forbes & Norris 1998) [3]. On the other hand, according to de Grijp et al. (1985), the spectral index between 25 μm and 60 μm, α(25,60) defined by $f_\nu \propto \nu^\alpha$, is also a powerful parameter for discriminating AGNs from starburst, with AGN-like colour, -1.5 $<$ α(25,60) $<$ 0.0. Thus, we plot 51 Seyfert 2s in the diagram q vs. α(25,60) (see Figure 2).

In Fig. 2, we define two regions: the SB region (α(25,60) $<$ -1.5 and 2.0 $<$ q $<$ 2.8) and the AGNs region (α(25,60) $>$ -1.5 and q $<$ 2.0). It is consistent with Fig. 1 in that most of SS galaxies are located in the SB region, since in these galaxies, both the FIR and radio emissions are dominated by star-forming activities (Sopp & Alexander 1991, Roy et al. 1998).

There are eight galaxies in the upper-left AGNs region, seven of them are Seyfert 2s with hidden Seyfert 1 nuclei (NGC 262, NGC 1068, NGC 1275, NGC 4507, NGC 5506, Mark 477 and Mark 1210). The only one without detection of hidden BLRs is NGC 3393, which might be due to the huge amount of obscuring matter in the line of sight ($N_H > 10^{25} cm^{-2}$, Bassani et al. 1999), and recently, Cooke et al. (1997) report that they have detected the broad emission lines, so it might contain a Seyfert 1 nucleus in the center. There is also one exception with the obscured Seyfert 1 nucleus but lying outside the AGNs region, which is IC 3639. But it is located very nearby. For four galaxies with possible weak hidden BLRs as indicated in Fig. 1, there is no 1.49GHz observation data for IC 4995, NGC 7672 is much closer to the AGNs region, and the other two sources (NGC 5347 and Mark 607), due to the weakness of the hidden Seyfert 1 nuclei and the presence of nuclear starburst, they locate neither in the AGNs region nor the starburst region. There is one galaxy (NGC 4639) to the right side of SB region, which has the largest FIR excess, and needs further consideration. It is shown that these galaxies have smaller q, which means that they have a radio excess, which might be related to the central AGN (Roy et al. 1998).

It indicates again that SS galaxies have similar properties as starburst galaxies, while PA galaxies are similar to Seyfert 1 galaxies.

4. CONCLUSIONS

We have collected 76 active galaxies with circumnuclear or nuclear star-forming activities, among which, 16 are Seyfert 1s, 51 Seyfert 2s and 9 LINERs. After studying their IR and radio properties of 51 Seyfert 2s, we confirm that there are two distinct types of Seyfert 2 galaxies, those with hidden Seyfert 1 nuclei share similar properties with Seyfert 1s, and those without, are similar to Starburst galaxies.

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[3] Sopp & Alexander (1991) have shown that in the case of radio-loud AGN, q is less than 2 while Condon et al. (1991) have suggested that "monsters" span a wide range in q values. Monsters in radio-selected samples generally have q $<$ 2 and can be easily recognized. Most recently, Ji et al. (2000) have used q to study LINERs, and found that the AGN- and starburst-supported LINERs can be distinguished by their FIR-to-radio ratio.

