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ASSOCIATIONS BETWEEN QUASI-STELLAR OBJECTS AND GALAXIES

G. BURBIDGE AND A. HEWITT
Center for Astrophysics and Space Sciences, University of California, San Diego
AND
J. V. NARLIKAR AND P. DAS GUPTA
Tata Institute of Fundamental Research, Bombay, India, and Inter-University Centre for Astronomy and Astrophysics, Poona University Campus, Pune, India
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ABSTRACT

We present a table listing all close pairs of QSOs and galaxies that we have been able to find in a computer-aided search of the extensive QSO catalog of Hewitt and Burbidge and the bright galaxy catalog of Sulentic and Tifft, together with an extensive search of the literature. The table contains 577 QSOs and more than 500 galaxies, and includes 28 low-redshift QSOs associated with 42 galaxies with the same redshifts as the QSOs. For the remainder, $z_Q \gg z_G$, since even when no galaxy redshift has been measured, we know that for $m_G < 21$, a normal galaxy will have $z_G \leq 0.2$. The majority of the angular separations of the pairs are less than 10′, corresponding, for example, to a maximum projected linear separation for $z_G = 0.01$ of about 180 kpc ($H_0 = 50$ km s^{-1} Mpc^{-1}).

In addition to the pairs so far described, we have also looked for pairings between 3CR radio galaxies and QSOs. For most of the pairs involving a powerful radio galaxy listed in the table, the separations are in excess of 1 Mpc and must be accidental. In only seven cases are the pairs close enough that physical associations may be suspected, so that only those cases are used in our general analysis.

We show in two figures that for 300 and 278 pairs, respectively, in which $z_Q \gg z_G$, there is a large excess of pairs with separations of 2′ or less, or about 60 kpc, over the numbers expected if the configurations were accidental, thus suggesting that the pairs are physically associated.

We analyze the plot z_G against the angular separation θ for 392 pairs. In 1972, when only five close galaxy–QSO pairs had been identified from a complete sample of QSOs and bright galaxies, it was shown that θ was proportional to z^{-1}, thus adding further to the evidence for physical association. This relation was further investigated in 1980, and now, with more than 390 pairs, the relation is still present. We discuss selection effects which bear on it and show that they are not important.

Our conclusion is that there is strong evidence that normal galaxies and QSOs tend to be clustered whether or not their redshifts are the same. This result supports the earlier work showing that many bright galaxies and QSOs with large redshift are physically associated, that small redshift QSOs and galaxies with the same redshift are clustered, and also the more recent work of Webster and her colleagues showing that faint galaxies tend to be clustered around high-redshift QSOs at very small separations ($\leq 6''$).

We believe that a general rule can be stated as follows: QSOs tend to lie in the vicinity of normal galaxies much more often than is expected by chance, *whether or not* the galaxies and the QSOs have the same redshifts. This rule can be extrapolated to apply to situations in which a single high-redshift galaxy is seen apparently in interaction with a small group (triplet, quartet, quintet, etc.) of galaxies all of about the same (lower) redshift.

In the final sections we emphasize that this rule cannot be explained in terms of gravitational microlensing, because, on the one hand, there are not enough faint QSOs to explain the effect seen at comparatively large angular separations involving bright galaxies, and, on the other, there is not enough mass (and hence mass points) to explain the effect where faint galaxies are seen very close to high-redshift QSOs.

It is concluded that some part of the redshift of all classes of active nuclei is not associated with the expansion of the universe. Several possible explanations are briefly described.

Subject headings: galaxies: clustering — galaxies: redshifts — gravitational lenses — quasars — radio sources: galaxies

I. INTRODUCTION

QSOs are far rarer than galaxies. Since they have, on the average, very large redshifts ($z \simeq 1.3$), and most galaxies so far studied have redshifts which range from very small values to moderate values ($z \approx 0.3$) for some of the faintest galaxies visible on the survey plates, with very few having $z > 1$, physical associations between these two different types of objects are expected to be very rare if the redshifts of the QSOs are measures of their distances. If this is correct, then, as has been pointed out many times, in cases of close juxtaposition between a QSO and a galaxy, it may be possible to detect absorption in the spectrum of the QSO due to material in the halo of the foreground galaxy.

