The host galaxy - AGN connection at low and high redshift.

Renato Falomo

INAF - Osservatorio Astronomico di Padova vicolo Osservatorio 5
35122-Padova, Italy

Abstract. The properties of radio loud active galaxies (radiogalaxies, BL Lac objects and radio loud quasar) at low and high redshift are briefly reviewed and compared. The recently derived empirical relations between central black hole mass and host properties allow one to explore the demographics of massive black hole in active galaxies. It is shown that all classes of active galaxies considered exhibit very similar host properties and, consequently, have central black holes of comparable mass. The future observing capabilities would allow the investigation of the evolution of the host galaxy properties up to \( z \sim 3 \), and will give insight into the joint formation of black holes and massive spheroids.

1. Introduction

The discovery that many and probably all apparently inactive nearby early type galaxies harbour a dormant black hole (BH) in their nuclei (e.g. Ferrarese 2002) has changed the view that distinguished active from inactive galaxies. It is also becoming clear that a full comprehension of the processes that produced the galaxies we observe today must take into account the formation of supermassive black holes in their centers. It is well assessed that the high energy phenomena observed in AGN occur in the nuclei of massive galaxies. Less understood is, however, the link between the properties of the active nucleus and those of the host galaxy. Nevertheless a number of issues are emerging from recent studies. Nuclear activity associated with radio emission is present almost exclusively on galaxies dominated by the spheroidal component. On the other hand radio quiet objects are found in both types of galaxies (bulge and disc dominated galaxies).

A detailed comparison of the host properties of various type of AGNs together with those of normal (inactive) galaxies can help to investigate the origin of the nuclear activity. In particular one can explore if and how the nuclear activity depends on the global properties (e.g. total luminosity and scale-length) of the galaxies, if there are difference in the stellar population with respect to inactive galaxies and what is the role of interactions (disturbed morphologies, close companions). Such kind of comparison can be done with different degree of details that depends in part on the distance of the sources and on the prominence of the nucleus with respect to the host galaxy. Radiogalaxies are the nearest active objects and exhibit only faint nuclei and are therefore the most...
easy AGN to study. On the other hand quasars are rare objects locally, have extremely bright nuclei and are rather more difficult to study.

The recent discovery that the BH mass ($M_{BH}$) is correlated with the properties of the bulge component of the host galaxy, which is translated into the relationships between $M_{BH}$ and the bulge luminosity (Kormendy & Richstone 1995; Magorrian et al. 1998; Richstone et al. 1998; Kormendy & Gebhardt 2001) and between $M_{BH}$ and the velocity dispersion $\sigma$ of the host galaxy (Ferrarese & Merritt 2000; Gebhardt et al. 2000; Merritt & Ferrarese 2001b) offers a new tool for evaluation of BH masses in AGNs if a reliable measurement of host galaxy luminosity or velocity dispersion is done.

While for AGN with strong emission lines (as QSO and Seyfert galaxies) the standard methods (e.g. reverberation mapping) under virial assumptions of the emitting regions can be used to derive $M_{BH}$ (see e.g. Wandel et al. 1999 and Kaspi et al. 2000), the above relations may be the only way to estimate $M_{BH}$ for active galaxies that lack of emission lines (as BL Lac objects) or that are too far (most of nearby radiogalaxies) to resolve the region of influence of the BH.

In addition the knowledge of the properties of the galaxies hosting active nuclei may also yield fundamental insight for probing the unification models of AGN. The main ingredient of the unification scenario of radio loud AGN (e.g. Urry and Padovani 1995) is that the observed properties of an object may depend on orientation effects (because of an isotropic obscuration or emission from the nucleus). Two objects with identical intrinsic properties may therefore exhibit apparent different nuclear activity because they are seen at different angles.

A simple test for this hypothesis is to compare the properties of the host galaxies (that do not depend on orientation) of various classes of AGN. Radio loud AGNs constitute only a small fraction of active galaxies but they seem to form a homogeneous class of sources whose phenomenology could be explained within the same scenario.

