Host galaxies and black hole masses of low and high luminosity radio loud active nuclei.

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ABSTRACT
We investigate the host galaxy luminosities of BL Lac Objects (BLLs) and Radio Loud Quasars (RLQs) at z<0.5 imaged with the Hubble Space Telescope (HST). From a homogeneous treatment of the data we construct the host galaxy luminosity functions (HGLFs) and find that RLQ hosts are \( \sim 0.5 \) mag brighter than those of BLL: \( < M_{R>RLQ} = -24.0, < M_{R>BLL} = -23.5 \). For both classes the HGLFs exhibit a remarkably different distribution with respect to that of normal (inactive) ellipticals, with clear preference for more luminous galaxies to show nuclear activity. We make use of the black hole mass – bulge luminosity (\( M_{BH} - L_{bulge} \)) relation, derived for nearby inactive ellipticals, to estimate the central black hole mass in our sample of radio loud active galaxies. In spite of a \( \sim 2 \) order of magnitude difference of intrinsic nuclear luminosity BLL and RLQ have BH of similar mass \( ( < M_{BH}/M_{\odot}>BLL = 5.6 \times 10^{9}, < M_{BH}/M_{\odot}>RLQ = 1.0 \times 10^{9} ) \). This implies that the two types of objects are radiating at very different rates with respect to their Eddington luminosity.

Key words: RLQ and BL Lacs - active galaxies

1 INTRODUCTION
There is a general consensus about the existence of supermassive black holes (SBH) at the center of normal galaxies as well as in the nuclei of active galaxies and quasars (see e.g. the recent review of Ferrarese 2002). A large body of data, in particular based on high resolution HST observations, is now available to strongly support the presence of such massive BH.

SBHs play an important role in the formation and evolution of massive galaxies 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 structures remains unclear but several attempts of explanation have been proposed (e.g. Silk & Rees 1998; Haehnelt & Kauffmann 2000; Adams et al 2001; Burkert & Silk 2001; Merritt & Ferrarese 2001a; Balberg & Shapiro 2002).

From the observational point of view it was shown that the BH mass 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). Any theory of SBH and galaxy formation must therefore take into account and explain such observed empirical relations (e.g. Silk & Rees 1998, Haehnelt & Kauffmann 2000; Ciotti and van Albada 2001). On the other hand, although these relations have a significant scatter (\( \sim 0.4 \) in Log \( M_{BH} \)), they offer a new tool for evaluation of BH masses in various types of AGN if a reliable measurement of the host galaxy luminosity or of \( \sigma \) 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 or that are too far away (as BL Lac objects and many nearby radiogalaxies) to resolve the region of influence of the BH with present-day instrumentation. The two different approaches lead to consistent estimates of BH masses within the assumed uncertainties of the two methods (McLure & Dunlop 2002).

Given the difficulty to obtain \( \sigma \) from spectroscopy of the galaxies hosting active nuclei, only for few AGN it was possible to use \( \sigma \) to evaluate \( M_{BH} \) (Ferrarese et al. 2001, Barth et al. 2002,2003; Falomo et al. 2002,2003). On the contrary the galaxy luminosity is much easier to measure for active galaxies and can therefore be used to determine \( M_{BH} \) for larger data set.

In this paper we use the \( M_{BH} - L_{bulge} \) relation to investigate and compare the BH mass distribution of a sample of low and high luminosity radio-loud AGNs (BL Lacs and RLQs respectively). Both classes are found to reside in massive giant ellipticals (Urry et al. 2000; Dunlop et al. 2001), which makes them rather...
homogeneous for such kind of analysis. To ensure uniformity of the results we have considered only objects at \( z \leq 0.5 \) and that have been imaged by HST. This allows us also to better constrain their host properties. In section 2 we describe our samples of BL Lacs and RLQs and compare their host galaxy luminosity functions. In section 3 we discuss the relation and derive the central black hole mass for each object. Finally in section 4 we discuss our findings comparing with recent results on radiogalaxies. In our analysis H\(_{0}\)=50 Km s\(^{-1}\) Mpc\(^{-1}\) and \( \Omega_0=0 \) were used.

2 LUMINOSITY OF THE HOST GALAXIES

We have collected host galaxy data for BL Lacs and RLQs at \( z \leq 0.5 \) imaged by HST with the WFPC2 and have constructed a homogeneous dataset of the host galaxies luminosities. This yields a sample 57 BL Lacs and 18 RLQs that represent, respectively, low and high luminosity radio loud active galaxies.