If some fraction of the QSOs are not at the distances measured by their redshifts but are much closer, then we may expect to find cases of genuine physical association between QSOs and galaxies with different redshifts. Such associations can be established either by finding luminous connections between galaxies and QSOs or by statistical methods. In such cases, absorption in the halo of the galaxy may or may not be detected in the spectrum of the QSO, depending on the path length in the halo and its composition and density.

It is well known that in some such cases absorption has been found. The first case known was that of 3C 232 and NGC 3067, which was one of the four pairs of 3C QSOs and bright galaxies shown by Burbidge *et al.* (1971) by statistical arguments to have separations too small to be accidental (cf. also Kippenhahn and de Vries 1974). The absorption was first detected by Boksenberg and Sargent (1978) in the Ca II H and K lines, and later at 21 cm by Haschick and Burke (1975). More recently, the VLA map of this pair at 21 cm shows that a hydrogen cloud appears to connect and envelop 3C 232 and NGC 3067 (Carilli, van Gorkom, and Stocke 1989; Burbidge 1989).

There are a number of pairs, or multiple QSOs lying very near to bright galaxies, where the redshifts of the galaxies are very different from those of the QSOs. The existence of such groupings when subjected to statistical analysis strongly suggests that some galaxies and QSOs with very different redshifts are physically associated (cf. Burbidge *et al.* 1971; Burbidge 1979; Arp 1987 and references contained therein; Sulentic 1988). There are also a number of pairs in which absorption in the spectrum of the QSO is seen at the redshift of the galaxy, thus implying that the QSO lies behind the galaxy.

There are also a number of comparatively small-redshift ($z \leq 0.4$) QSOs which have been found to have galaxies nearby at the same redshift (Stockton 1978*a*; Heckman *et al.* 1984; Green and Yee 1984; Yee 1987; Hutchings *et al.* 1984; Hutchings, Johnson, and Pyke 1988). These are usually taken as providing evidence that the redshifts of the QSOs are due to the expansion of the universe.

In order to further investigate the association between galaxies and QSOs, it is important to find and list all of the close pairings between QSOs and galaxies which can be found. In 1980, two of us published such a list, which contained 117 QSOs and 82 galaxies (Hewitt and Burbidge 1980). In the decade since then, many more close pairs have been found, while the number of QSOs with measured redshifts has now increased to more than 4000 (Hewitt and Burbidge 1987, 1989).

We give in Table 2 (at the end of this paper) an updated list of pairings which now contains 567 QSOs and more than 500 galaxies. The following section describes this table in detail. A brief glance at it is, however, sufficient to convince oneself that the prima facie evidence for the existence of close pairing of QSOs and galaxies with very different redshifts has grown over the years. There also appears to be no doubt that the number of pairs of QSOs and galaxies with the same redshifts has grown and is statistically significant.

A basic question is whether the evidence for the pairing of galaxies and QSOs with very different redshifts has also grown stronger. It is this issue that we shall examine in §§ III–V.

II. THE DESCRIPTION OF TABLE 2 AND ITS USES

The material in Table 2 has been put together using several sources as follows: Following the publication of our earlier list (Hewitt and Burbidge 1980), the Herstmonceux group (Pocock *et al.* 1984; Monk *et al.* 1986, 1988) have published three papers in which they have added to the compilation by Hewitt and Burbidge by surveying the literature. In addition to this, they surveyed the fields around a number of bright, very nearby galaxies out to large angular distances (which still in some cases correspond to linear projected distances (≤ 100 kpc). They restricted their literature search to QSOs brighter than about 17.5 mag. Their results have been incorporated in Table 2.

Next we carried out a computer search by using the Hewitt-Burbidge catalog of QSOs and the *Revised New Catalogue of Nonstellar Astronomical Objects* (Sulentic and Tifft 1973). All pairs with a separation of 10′ or less were picked out by the computer, and then each pair was looked at in detail. This gave us about 400 pairs involving comparatively bright galaxies. Included among them were a number which had been discovered earlier, many by Arp and his colleagues.

In addition, Stocke *et al.* (1987) have given a list of X-ray–emitting QSOs with large redshifts which lie close enough to moderate-redshift galaxies so that statistical arguments suggest that they are physically associated, and these are included.

Also among all of the QSOs known there is a small number which, when they were first investigated, were found to have faint galaxies nearby. We have made a careful search of all of the QSOs in our catalogs and have included all QSOs with faint companions which are listed there.