In this paper I’ll first review the properties of the galaxies hosting low redshift ($z<0.5$) radio loud active nuclei. This includes radiogalaxies, BL Lac objects and radio loud quasars (RLQs). Then using the relationships between BH mass and host properties I derive and compare the distribution of BH masses in the various classes of active galaxies. In the second part of this work I’ll sketch the view of quasar hosts beyond $z \sim 1$. Finally a summary of the main conclusions of this work are given together with a perspective of the future studies on high redshift sources.

2. Host galaxies of radio loud active nuclei at $z < 0.5$.

In this section I’ll briefly review the properties of the galaxies hosting active nuclei that exhibit strong radio emission. These include radio galaxies at $z < 0.2$, BL Lac objects and radio loud quasars at $z < 0.5$. In order to make the comparison of host properties as much as possible homogeneous I considered ground based data for low redshift radiogalaxies while only observations taken with HST were considered for the active galaxies with bright nuclei (BLL and RLQ). Moreover all the data presented here have been homogenized in terms of used passband, galactic extinction, k-correction and use the same cosmological
parameters ($H_0 = 50 \text{ km s}^{-1} \text{ Mpc}^{-1}$ and deceleration parameter $q_0 = 0$ are used throughout this paper).

2.1. Radiogalaxies

Nearby radiogalaxies (RGs) are the most easy active objects to study because of they are relatively abundant in the local universe and their nuclei are faint compared with the starlight emission. The largest and homogeneous optical study of nearby radiogalaxies has been presented by Govoni et al (2000). They report detailed surface photometry for 79 objects at $z < 0.12$ and extracted from two complete samples of radiosources (see Fasano et al 1996 for details). It turns out that RGs are systems dominated but the spheroidal component with average absolute magnitude $\langle M_R(\text{tot}) \rangle = -24.0$; FRI sources are hosted in galaxies $\sim 0.5$ mag more luminous than FRII galaxies.

The detailed study of the luminosity profiles showed the presence of nuclear point sources whose luminosity is about few percent that of the whole galaxy. The luminosity of this component appears correlated with the core radio power but independent of the luminosity of the host galaxy. This result has been well confirmed by HST observations where these nuclei are well visible on direct images (Chiaberge Capetti & Celotti 1999). The shape of the luminosity profile has also emphasized the frequent presence of an excess of light with respect to the bulge component which could be interpreted as due to a conspicuous halo. As far as the internal structure of these galaxies is concerned (ellipticity, isophote shape, twisting), it was shown that radio galaxies are indistinguishable from the normal (non radio) ellipticals.

As a whole, these studies have therefore shown that the optical morphological/structural and photometrical properties of radio and non-radio ellipticals are remarkably similar, suggesting that all ellipticals may go through a phase of nuclear activity lasting for a small fraction of the total life of the galaxy.

At variance with this, however, it was found that RG are on average slightly bluer and with a bluer gradient across the galaxy with respect to a sample of non radio ellipticals. This suggests a possible effect connecting the phase of radio activity with that of star formation.

It is known that the global properties of early–type galaxies are fairly well described through a three dimensional space of observables which, besides the effective radius $r_e$ and the corresponding average surface brightness $\mu$, involves the central velocity dispersion $\sigma_c$ (Djorgovski & Davis 1987, Dressler et al 1987). A full comparison between radio and non radio galaxies needs therefore to take into account also the kinematical properties.