Since most of the observations were obtained in the F702W and F675W filters we converted all HST magnitudes into R Cousins band (Holtzman et al. 1995). In the few cases where the filters F555W, F606W were used we applied a color correction V-R = 0.61 for the elliptical host galaxies (Fukugita et al. 1995). Absolute magnitudes have been k-corrected following Poggianti (1997) prescriptions and corrected for galactic reddening using the Bell Lab Survey of neutral hydrogen N\(_{\text{H}}\) (Stark et al. 1992) with the conversion logN\(_{\text{H}}\)/E(B-V)=21.83 cm\(^{-2}\) mag\(^{-1}\) (Shull & van Steenberg 1985) assuming a total-to-selective extinction A\(_{\text{V}}\)=2.3E(B-V) (Cardelli, Clayton & Mathis 1989). Since the objects are distributed over a significant redshift interval we have also applied a correction to set the host galaxy luminosity to present epoch assuming a passive stellar evolution for massive ellipticals (Bressan et al. 1994). This correction (\( \Delta m \sim -0.2 \)) allows us to properly use the \( M_{\text{BH}} - L_{\text{bulge}} \) relations which refers to local galaxies. In the following \( M_R \) represents the host galaxy absolute magnitude including all correction terms specified above.

2.1 The BL Lac Objects sample

The HST snapshot image survey of BL Lacs (Urry et al. 2000, Scarpa et al. 2000) has provided a homogeneous set of 110 short exposure high resolution images through the F702W filter. From this we have extracted all resolved objects at \( z \leq 0.5 \), yielding 57 sources with redshift between 0.027 and 0.495 \( (z \approx 0.20 \pm 0.11) \). The host galaxy morphology of these objects is always well described by an elliptical model (Scarpa et al. 2000). The absolute \( M_R \) magnitude for each object is reported in Table 1. The host galaxy average luminosity is \( \langle M_R \rangle = -23.49 \pm 0.5 \), roughly one magnitude brighter than the characteristic galaxy magnitude \( M_\gamma = -22.75 \) (Metcalfe et al. 1998). According to the shape of their spectral energy distribution (SED), BL Lacs are broadly distinguished into two types (see Padovani & Giommi 1995) : those the SED of which peaks at near-infrared/optical and the \( \gamma \)-ray MeV regions (low frequency peaked BL Lacs or LBL), and those that have SED peaking in the UV/X-ray and the \( \gamma \)-ray TeV energies (called high frequency peaked BL Lacs or HBL). As shown by Urry et al. 2000 the host galaxy properties of HBL and LBL Lacs are indistinguishable, and therefore the two subclasses will not be separated for this analysis.