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TABLE 1

ACTIVE GALAXIES WITH CIRCUMNUCLEAR/NUCLEAR STARBURSTS

Galaxy Name	α(2000)	δ (2000)	z	Type	Dist[a]	B_T^0	V_{GSR}	Ref[b]
Mark 334	00:03:09.6	+21:57:36.6	0.02196	Sy1.8	90.2		6763	GD97
NGC 262	00:48:47.1	+31:57:25.1	0.01503	Sy2	62.3	13.94	4669	GD97
IC 1816	02:31:50.9	−36:40:16.2	0.01695	Sy1	67.8	13.66	5086	Sc99
NGC 985	02:34:37.8	−08:47:15.4	0.04314	Sy1	172.2	13.89	12916	Ar99
NGC 1068	02:42:40.7	−00:00:47.8	0.00379	Sy2	14.4	9.47	1144	GD97
NGC 1097	02:46:19.1	−30:16:28.0	0.00425	Sy1	14.5	9.92	1255	St96a
NGC 1144	02:55:12.2	−00:11:00.8	0.02885	Sy2	115.3	13.21	8646	Gao97
Mark 1066	02:59:58.6	+36:49:14.3	0.01202	Sy2	49.4	13.04	3705	GD00
NGC 1275	03:19:48.2	+41:30:42.1	0.01756	Sy2	71.5		5362	Pr87
NGC 1326	03:23:56.4	−36:27:51.6	0.00454	LINER	16.9	11.39	1244	St96b
Mark 607	03:24:48.7	−03:02:32.7	0.00906	Sy2	35.7		2674	Sc99
NGC 1365	03:33:36.4	−36:08:25.5	0.00546	Sy1.8	16.9	9.93	1541	Fo98
NGC 1386	03:36:45.4	−35:59:57.0	0.00290	Sy2	16.9	12.12	741	Sc99
NGC 1598	04:28:33.4	−47:46:56.1	0.01712	LINER	65.9	13.44	4939	St96b
NGC 1672	04:45:42.1	−59:14:56.9	0.00450	Sy2	14.5	10.25	1155	de99
NGC 1667	04:48:37.1	−06:19:11.9	0.01517	Sy2	59.5	12.41	4459	Fo98
NGC 1808	05:07:42.3	−37:30:45.9	0.00334	Sy2	10.8	10.45	835	Ko96
ESO 362-G08	05:11:09.0	−34:23:35.9	0.01596	Sy2	61.5	13.51	4616	Sc99
ESO 362-G18	05:19:35.8	−32:39:30.9	0.01264	Sy1.5	48.0	13.58	3603	Ts95
Mark 1210	08:04:05.8	+05:06:49.7	0.01350	Sy2	52.1	14.21	3910	St99
NGC 2639	08:43:38.1	+50:12:20.0	0.01113	Sy1.9	44.2	12.19	3315	GD97
NGC 2681	08:53:32.8	+51:18:50.0	0.00231	LINER[c]	13.3	10.88	725	GD97
NGC 2782	09:14:05.1	+40:06:49.4	0.00855	Sy1	37.3	12.01	2551	Yo99
NGC 3081	09:59:29.5	−22:49:34.6	0.00796	Sy2	32.5	12.59	2164	St96b
NGC 3147	10:16:53.6	+73:24:02.7	0.00941	Sy2	40.9	11.24	2935	La97
NGC 3185	10:17:38.5	+21:41:18.1	0.00406	Sy2	21.3	12.65	1159	GD97
NGC 3227	10:23:30.6	+19:51:54.0	0.00386	Sy1.5	20.6	11.18	1079	GD97
NGC 3393	10:48:23.4	−25:09:42.8	0.01251	Sy2	47.1	12.64	3532	Ts95
NGC 3660	11:23:32.2	−08:39:30.2	0.01227	Sy2	47.1		3529	GD97
Mark 423	11:26:48.5	+35:15:03.1	0.03227	Sy1.9	128.7	14.64	9650	Ra93
NGC 3758	11:36:29.0	+21:35:47.8	0.02985	Sy1	118.2	15.00	8865	Ra93
NGC 3783	11:39:01.8	−37:44:18.7	0.00973	Sy1	38.5	12.04	2728	Ts95
NGC 3982	11:56:27.9	+55:07:36.2	0.00370	Sy2	17.0	11.68	1184	Fo98
NGC 4303	12:21:54.9	+04:28:25.1	0.00522	Sy2	15.2	10.12	1486	Co99
NGC 4314	12:22:31.9	+29:53:43.3	0.00321	LINER	9.7	11.17	965	GD97
NGC 4321	12:22:54.9	+15:49:20.8	0.00524	LINER	16.8	9.98	1540	Kn98
NGC 4507	12:35:36.5	−39:54:33.3	0.01180	Sy2	44.3	12.28	3320	Ts95
NGC 4593	12:39:39.4	−05:20:39.3	0.00900	Sy1	39.5	11.43	2393	GD97
IC 3639	12:40:52.9	−36:45:21.5	0.01092	Sy2	41.8	12.71	3137	St99
NGC 4639	12:42:52.4	+13:15:27.2	0.00337	Sy1.8	16.8	11.85	963	GD97
NGC 4736	12:50:53.1	+41:07:13.6	0.00103	LINER	4.3	8.75	360	GD97
NGC 4945	13:05:27.5	−49:28:05.6	0.00187	Sy2	3.7	7.43	383	Co97
NGC 5128	13:25:27.6	−43:01:08.8	0.00183	Sy2	4.9	7.30	398	Ma00
NGC 5135	13:25:43.9	−29:50:02.3	0.01372	Sy2	52.8	12.37	3959	GD98