Using photometrical and dynamical data for 73 low red-shift ($z<0.2$) radio galaxies (Bettoni et al 2001) were able to compare the Fundamental Plane (FP) of RG (see Fig 1) with that defined by inactive ellipticals (Jorgensen et al. 1996, JFK96). They showed that the same FP holds for both radio and non radio ellipticals. Radio galaxies occupy the region of the most luminous and large ellipticals. The consistency even of the kinematics properties lead further support to the idea that virtually, all ellipticals have the basic ingredients for becoming active.
2.2. BL Lac objects

Until about a decade ago the host galaxies of BL Lacs were poorly investigated and only for the nearest and most famous sources the global properties of the galaxies were known (see e.g. Ulrich 1989). The dramatic improvement of the telescope instrumentation and detectors has allowed one to perform a more systematic study of the faint nebulosity associated with BL Lacs. Using high quality imaging obtained from ground based telescopes (mainly CFHT at Hawaii, NTT at ESO Chile and NOT at La Palma) various groups have provided systematic measurements of the basic properties of the hosts (Wurtz et al 1996 Falomo 1996, Falomo and Kotilainen 1999, Nilsson et al 2002 this conference) for large samples of objects. These works have consistently shown that BL Lac hosts are virtually all massive ellipticals (average luminosity $M_R = -23.7$ and effective radius $R_e = 10$ kpc) located in poor groups (but there are some notable exceptions: PKS 0548-32, Falomo et al 1995) The few exceptions to this scheme (i.e. claims of disc dominated host galaxies) regards specific objects (e.g. AO...
0235+164, PKS0537-441, MS0205.7+3509) that were proposed to be candidates for microlensing (e.g. Stickel et al 1988a,b; Stocke Wurtz & Perlman 1995) For these sources various pro and con observations have been reported and discussed in the literature (Abraham et al 1993; Falomo Melnick & Tanzi 1992; Falomo et al 1997; see also Heidt at this conference). To the present time there is not convincing case of a BL Lac object hosted in (or superposed to) a disc dominated galaxy.

A further significant improvement to the knowledge of the properties of the galaxies hosting BL Lacs has been provided by the R band (F 702W filter) high resolution images collected by WFPC2 camera on-board of HST during a snapshot (short exposure) survey of BL Lacs (Scarpa et al 2000, Urry et al 2000). This has produced a homogeneous set of high quality images for 110 BLL from which their environments can be investigated. All (57) but three targets at z < 0.5 have been well resolved and emphasized the early type morphology of the hosts. Characterization of the host global properties indicated that they are indistinguishable from the population of luminous inactive ellipticals. These data also showed that no significant difference is present between the hosts of HBL and those of LBL in spite of the remarkable difference of their SED (Urry et al 2000).

Moreover for lower redshift (z < 0.2) objects a detailed study of isophote centering, twisting and isophote shape was performed (Falomo et al 2000). It was found that both the ellipticity and the isophotal shape distributions are similar to those of radio galaxies and radio-quiet ellipticals. This suggests that tidal interactions are very infrequent or are short-lived with respect to the nuclear activity time scale. Moreover no indication of off-centering of the galaxy isophotes with respect to the nucleus (with accuracy of ~ 0.05 arcsec) was found, meaning that the unresolved nuclear source truly sits at the center of its galaxy. This rules out the microlensing hypothesis for BL Lacs, which predicts frequent off-centering of the nucleus (Ostriker & Vietri 1990). HST imaging therefore confirm with high level of details that the hosts of BL Lacs are not different from "normal" unperturbed massive spheroidal galaxies.