| Objects | \( z \) | \( M_R \) | \( M_{\text{BH}} \) |
|---------|------|-------|-------|
| 0122+090 | 0.339 | -23.45 | 8.73 |
| 0145+138 | 0.124 | -22.61 | 8.31 |
| 0158+001 | 0.229 | -22.84 | 8.42 |
| 0229+200 | 0.139 | -24.47 | 9.24 |
| 0257+342 | 0.247 | -23.83 | 8.92 |
| 0317+183 | 0.190 | -23.53 | 8.77 |
| 0331+362 | 0.308 | -24.06 | 9.03 |
| 0347–121 | 0.188 | -23.02 | 8.51 |
| 0350–371 | 0.165 | -23.19 | 8.60 |
| 0414+009 | 0.287 | -24.59 | 9.30 |
| 0502+675 | 0.314 | -23.60 | 8.80 |
| 0506–039 | 0.304 | -23.53 | 8.77 |
| 0521–365 | 0.355 | -23.24 | 8.62 |
| 0525+713 | 0.249 | -24.26 | 9.13 |
| 0548–322 | 0.069 | -23.63 | 8.82 |
| 0607+710 | 0.267 | -24.10 | 9.05 |
| 0706+591 | 0.125 | -23.90 | 8.95 |
| 0737+744 | 0.315 | -24.04 | 9.02 |
| 0806+524 | 0.138 | -23.39 | 8.70 |
| 0829+046 | 0.180 | -23.64 | 8.82 |
| 0927+500 | 0.188 | -22.96 | 8.48 |
| 0958+210 | 0.343 | -23.32 | 8.66 |
| 1011+496 | 0.200 | -23.41 | 8.71 |
| 1028+511 | 0.361 | -23.75 | 8.88 |
| 1104+384 | 0.031 | -23.15 | 8.58 |
| 1133+161 | 0.460 | -23.33 | 8.67 |
| 1136+704 | 0.045 | -22.84 | 8.42 |
| 1212+078 | 0.136 | -23.79 | 8.90 |
| 1215+303 | 0.130 | -23.66 | 8.83 |
| 1218+304 | 0.182 | -23.38 | 8.69 |
| 1221+245 | 0.218 | -22.29 | 8.15 |
| 1229+643 | 0.164 | -23.91 | 8.96 |
| 1248–296 | 0.370 | -23.81 | 8.91 |
| 1255+244 | 0.141 | -23.17 | 8.59 |
| 1407+595 | 0.495 | -24.32 | 9.16 |
| 1418+546 | 0.152 | -23.93 | 8.97 |
| 1426+428 | 0.129 | -23.54 | 8.77 |
| 1440+122 | 0.162 | -23.53 | 8.77 |
| 1458+224 | 0.235 | -23.48 | 8.74 |
| 1514–241 | 0.049 | -23.48 | 8.74 |
| 1534+014 | 0.312 | -23.93 | 8.97 |
| 1704+400 | 0.280 | -22.95 | 8.48 |
| 1728+502 | 0.055 | -22.32 | 8.16 |
| 1749+096 | 0.320 | -23.32 | 8.66 |
| 1757+703 | 0.407 | -23.26 | 8.63 |
| 1807+698 | 0.051 | -23.89 | 8.95 |
| 1853+671 | 0.315 | -24.04 | 9.02 |
| 1914+001 | 0.229 | -22.84 | 8.42 |
| 2005–489 | 0.069 | -23.63 | 8.82 |
| 2007+777 | 0.342 | -23.59 | 8.80 |
| 2143+070 | 0.237 | -23.46 | 8.73 |
| 2200+420 | 0.069 | -23.53 | 8.77 |
| 2201+044 | 0.027 | -22.51 | 8.26 |
| 2254+074 | 0.190 | -24.23 | 9.12 |
| 2326+174 | 0.213 | -23.47 | 8.74 |
| 2344+514 | 0.044 | -24.13 | 9.07 |
| 2356–309 | 0.165 | -23.06 | 8.53 |
2.2 The RLQs sample

Since there is not a homogeneous and large set of HST observations for RLQs, we have constructed a sample of 18 RLQ from the merging of three different subsets (BK: Bahcall et al. 1997 and Kirhakos et al. 1999; Bo: Boyce et al. 1998; D: Dunlop et al. 2003). Bahcall et al. 1997 and Kirhakos et al. 1999 studied 8 RLQ in the F606W and F555W filters and in the redshift range 0.158< z < 0.367; Boyce et al. 1998 reported the analysis for 5 sources with 0.223< z < 0.389 in the F702W filter. The largest subsample was investigated by Dunlop et al. (2001), who report host galaxy properties for 10 radio-loud quasars with 0.1< z < 0.25 observed in the F675W filter. As in the case of BLL, an elliptical model is always a good representation for the host galaxies. The average properties of the three subsamples are reported in Table 2. Our evaluations of M_R are consistent with absolute values reported by the quoted authors when galactic extinction, filter correction and evolution correction are taken into account. Since these subsets have statistically indistinguishable host luminosity distributions we have merged these subsamples to construct a representative sample of RLQ (see also Treves et al. 2002), taking average values for objects observed twice. The combined dataset consists of 18 objects with redshift in the range 0.158 < z < 0.389, < z > = 0.26±0.07 and < M_R >= -24.04±0.4. In Table 3 we give for each source the redshift z, the assumed galactic extinction in the R-band A_R, the host galaxy apparent magnitude R and the absolute magnitude M_R. In figure 1 we compare the redshift distributions for the RLQ and BLL samples.

| Sample | N (a) | < z > (b) | < M_R > (c) |
|--------|------|---------|---------|
| BK     | 8    | 0.26    | -23.92±0.61 |
| Bo     | 5    | 0.30    | -24.23±0.27 |
| D      | 10   | 0.22    | -24.02±0.29 |

Table 2. Average properties of three subsample of RLQs: (a) The sample (BK=Bahcall et al. 1997 and Kirhakos et al. 1999; Bo=Boyce et al. 1998; D: Dunlop et al. 2001); (b) Number of objects; (c) average redshift; (d) average absolute host galaxy magnitude.