TABLE 1. *continued*

Galaxy Name	α(2000)	δ (2000)	z	Type	Dist[a]	B_T^0	V_{GSR}	Ref[b]
NGC 5194	13:29:52.4	+47:11:53.8	0.00154	LINER	7.7	8.67	551	GD97
NGC 5248	13:37:32.2	+08:53:05.9	0.00385	Sy2	22.7	10.63	1128	PR98
NGC 5347	13:53:17.8	+33:29:27.0	0.00779	Sy2	36.7	13.10	2443	GD98
NGC 5427	14:03:25.6	−06:01:42.3	0.00873	Sy2	38.1	11.73	2592	GD98
Circinus	14:13:09.3	−65:20:20.6	0.00145	Sy2	4.2	8.50	268	Co97
NGC 5506	14:13:14.9	−03:12:27.2	0.00618	Sy1.9	28.7	12.26	1782	Ma94
NGC 5643	14:32:40.7	−44:10:28.5	0.00400	Sy2	16.9	10.23	1066	Sc99
Mark 477	14:40:38.1	+53:30:16.0	0.03780	Sy2	153.5	15.23	11511	He97
NGC 5728	14:42:23.9	−17:15:11.0	0.00930	Sy2	42.2	11.72	2735	Ca96
NGC 5953	15:34:32.4	+15:11:37.7	0.00656	Sy2	33.0		2040	Co97
NGC 6221	16:52:46.7	−59:12:59.0	0.00494	Sy2	19.4	9.77	1368	Co97
NGC 6300	17:16:59.2	−62:49:11.2	0.00370	Sy2	14.3	10.20	997	Ev96
NGC 6574	18:11:51.3	+14:58:52.1	0.00761	Sy2[d]	35.0	11.79	2441	Ko00
NGC 6764	19:08:16.4	+50:55:59.6	0.00806	Sy2	37.0	12.14	2637	Bo90
NGC 6814	19:42:40.6	−10:19:24.6	0.00521	Sy1.5	22.8	11.32	1676	GD97
NGC 6810	19:43:34.2	−58:39:20.6	0.00677	Sy2	25.3	11.49	1888	Co97
NGC 6860	20:08:46.1	−61:05:55.9	0.01488	Sy1	58.5	13.21	4385	Li93
IC 4995	20:19:59.1	−52:37:19.8	0.01609	Sy2	62.1	14.08	4657	Br98
NGC 6951	20:37:14.5	+66:06:19.7	0.00475	Sy2	24.1	10.71	1645	Pe00
Mark 509	20:44:09.7	−10:43:24.5	0.03440	Sy1.2	138.4	14.41	10380	Wi88
NGC 7130	21:48:19.5	−34:57:09.2	0.01615	Sy2	64.7	12.88	4850	Co97
NGC 7177	22:00:41.3	+17:44:16.5	0.00384	LINER	18.2	11.47	1343	Di00
NGC 7214	22:09:07.6	−27:48:35.5	0.02313	Sy1.2	91.5	12.83	6865	Ra98
NGC 7213	22:09:16.2	−47:10:00.4	0.00598	Sy1.5	22.0	11.13	1767	St96b
NGC 7469	23:03:15.6	+08:52:26.4	0.01632	Sy1.2	67.4	12.64	5053	GD98
Mark 315	23:04:02.6	+22:37:27.5	0.03887	Sy1.5	160.2	14.34	12016	Wi88
NGC 7479	23:04:56.6	+12:19:22.7	0.00794	Sy2	33.9	11.22	2544	La99
NGC 7552	23:16:11.0	−42:34:59.0	0.00529	LINER	19.5	11.13	1568	Fo94
NGC 7582	23:18:23.5	−42:22:14.0	0.00525	Sy2	17.6	10.83	1551	Co97
NGC 7592	23:18:22.5	−04:24:58.5	0.02444	Sy2	99.1		7429	Ra92
NGC 7590	23:18:54.6	−42:14:21.0	0.00532	Sy2	17.3	11.46	1569	Ts95
NGC 7672	23:27:31.4	+12:23:06.4	0.01338	Sy2	57.0	14.31	4274	GD97