2.3. Radio loud quasars

The host galaxies of low redshift (z < 0.5) quasars have been thoroughly investigated using both ground-based imaging (e.g. McLeod & Rieke 1995; Taylor et al. 1996; Percival et al. 2000) and the Hubble Space Telescope (HST; e.g. Bahcall et al. 1997; Boyce et al. 1998; McLure et al. 1999). These investigations have shown that most quasars live in galaxies at least as bright as the Schechter function’s characteristic luminosity L* (e.g. Mobasher, Sharles & Ellis 1993). While most quasar host galaxies are brighter than L*, and in many cases comparable to brightest cluster member galaxies (BCM; Thuan & Puschell 1989), some undetected or marginally detected hosts may be under-luminous. Recent morphological studies of host properties at low z (e.g. Taylor et al. 1996; Percival et al. 2000) have concluded that while RLQs are found exclusively in giant elliptical galaxies, radio-quiet quasars (RQQ) reside in both elliptical and spiral (disc dominated) galaxies. It has been suggested that the morphological type may depend on the power of the quasar, with the most luminous quasars found only in spheroidal host galaxies (Taylor et al. 1996).
Since there is not a homogeneous and large set of HST observations for RLQs, I have constructed a sample of objects from merging three different sub-sets (Bahcall et al. 1997; Boyce et al. 1998; Dunlop et al. 2001). Since the subsets have statistically indistinguishable host luminosity distributions (Treves et al 2001) we have merged these subsamples have been merged. The combined data set consists therefore of 18 objects with redshift in the range 0.158< \( z < 0.389 \), \( < z > = 0.26 \pm 0.07 \) and \( < M_R > = -24.04 \pm 0.4 \) (see also Falomo et al 2002) As in the case of BLL an elliptical model is always a good representation for the host galaxies. Although based on small (but homogeneous) samples the comparison between BL Lacs and RLQs suggests that the latter are hosted in galaxies that are systematically more luminous by \( \sim 0.5 \) magnitudes. High power nuclear activity like that observed in the RLQ sample appear therefore to occur only in the most luminous and massive galaxies and it is therefore a rare event.

3. Super massive Black Holes and host galaxies properties

There is a large consensus about the existence of supermassive black holes (SBHs) at the center of nearby inactive galaxies as well as in the nuclei of active galaxies and quasars (see e.g. Ferrarese 2002 for a recent review). A large body of data, in particular based on high resolution HST observations, is now available (see e.g. Kormendy & Gebhardt 2001) to support the presence of such massive BH using different techniques.

SBHs play an important role in the formation and evolution of massive spheroids and are also a key component for the development of the nuclear activity. In spite of this apparently ubiquitous presence of SBH in galaxies our understanding on how the galaxies and their central BHs are linked in the process of formation of the observed structures is still poorly understood (Silk & Rees 1998; Kauffmann & Helmert 2000; Adams et al. 2001).

From the observational point of view it was shown that (\( M_{BH} \)) is correlated with the bulge mass (\( M_{bulge} \)) component of the host galaxy which is translated into a relationship between \( M_{BH} \) and bulge luminosity \( L_{bulge} \) (Magorrian et al. 1998;Kormendy & Gebhardt 2001 ) and between \( M_{BH} \) and the velocity dispersion (\( \sigma \)) (Ferrarese & Merritt 2000; Gebhardt et al. 2000 ). These relationships are based on a small number (~40) of nearby galaxies for which direct dynamical measurements of \( M_{BH} \) have been secured. On the other hand, although these empirical relationships have a scatter of \( \sim 0.4 \) dex, they offer a new tool for evaluating \( M_{BH} \) of AGN provided that bulge luminosities and/or velocity dispersion be measured (e.g. McLure & Dunlop 2002 ).

Bettoni et al (2002) have derived the relations between \( M_{BH} \) and \( L_{bulge} \) and \( \sigma \) using a sample of 20 E-type galaxies in the Kormendy & Gebhardt (2001) galaxy list with measured BH masses. The two relations are:

\[
\text{Log}(M_{BH}/M_\odot) = -0.50 \times M_R - 2.97
\]

(1)

\[
\text{Log}(M_{BH}/M_\odot) = 4.55 \times \text{Log} (\sigma) - 2.27 ;
\]

(2)

The two relations were used to evaluate the mass of the BH in RGs, BL Lacs and RLQs samples discussed in the previous sections. For the sample
Figure 2. Left: Black Hole mass distribution for radiogalaxies (RG) and BL Lacs (BLL) using the relationship (see eq. 1 in the text) between $M_{BH}$ and $M_R$ (host). Right: Same as left panel but for RLQs and BLLs.

of 73 RGs a mean value (using eq. 2) $< \log(M_{BH}) >=8.66\pm0.45$ is found and a slighter higher value if host galaxy luminosities (eq. 1) are used: $< \log(M_{BH}) >=8.94\pm0.37$. The reason for this ($\sim$ a factor of 2) systematic difference is not well understood but it needs to be taken into account when comparing BH masses using different methods (see also discussion in Bettoni et al 2002).