2.3 Comparison of the host luminosity of BLL and RLQ

Both BLL and RLQ in our sample have been mostly discovered as counterparts of radio and/or X-ray sources. Therefore the objects considered here were selected on the basis of the nuclear properties, and because there is not a significant correlation between the nuclear and host galaxy luminosity (Urry et al. 2000; Percival et al. 2001; Dunlop et al. 2003), we can consider the distribution of the host galaxy luminosity unbiased by selection effects. Moreover the homogeneous treatment of the data attests a reliable comparison of host luminosity between the two classes (BLLs and RLQs). The main limitation of this comparison remains however the exiguity of the RLQ sample.

We find that the average absolute magnitude of RLQ is about 0.5 magnitude brighter than that of BLL. The difference is illustrated in figure 2 where we compare the cumulative absolute magnitude distributions of the hosts for the two samples (a KS test indicates that they are statistically different at the > 99% level). Since the two samples span slightly different redshift range we checked that this does not affect our result. If we consider a subsample of BLL with redshift distribution matched with that of RLQ (see figure 1(c)) we find < M_R >_{BLL} (matched)= -23.54±0.47 thus confirming our finding. Given the homogeneity of data analysis and the procedure for the selection of the objects we believe that this difference is not biased. We note, however, that a larger number of objects (in particular of RLQ) is required to confirm this result on a firm statistical basis.

To further compare the luminosity distributions of the host galaxies we constructed the host galaxy luminosity function (HGLF) for the two subsets of objects. To set the normalization of the HGLFs we simply assume the space density of both class of objects as derived from studies of complete samples. For BL Lacs we use the value $\Phi_0 = 10^{-5}$ Mpc$^{-3}$mag$^{-1}$ of the FR I radio-galaxies luminosity function at $M_R$=-22.8 given by Padovani and Urry (1991) under the assumption that FR I radio-galaxies are the parent...
population of BL Lacs (e.g. Urry and Padovani 1995). For RLQ, we took the value of the LF of close-by radio quiet QSO (Koehler et al 1997, Grazian et al 2000) at $M_B = -25.1$, which corresponds to the average value of the nuclear magnitude for our sources, and scaled it by a factor 10 to account for the ratio between RQQ and RLQ (e.g. Moderski et al 1998). This yields $\Phi_0 = 2.3 \times 10^{-9}$ Mpc$^{-3}$ mag$^{-1}$.

In figure 3 we show the HGLF of BLL and RLQ compared with that of inactive ellipticals (Metcalfe et al. 1998). To quantify the differences in shape of the HGLF we fitted the luminosity distributions of the host galaxies with a modified Schechter function $\Phi = K \times \Phi_S \times (L/L^*)^\beta \times \exp(-L/L^*)$, where $\Phi_S$ is the Schechter function for elliptical galaxies (Metcalfe et al. 1998): $\Phi_S = \Phi^* \times (L/L^*)^\alpha \times \exp(-L/L^*)$, assuming $\Phi^* = 8.5 \times 10^{-2}$ Mpc$^{-3}$, $\alpha = 1.2$ and $L^* = 2.25 \times 10^{48}$ erg s$^{-1}$ (Metcalfe et al. 1998). The best fit to HGLF was estimated minimizing $\chi^2$ for the function $\Phi$. We find $\beta = 2.7 \pm 0.2$ for BLLs, $\beta = 3.6 \pm 0.3$ for RLQ. The shapes of the two HGLF are somewhat different, but only at the 2-$\sigma$ level.

This suggests that a given elliptical has a probability of having a radio-loud active nucleus depending on the galaxy luminosity. Moreover one can argue that the steepness of this behavior depends on the intrinsic luminosity of the nucleus as hinted by the different value of $\beta$ for BLL and RLQ.