[a]: in unit of Mpc; [b]: References for evidence of starburst: Ar99 = Arribas et al. 1999; Bo90 = Boer et al. 1990; Br98 = Bransford et al. 1998; Ca96 = Capetti et al. 1996; Co97 = Colina et al. 1997; Co99 = Colina et al. 1999; de99 = de Naray et al. 1999; Di00 = Diaz et al. 2000; Ev96 = Evans et al. 1996; Fo94 = Forbes et al. 1994; Fo98 = Forbes et al. 1998; Gao97 = Gao et al. 1997; GD97 = Gonzalez Delgado et al. 1997; GD98 = Gonzalez Delgado et al. 1998; GD00 = Gonzalez Delgado 2000; He97 = Heckman et al. 1997; Kn98 = Knapen 1998; Ko96 = Kotilainen et al. 1996; Ko00 = Kotilainen et al. 2000; La97 = Laurent et al. 1997; La99 = Laine et al. 1999; Li93 = Lipari et al. 1993; Ma00 = Marconi et al. 2000b; Ma94 = Maiolino et al. 1994; Pe00 = Perez et al. 2000; Pr87 = Pronik & Metik 1987; PR98 = Perez-Ramirez & Knapen 1998; Ra92 = Rafanelli et al. 1992; Ra93 = Rafanelli et al. 1993; Ra98 = Radovich et al. 1998; Sc99 = Schmitt, Storchi Bergmann & Cid Fernandes, 1999; St96a = Storchi Bergmann et al. 1996a; St96b = Storchi Bergmann et al. 1996b; St99 = Storchi Bergmann 1999; Ts95 = Tsvetanov & Petrosian 1995; Wi88 = Wilson 1988; Yo99 = Yoshida et al. 1999. [c] is from Veron & Veron (2000); [d] is from Ko00.