Only for a small number of BL Lac objects the stellar velocity dispersion of the host galaxy has been measured (Falomo Kotilainen and Treves 2002; see also Kotilainen et al at this conference ). The BH mass of 7 BL Lacs derived from measurements of $\sigma$ is $< \log(M_{BH}) >=8.62\pm0.23$ while using the host galaxy luminosity of the sample of 57 objects at $z < 0.5$ imaged by HST a slightly higher value of BH mass is found $< \log(M_{BH}) >=8.76\pm0.25$ (see also Falomo Carangelo & Treves 2002).

For RLQs no measurements of the stellar velocity dispersion are available therefore $M_{BH}$ can be derived only from the luminosity of the host galaxy. Again if we consider only objects imaged by HST the derived average BH mass is $< \log(M_{BH}) >=9.05\pm0.20$. The distributions of BH masses for the three subsamples are compared in Figure 2.

It turns out thus that within a factor of two RGs, BLL and RLQs have similar BH masses but their total intrinsic nuclear luminosities are remarkably different. In addition to the higher observed nuclear/host ratio of RLQ with respect to BLL for the latter a substantial beaming factor is present ($\delta \sim 15$ see Ghisellini et al. 1998, Capetti & Celotti 1999). Both effects make the intrinsic nuclear luminosities different by a factor $\sim 100$. This implies a dramatic difference of the Eddington ratio $\xi_E = L/L_E$ where $L_E=1.25\times10^{38}\times(M_{BH}/M_\odot)$ erg s$^{-1}$ (see also O’Dowd et al 2001; Treves et al 2001). Basing on the estimated total QSO luminosity of $L_\sim 3\times10^{12}L_\odot$ (e.g. Elvis et al. 1994) and assuming BH masses of $1\times10^9 M_\odot$, it is found that RLQ may be emitting at rates of
10% or higher than their Eddington power, while BLL are always emitting at regimes that are much lower than $L_E$. Given the similarity of BH masses the key parameters distinguishing RLQs from BLL should be considered the accretion rate $\dot{M}$ (see also Cavaliere and D’Elia 2002), and the jet beaming parameter $\delta$, rather than the black hole mass.

4. Host galaxies of radio loud active nuclei at high redshift

A good knowledge of quasar host galaxies is essentially limited to $z < 1$ and it has enabled only a preliminary insight into the cosmological ($z$–dependent) quasar–host galaxy connection. This evolution should become much clearer in the redshift interval $1 < z < 3$, since $z \sim 2$ is close to the epoch of the most vigorous nuclear activity. The observed similarity of the cosmic quasar evolution with the rate of galaxy formation (e.g. Franceschini et al 1999) may represent the overall effect of a fundamental link between massive galaxies and their nuclei, that has driven their formation history.

Due to the increasing difficulty of detecting quasar hosts at high redshift only a few studies of RLQ hosts at $z > 1$ have been conducted so far. Using 4m class telescopes (e.g. Lehnert et al. 1992, 1999; Hutchings et al. 1999) the observations suggest RLQs are hosted in very luminous galaxies with possibly high star formation rates. On the other hand similar studies of RQQs at $z \sim 2.5$ (e.g. Lowenthal et al. 1995) were unable to resolve the hosts.

More recently deep, high spatial resolution NIR images of high redshift RLQs obtained either using large ground based telescopes (Falomo et al 2002) or HST (Kukula et al 2001) show a modest increase with redshift of host luminosity, which is consistent with that expected from simple passive evolution of massive spheroids. The luminosities of the high $z$ RLQs hosts ($M_H \sim -27.5$) are very similar to those of high redshift 6C RG (Eales et al. 1997). The scenario appears, however, different for RQQ hosts since HST and NICMOS imaging of 5 ($z \sim 2$) RQQs (Ridgway et al 2000) indicates their host are 1-2 less luminous than those found in RLQs.