It turns out therefore that both types of radio loud active galaxies exhibit a remarkable different distributions with respect to normal ellipticals, with clear preference for more luminous (and massive) galaxies to show nuclear activity. This behavior disagrees with that found by Wisotzki et al. (2001) for the host galaxies of radio-quiet QSO. The shape of HGLF of the latter objects in fact appears to be consistent with that of ordinary inactive early type galaxies.

3 MASS OF THE CENTRAL BLACK HOLE

Basing on dynamical studies of nearby early type galaxies it was shown that there is a linear relation between the luminosity of the spheroidal component of a galaxy ($L_{bulge}$) and the mass $M_{BH}$ of the central black hole (e.g. Kormendy & Gebhardt 2001 and references therein). This correlation has a scatter of $\sim 0.4$ in $\log(M_{BH})$ that can be ascribed mainly to the errors of measurements of $M_{BH}$ and to the uncertainties to disentangle the bulge from the disc component of the galaxies. Nevertheless it can be used to estimate $M_{BH}$ for our objects provided that consistent and reliable host galaxy luminosities are used.

To avoid systematic effects it is important that the adopted absolute magnitude of the galaxy be homogeneous (in terms of spectral band, adopted cosmology, extinction correction, filter, etc) with that used to derive the $M_{BH} - L_{bulge}$ relation. To satisfy this requirement we used the relationship between $M_{BH}$ and $L_B$ derived by Bettoni et al. (2003) for 20 inactive ellipticals assuming the same calibrations of $M_R$ we have adopted here.

From the analysis of the inactive sample of ellipticals Bettoni et al. give

$$\log(M_{BH}/M_\odot) = -0.50 \times M_R - 3.0$$

(1)

that is used to derive $M_{BH}$ from absolute (total) magnitude $M_B$ of ellipticals ($H_0=50$ Km s$^{-1}$ Mpc$^{-1}$). This relation has rms scatter of 0.38 in $\log(M_{BH})$ and it is similar to that derived by McLure & Dunlop (2002).

Since the host galaxies in the samples considered here are all bona-fide ellipticals we used relation (1) to derive $M_{BH}$ for the two samples of radio loud AGN (BL Lacs and RLQs) and report the value for each object in table 1 and 2, respectively. The uncertainty on the estimated black hole mass is dominated by the scatter of relation (1) while the uncertainties on the host galaxy magnitude are usually smaller.

The distributions of $M_{BH}$ for the two samples are shown in Figure 4. The two classes exhibit an average difference by a factor $\sim 2$ in $M_{BH}$ as a consequence of the different average host luminosity. We find that the average values of $M_{BH}$ are $< \log(M_{BH}/M_\odot) > = 8.75 \pm 0.25$ and $< \log(M_{BH}/M_\odot) > = 9.02 \pm 0.20$ respectively for BLLs and RLQs.

A complementary method to derive BH masses is based on the relation between the BH masses and $\sigma$ of the host galaxy (Gebhardt et al. 2000 and Ferrarese et al. 2000). This has been applied to a small number of nearby BL Lac objects (Falomo et al. 2002,2003; Barth et al. 2002,2003). As shown by Falomo et al 2003 there is a good agreement in the results obtained with the two techniques.

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**Figure 2.** Comparison of the cumulative host galaxy absolute magnitude (R band) distributions of RLQ (dotted line) and BL Lacs (solid line).

**Figure 3.** The HGLF of RLQs and BL Lacs (filled points) compared with the fit (solid lines) with a modified Schechter function (see text). A slightly different value of $\beta$ is found for BLL ($\beta = 2.7$) and RLQ ($\beta = 3.6$). The dotted line is the fit to RLQ data normalized to the BLL data. The dashed curve represents the luminosity function of elliptical galaxies of Metcalfe et al. (1998).
Thus no estimates of BH mass of RLQ are available from σ because of the lack of measurements.

Wu, Liu and Zhang (2002) and Woo and Urry (2002) have derived estimates of the BH mass of BL Lacs using the $M_{BH} - σ$ relation where the latter quantity was inferred from measurements of the effective surface brightness and the effective radius of the host galaxy and by assuming these are linked to σ through the Fundamental Plane relationship. Although in principle this method could work we believe it is less accurate than the direct use of the $M_{BH} - M(\text{bulge})$ relation. In fact in addition to the uncertainty in the measured quantities ($M_{BH}$) distributions of RLQs and BLLs indicate that such kind of nuclear activity occurs preferentially (or lasts longer) in massive galaxies. The different distributions of host luminosity for BLL and RLQ may simply reflect the very large range of intrinsic nuclear luminosity (about two orders of magnitude, see below). High power nuclear activity like that observed in RLQ can occur only in the most luminous and massive galaxies and it is therefore a rare event. On the other hand, low power nuclear activity as that observed in BL Lacs (or in radio galaxies believed to be identical objects non affected by beaming effects) can be present also in galaxies with intermediate luminosities.