TABLE 2

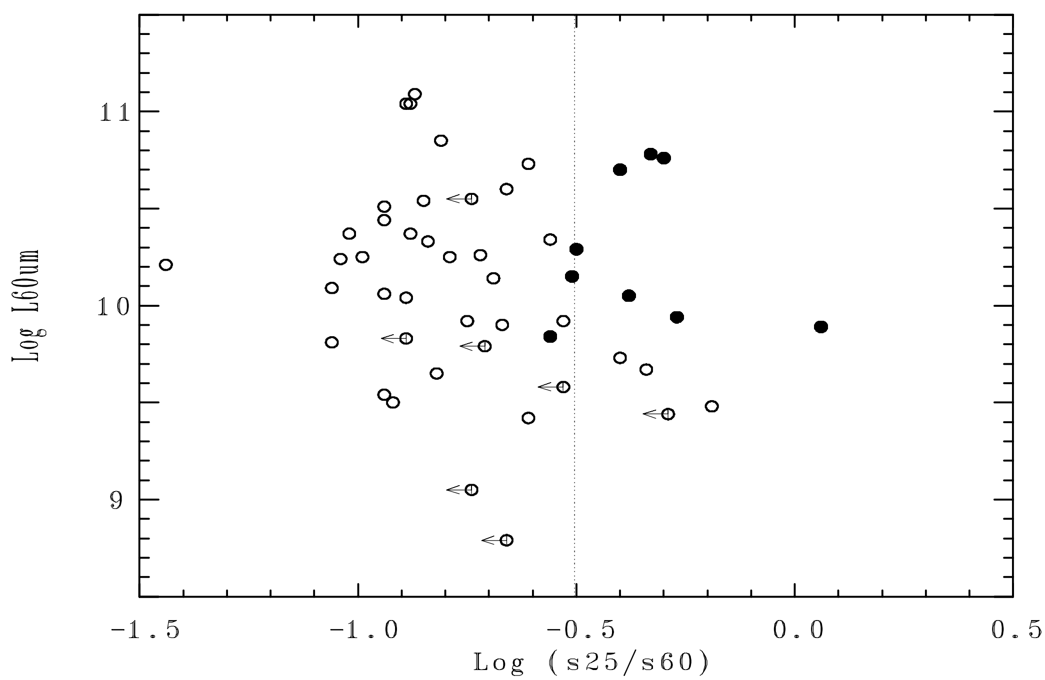
BASIC DATA FOR ACTIVE GALAXIES

Galaxy Name	T	incl	W20	s12[a]	s25[a]	s60[a]	s100[a]	f149[b]
Mark 334	4.9	44.6	377.4	0.25L	1.05	4.26	4.51	28.4
NGC 262	-0.5	15.9	90.4	0.31	0.77	1.44	1.83	292.7
IC 1816	2.0	33.7		0.25L	0.42	1.42	2.39	35.1
NGC 985	9.9	27.2		0.27L	0.55	1.44	2.00	17.3
NGC 1068	3.0	31.7	299.7	38.30	86.83	185.80	240.50	4849.0
NGC 1097	3.3	48.9	398.9	1.84	5.80	45.85	83.79	250.2
NGC 1144	-4.2	70.4		0.26	0.70	5.32	11.59	155.5
Mark 1066	-1.1	54.7		0.50	2.31	10.45	13.10	100.9
NGC 1275	-2.2	52.0		0.97	3.62	7.22	8.01	22829.7
NGC 1326	-0.8	54.3	265.2	0.27	0.79	8.31	14.30	34.4
Mark 607	1.1	83.8		0.33	1.08	2.36	2.88	6.5
NGC 1365	3.2	58.2	398.7	3.21	11.09	78.15	141.50	376.8
NGC 1386	-0.8	90.0		0.50	1.44	5.89	9.92	37.8
NGC 1598	5.0	56.1		0.25L	0.21L	1.45	4.23	−−[c]
NGC 1672	3.3	33.1	276.2	1.47	4.03	34.80	69.46	−−
NGC 1667	5.0	39.7	324.2	0.38	0.67	5.85	14.67	77.3
NGC 1808	1.2	60.6	333.6	4.12	15.87	97.12	136.50	528.8
ESO 362-G08	-0.4	74.9		0.25L	0.19L	0.64	0.82	3.4
ESO 362-G18	0.1	58.7		0.25L	0.59	1.49	2.02	15.0
Mark 1210		5.8		0.55	2.09	1.84	1.51	114.9
NGC 2639	1.0	43.3		0.35L	0.39L	2.00	7.07	115.7
NGC 2681	0.4	0.0		0.35	0.59	7.07	11.40	10.2
NGC 2782	1.1	49.8	190.3	0.51	1.47	8.47	13.81	125.5
NGC 3081	-0.1	41.0	257.0	−[d]	−	−	−	5.7
NGC 3147	4.0	31.2	396.8	0.52	0.61	6.66	24.63	92.5
NGC 3185	1.0	54.2	284.4	0.25L	0.29L	1.58	3.68	5.6
NGC 3227	1.5	49.2	418.7	0.67	1.74	7.98	17.46	100.7
NGC 3393	1.1	23.7		0.25L	0.71	2.38	3.93	81.5
NGC 3660	3.9	36.8	291.9	0.26L	0.25L	1.95	4.65	14.8
Mark 423	3.0	57.6		0.28L	0.25L	1.37	2.30	14.2
NGC 3758	2.7	27.4	332.9	4.24L	0.28	1.43	2.43	11.2
NGC 3783	1.4	28.5		0.77	2.43	3.37	5.12	44.6
NGC 3982	3.1	30.5	234.3	0.48	0.84	6.92	16.00	57.7
NGC 4303	4.0	25.4	170.9	0.49L	0.61L	23.52	61.69	435.8
NGC 4314	1.0	19.3		0.25L	0.39	3.76	7.59	14.1
NGC 4321	4.0	36.8	269.5	0.79	1.31	18.23	57.63	87.1
NGC 4507	1.9	35.4		0.46	1.41	4.58	5.60	67.4
NGC 4593	3.0	47.1	366.8	0.34	0.92	2.81	6.00	4.8
IC 3639	4.0	20.3		0.65	2.30	7.20	11.14	89.0
NGC 4639	3.6	49.1	330.4	0.25L	0.31L	1.41	4.54	1.8
NGC 4736	2.5	30.1	232.4	2.78	3.48	56.07	105.20	269.9
NGC 4945	6.1	84.6	381.6	3.63	14.24	388.10	685.60	−−
NGC 5128	-2.3	50.4	555.6	11.14	14.99	171.50	337.60	−−
NGC 5135	2.3	22.5	141.4	0.67	2.48	16.18	30.83	200.5