There is also evidence that the systematic difference of host luminosity between RLQs and RQQs, already noted at low redshift (e.g. Bahcall et al. 1997), is more significant at higher redshift. This suggest a different formation and/or evolutionary history of the two types of AGN depending on whether or not they can develop radio emission.

Models of galaxy formation and evolution based on hierarchical clustering (e.g. Kauffmann & Hahnelt 2000) predict progressively less luminous host galaxies for quasars at high redshift. This seems to be in reasonable agreement with the observations of high $z$ RQQ hosts (Ridgway et al. 2000; Hutchings 1995), which may still be undergoing major mergers to evolve into the low redshift giant ellipticals. This scenario, contrasts with the results for high $z$ RLQs. Note, however, that the available data set of the properties of high redshift hosts galaxies is still very scanty and further high quality observations extended up to $z \sim 3$ are needed to properly assess the above points.
5. Conclusions and future perspectives

I have shown that at low redshift ($z < 0.5$) the galaxies hosting radio sources exhibit very similar properties. In all classes considered (RG, BL Lacs and RLQs) the hosts are luminous galaxies dominated by the spheroidal component. These objects seem to follow the behaviour of massive spheroids that are well formed at $z > 2$ and then undergo passive evolution.

Assuming that the relationship between galaxy mass (luminosity or velocity dispersion) and central black hole mass, found for nearby early type galaxies, holds also for these more distant active galaxies, the similarity of host properties translates into a similarity of $M_{BH}$. The differences in the observed nuclear properties must therefore be either in their viewing angle or/and in the level of accretion. Also a different BH spin could play a relevant role.

Further studies of the host galaxies and their nuclei require to extend the analysis to higher redshift. In particular it is important to explore, with a statistical data set, QSO hosts up to $z \sim 3$ in order to assess the host evolution around the peak of QSO activity. To pursue this goal it is imperative to gather observations with high spatial resolution and great efficiency in order to detect the faint nebulosity surrounding the bright nuclei. These requirements appear well matched by next generation instrumentation, in the near IR, that make use of adaptive optics at large ground based telescopes or with the future James Webb Space Telescope in space.

Acknowledgments. I wish to thank D. Bettoni, N. Carangelo, G. Fasano, J. Kotilainen, and A. Treves for comments and usage of unpublished data.