Also included in Table 2 are those QSOs whose fields have been searched for galaxies at the same redshift. Most of the QSOs involved in these studies have small redshifts. However, some studies have been made of faint galaxies close to high-redshift QSOs (cf. Green and Yee 1984). Also, studies of the galaxies near low-redshift QSOs have sometimes led to the finding of some galaxies with very different redshifts (cf. Stockton 1978*a*). The detailed imaging work (Green and Yee 1984; Hutchings *et al.* 1984; Hutchings, Johnson, and Pyke 1988) has led to many galaxies being listed. While we have tried to include in Table 2 all QSOs whose fields have been looked at, the reader is referred to the original papers when many galaxies are involved. In these latter cases, we have put in the table the statement "faint galaxies" followed by the reference number.

Finally, in order to see whether or not there are any close connections between QSOs and another class of high-redshift objects, we have compared our QSO catalog with the catalog of 3CR radio galaxies using the list of those with redshifts given by Spinrad *et al.* (1985) together with radio galaxies with unpublished redshifts which Spinrad communicated to us. There is a wide range of redshifts among the 3CR radio galaxies. Since we are concerned ultimately with pairs for which the projected linear separations are small, the pairs in this category which we list depend on the redshifts of the galaxies. In general in Table 2, we have only listed pairs with separations of 30′ or less, but for some galaxies comparatively nearby, we have listed pairs with wider angular separations.

In all cases in which a distance to the galaxy can be estimated, we have calculated from the angular separation a linear projected distance. To do this, we have used either the redshift with a Hubble constant of 50 km s^{-1} Mpc^{-1} or a distance modulus directly taken from, e.g., Sandage and Tammann (1981).

A principal reason for compiling Table 2 is to obtain an extensive list from which attempts to detect absorption can be made.

In § I we mentioned the complicated case of NGC 3067 and 3C 232. A number of other QSO–galaxy pairs have been studied for absorption, and the following QSOs in Table 2 have been found to contain absorption at the redshift of the paired galaxy: 0109+200 (Wills *et al.* 1980), 0119−046 (Junkkarinen 1989), 0151+045 (Bergeron 1988), 0235+164 (Burbidge *et al.* 1976), 0248+430 (Kuhr 1980; Junkkarinen 1989), 0446−208 (Blades, Hunstead, and Murdoch 1981), 1038+064 (Weymann *et al.* 1979), 1127−145 (Cristiani 1987), 1209+107 (Young, Sargent, and Boksenberg 1982), 1327−206 (Kunth and Bergeron 1984), 1511+103 (Foltz *et al.* 1986), 2020−370 (Boksenberg *et al.* 1980), 2128−12 (Bergeron and Kunth 1984), 2135−147 (Bergeron and Kunth 1983), and 2145+067 (Wills *et al.* 1980).

In addition, we note from the literature that there are also some cases in which absorption has been looked for and not found—for example, the work by Morton, York, and Jenkins (1986).

Broadly speaking, there are four categories of QSO–galaxy pairs listed in Table 2.

1. First, there are the pairs in which QSO and galaxy have approximately the same redshift. In all of these cases, the galaxies are faint (<17 mag).

2. Next we have a fairly large number of pairs, found mostly by studying the literature, in which a faint galaxy is seen close to a QSO with a large redshift. In many of these cases no redshift is available for the galaxy, and in some cases no estimates of magnitude either. However, the fact that the QSO has a large redshift means that there must be a redshift discrepancy in the pairs.

3. Third, we have the large number of QSO–bright galaxy pairs with $m_g \leq 15$. The majority of the galaxies have NGC numbers. Many of the pairs were originally found by Arp, but there is a large number of pairs which are new. In all of these cases, the redshifts of QSO and galaxy are very different.

4. Finally, we have included a small number of pairs involving a 3CR radio galaxy and a QSO, but since the 3CR radio galaxies are rare and are mostly at comparatively large redshifts, the separations are very wide, and, as we shall show in § V, they are not statistically significant. Only in a few special cases is it reasonable to suppose that the pairing has any physical significance. We shall return to this question in § V.