TABLE 2. *continued*

Galaxy Name	T	incl	W20	s12[a]	s25[a]	s60[a]	s100[a]	f149[b]
NGC 5194	4.0	48.1	197.5	1.36	2.38	32.00	122.90	430.3
NGC 5248	4.0	40.9	281.7	0.96	1.49	17.70	44.00	160.3
NGC 5347	2.0	39.9	114.5	0.29	0.92	1.44	2.71	6.0
NGC 5427	5.0	38.9		0.28	0.62	4.86	16.46	86.2
Circinus	3.2	67.4	303.1	18.80	68.44	248.70	315.90	−−
NGC 5506	1.3	90.0	330.5	1.30	3.64	8.81	9.72	339.4
NGC 5643	5.0	28.8	205.4	0.86	3.35	18.71	44.19	−−
Mark 477		40.5		0.25L	0.54	1.35	1.85	60.8
NGC 5728	1.1	58.1	412.9	0.32L	0.81	8.40	15.17	70.8
NGC 5953	0.2	46.6	261.3	0.56	1.07	10.42	20.31	91.7
NGC 6221	4.8	50.2	311.4	1.49	5.27	36.32	84.50	−−
NGC 6300	3.1	54.2	326.3	0.74	2.15	14.05	40.25	−−
NGC 6574	4.0	42.5	373.6	0.92	1.67	14.48	27.82	102.2
NGC 6764	3.6	58.1	294.0	0.38	1.33	6.48	11.90	110.9
NGC 6814	4.0	11.1	97.6	0.33	0.59	5.69	18.16	51.9
NGC 6810	2.1	86.0		1.05	3.48	18.12	34.50	−−
NGC 6860	3.0	58.6		0.24L	0.35	1.05	2.58	−−
IC 4995	-2.0	57.8		0.25L	0.36	0.90	1.28	−−
NGC 6951	4.0	26.1	328.8	0.45	1.17	13.49	37.14	70.4
Mark 509		36.3		0.34	0.74	1.42	1.43	19.2
NGC 7130	1.1	23.8		0.63	2.14	16.67	26.27	190.6
NGC 7177	2.5	51.3	312.0	−	−	−	−	27.7
NGC 7214	4.4	48.7		0.25L	0.37	2.13	5.24	29.2
NGC 7213	0.9	29.6	443.9	0.63	0.74	2.56	8.63	−−
NGC 7469	1.1	48.9	386.3	1.30	5.48	26.95	35.22	181.0
Mark 315	-5.0	78.2	289.9	0.39L	0.37	1.50	2.83	22.8
NGC 7479	4.4	40.9	376.3	0.75	3.32	12.12	24.93	101.4
NGC 7552	2.4	28.2	230.6	2.98	11.96	72.93	100.90	−−
NGC 7582	2.0	68.6	382.4	1.35	6.33	48.01	72.76	−−
NGC 7592	-0.9	40.1		0.36L	1.10	8.07	10.71	76.1
NGC 7590	4.0	71.3	458.2	0.52	0.84	7.39	18.02	−−
NGC 7672	3.0	40.6		0.25L	0.28L	0.54	1.15	6.5