On the assumption that the galaxy luminosity is correlated with the central BH mass, the host galaxy luminosity can be translated into central BH masses. It turns out thus that, within a factor of two, BLL and RLQ 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 we have to take into account the fact that, while we consider RLQ basically unbeamed, for BLL a substantial beaming factor is present (δ ∼ 15 see Ghisellini et al. 1998, Capetti & Celotti 1999). The intrinsic nuclear luminosities therefore differ by about a factor 100. This implies a dramatic difference of the Eddington ratio $\xi_E = L/LE$ where $L_E = 1.25 \times 10^{38} (M_{BH}/M_\odot)$ erg s$^{-1}$ (see also O'Dowd et al 2001, 2002; Treves et al 2002). Basing on the estimated total QSO luminosity of $L \sim 3 \times 10^{42} L_\odot$ (e.g. Elvis et al. 1994) and assuming BH masses of $1-5 \times 10^9 M_\odot$, we find 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 $L_E$.

According to the unification schemes of radio loud AGN (e.g. Urry and Padovani 1995) BL Lacs are radiogalaxies the jet of which is closely oriented toward the observer. Based on arguments of number density, luminosity functions and unbeamed properties (as the extended radio luminosity or the host galaxies) the parent population of BL Lacs is likely formed by FR I radio galaxies with some contamination by FR II sources (Padovani and Urry 1990; Wurtz et al 1996; Falomo and Kotilainen 1999; Cassaro et al 1999; Urry et al 2000). Under this hypothesis the BH mass of BL Lacs ($< log(M_{BH}/M_\odot) > = 8.75 \pm 0.25$ ) and of the parent (unbeamed) objects must be identical. In figure 5 we compare the distribution of the BH mass for our sample of BL Lacs with that of low redshift radiogalaxies from the sample of Govoni et al 2000 (see also Bettoni et al 2003). The two distributions are rather similar although the most massive BH in luminous FR I radiogalaxies do not appear to have counterparts in the known BL Lacs. The average values of $M_{BH}$ are $< log(M_{BH}/M_\odot) > = 9.04 \pm 0.30$ and $< log(M_{BH}/M_\odot) > = 8.78 \pm 0.35$ for, respectively, FR I and FR II radio galaxies.

Finally we wish to note that in addition to the mass the other parameter which characterizes a black hole and that may play a relevant role in the observed phenomenology is the BH spin. It has been suggested that the spin energy is responsible for the jet emission $L_j$ and therefore for the development of the radio-emission (e.g. Blandford 2000, Dunlop et al 2003). The spin is clearly not directly measurable but it could be deduced from an estimate of $L_j$ and the BH mass using the Blandford and Znajek (1977) formula. While $L_j$ could be obtained from the spectral energy distribution (e.g. Tavecchio et al 2000, 2002), the BH mass may come through the procedures described in this work.

4 DISCUSSION

The analysis of HST images for low redshift BL Lacs and radio loud quasars has shown that for both types of active nuclei the host galaxies are very luminous ellipticals. On average they are ∼1-2 mag more luminous than the typical galaxy luminosity (M$^r_{B} \sim - 22.75$; Metcalfe et al. 1998). After homogeneous treatment of the data we also found that host galaxies of RLQ are systematically more luminous by ∼0.5 magnitudes than BL Lac hosts. Although this result does not seem to depend on the selection of the objects, a larger sample of RLQ is needed to reach a firm conclusion. We have shown that the distribution of the host galaxy luminosity exhibits a marked drop towards less luminous galaxies and that it is somewhat different for the two classes (BLL and RLQ). This
Figure 5. Black hole mass distribution of our sample of BL Lacs (top panel) compared with that of FR I (middle panel) and FR II (bottom panel) radio-galaxies studied by Bettoni et al (2003). The open histograms in the middle and bottom panels refer to the distribution of the whole sample of radio-galaxies (see text).

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