References

Abraham, R.G., McHardy, I.M., Crawford, C.S. 1991, MNRAS 252, 482
Adams, F.C., Graff, D.S., & Richstone, D.O., 2001 ApJ, 551, L31
Bahcall, J.N., Kirhakos, S., Saxe, D.H., & Schneider, D.P., 1997, ApJ, 479, 642
Bettoni, D., Falomo, R., Fasano, G., Govoni, F., et al. 2001, A&A, 380, 471
Bettoni, D., Falomo, R., Fasano, G. 2002, A&A, in press
Boyce, P.J., Disney, M.J., Blades, J.C., et al. 1998, MNRAS, 298, 121
Capetti, A. & Celotti, A., 1999, MNRAS, 304, 404
Chiaberge, M., Capetti, A., Celotti, A. 1999 A&A 349 77.
Djorgovski, S., Davis, M. 1987, ApJ, 313, 59
Dressler, A., Lynden-Bell, D., Burstein, D., et al. 1987, ApJ, 313, 42
Dunlop, J.S., McLure, R.J., Baum, S.A., O’Dea, C.P., & Hughes, D.H., 2001, sub MNRAS, astro-ph 0108397
Elvis, M., Wilkes, B.J., McDowell, J.C., Green, R.F., et al. 1994, ApJS, 95, 1
Falomo, R., Melnick, J., Tanzi, E.G., 1992, A&A 255, L17
Falomo, R. 1996, MNRAS, 283, 241
Falomo, R., Kotilainen, J., Pursimo, T., et al. 1997, A&A 321, 374
Falomo, R., Carangelo, N. and Treves, A. 2002, MNRAS submitted
Falomo, R., Kotilainen, J.K., Treves, A., 2002, ApJ 569, L35
Falomo, R. Pesce, J.E. and Treves A., 1995 ApJ 438 L9.
Fasano, G., Falomo, R., & Scarpa, R. 1996, MNRAS, 282, 40
Ferrarese L., Merritt D., 2000, ApJ, 539, L9
Ferrarese L., 2002, astro-ph/0203047.
Franceshini A., Ha singer G., Miami T, Aliquot D. 1999, MNRAS 310, 5
Ferrarese, L. 2002, astro-ph/0207056.
Gebhardt K., Bender R., Bower G., Dressler A., et al, 2000, ApJ, 539, L13
Ghisellini G., Celotti A., Fossati G., et al 1998, MNRAS, 301, 451
Hutchings, J.B., Crampton, D., Morris, S.L., et al 1999, AJ 117, 1109
Hutchings, J.B., 1995, AJ, 109, 928
Jorgensen, I., Franx, M., Kjaergaard, P. 1996, MNRAS. 280, 167(JFK96)
Kaspi S., Smith P.S., Netzer H., Maoz D., et al 2000, ApJ, 533, 631
Kauffmann G., Hahnelt M., 2000, MNRAS 311, 576
Kotilainen J.K., Falomo R., Scarpa R., 1998, A&A 332, 503
Kormendy J. & Richstone D., 1995, ARA&A, 33, 581
Kormendy J. & Gebhardt K., 2001, AIP conference proceedings, Vol. 586, p.363
Kukula M.J. et al., 2001, MNRAS 326, 1533
Lehnert,M.D., Heckman,T.M., Chambers,K.C., Miley,G.K., 1992, ApJ 393, 68
Lowenthal, J.D., Kook, D.C., Gunman, R. et al., 1997, ApJ 481, 673
Magorrian J., Tremaine S., Richstone D., Bender R., et al 1998, ApJ, 115, 2285
McLeod, K.K., Rieke, G.H., 1995, ApJ 454, L77
McLure R.J. & Dunlop J.S., 2002, MNRAS, 331, 795
Merritt D. & Ferrarese L., 2001b, ApJ, 547, 140
Mobasher,B., Sharples,R.M., Ellis,R.S., 1993, MNRAS 263, 560
Ostriker,J.P., Vietri,M. 1990, Nat 344, 45
Percival, W.J., Miller, L., McLure, R.J., Dunlop, J.S., 2000, MNRAS, in press
Richstone D., Ajhar E.A., Bender R., Bower G., et al 1998, Nature, 395A, 14
Ridgway,S., Heckman,T., Calzetti,D., Lehner,M. 2001, ApJ 550, 122
Scarpa R., Urry C.M., Falomo R., Pesce J. & Treves A., 2000, ApJ, 532, 740
Silk,J., Rees,M.J., 1998, A&A 331, L1
Stickel,M., Fried,J.W., Kühr,H., 1988a, A&A, 198, L13
Stickel,M., Fried,J.W., Kühr,H., 1988b, A&A, 206, L30
Taylor, G.L., Dunlop, J.S., Hughes, D.H., Robson, E.I., 1996, MNRAS 283, 930
Tresse, L., Maddox,S.J., 1998, ApJ 495, 691
Treves A., Carangelo N., Falomo R., 2001, Issues in Unification of AGNs, to be published in PASP Conference Series, astro-ph 0107129
Thuan,T.X., Puschell,J.J., 1989, ApJ 346, 34
Urry C.M., Padovani P., 1995, PASP, 107, 803
Urry C. M., Scarpa R., O'Dowd M., Falomo R., et al 2000, ApJ, 532, 816
Ulrich,M-H. 1989, in BL Lac Objects, Ed. Maraschi et al., p45.
Wandel A., Peterson B.M., Malkan M.A., 1999, ApJ, 526, 579