[a] in unit of Jy; [b] in unit of mJy; [c] without information of 1.49 GHz radio emission; [d] nondetection by IRAS.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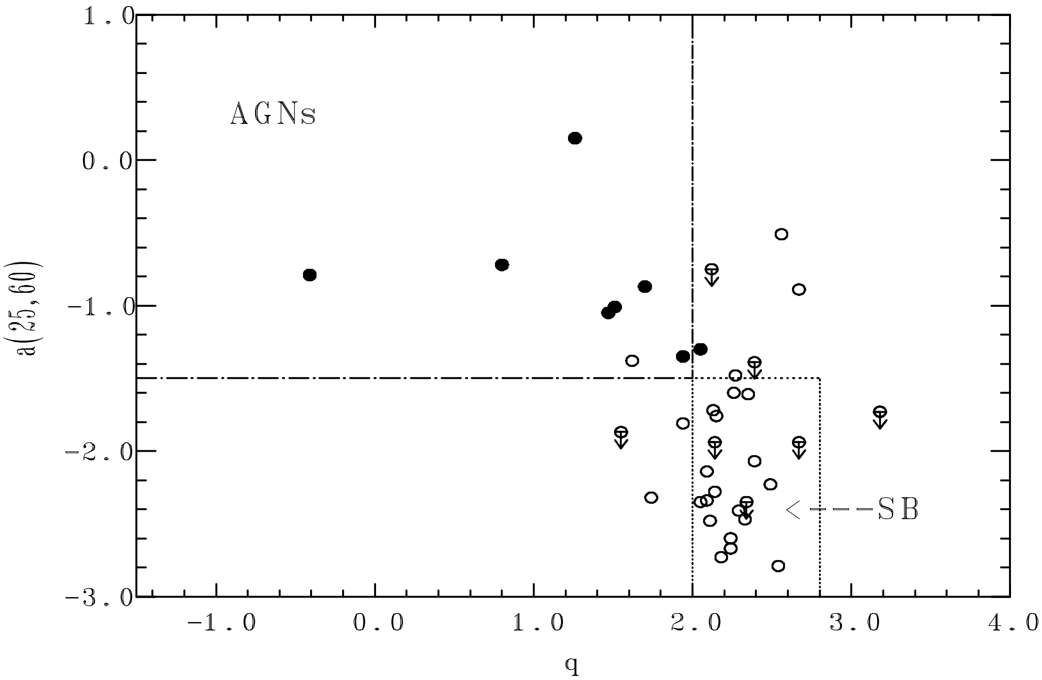

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