In Table 2 there are listed 577 QSOs and more than 500 galaxies. Of these, there are 29 QSOs and 42 galaxies where in each case the QSO and the neighboring galaxy or galaxies have the same redshift. That these are physical associations is not in doubt. The discussion and analysis carried out in §§ III and IV bears on the question of whether or not pairs of galaxies and QSOs with different redshifts are physically associated. Thus in these analyses we have omitted all galaxy–QSO associations with the same redshift.

A study of Table 2 also shows there is a considerable number of cases where a single QSO lies near to several galaxies with much smaller redshifts, and there are also cases in which a single galaxy with a small redshift appears to be surrounded by several QSOs with very different redshifts. In order to avoid duplication among the pairs, we have used the following criteria of selection: In the fields where there is more than one galaxy in close proximity to a QSO, we have chosen the one for which the angular separation is the least. When several QSOs lie close to one galaxy, we count each QSO–galaxy pair separately.

Included in the table are 84 pairs of QSOs and galaxies for which we have no z_G but a measured angular separation, 14 pairs in which we have a measured z_G but no measured angular separation, and 16 pairs in which a close association has been noted but neither the separation of the pair nor the redshift of the galaxy has been measured.

It is clearly very important that a program be initiated to obtain redshifts for those galaxies in Table 2 for which no redshifts are available.

III. 3CR RADIO GALAXIES AND QUASI-STELLAR OBJECTS

We briefly consider possible associations between QSOs and 3CR radio galaxies. While some of the best known QSOs were discovered because they were 3CR sources, because both this class of strong radio sources and QSOs are rare, we do not expect to find many close pairs unless they are physically associated.

This turns out to be the case. In Table 2 only 24 3CR radio galaxies with 25 QSOs are listed. This is the case even though we have allowed in the 3CR search all pairs with separations of 30′ or less, a much larger separation limit than has been used for the majority of the other pairs.

Of these pairs, 17 have angular separations which convert to projected distances of more than 1 Mpc, with about one-half having separations of at least 10 Mpc (depending on the value for q_0, which is assumed). These are obviously all accidental pairs.

The interesting cases which remain, all of which may be real physical pairs, are the following:

1. 3CR 31 (NGC 383), which has a QSO within 985″, or 480 kpc.
2. 3CR 66B, which has a BL Lac object, 3C 66A, within 390″, or 240 kpc.
3. 3CR 272.1 (NGC 4374), a member of the Virgo Cluster, which has a QSO within 158″, or 17 kpc.
4. 3CR 274 (M87), also in the Virgo Cluster, which has a QSO within 1213″, or 129 kpc.
5. 3CR 303, which has a QSO within 20″, or 82 kpc.
6. 3CR 435A, which has what we believe to be a QSO within 10″, or 140 kpc. (McCarthy, van Breugel, and Spinrad 1989, who have studied the pair 3CR 435A and 3CR 435B, have concluded that 3CR 435A is a radio galaxy, but that 3CR 435B is a foreground star with $z = 0$ occulting a second radio galaxy with $z = 0.8$. The combination of improbable events, involving the occurrence of two independent 3CR radio sources within 10″ of each other, *and also* the occultation of the optical center of one of them by a Galactic star, is too much for us to believe. It is for this reason that we include the pair in Table 2, believing that 3CR 435B is a QSO.)
7. 3CR 441, which has a QSO within 51″, or 1 Mpc.

Because these pairs have small galaxy redshifts and/or small angular separations, all of them have been used in our analyses when appropriate. However, objects 1 and 4 are not included in Figure 1 since their angular separations are more than 10′, and neither of objects 1, 2, and 7 is included in Figure 2, where the projected separation limit is 200 kpc.

In what follows we discuss the likelihood, based on the catalog of 3CR radio galaxies, that these are physical pairs. In the 3CR catalog there are about 300 radio galaxies (RGs) spread at random over about two-thirds of the sky (≈27,000 square degrees) and about 5000 QSOs so far identified over the whole sky with a surface density of about 20 per square degree at 20 mag. This means that there should be about 540,000 QSOs over that part of the sky covered by the 3CR catalog.

The objects 3CR 303, 3CR 435, and 3CR 441 are of particular interest, since in each case the close-by QSO has been found only after detailed studies of the field of the radio galaxy. For a population of objects distributed at random on the sky, we have

$$\langle n \rangle = 8.64 \times 10^{-4} \Gamma(<m) \theta^2 N ,$$

where $\langle n \rangle$ is the number of objects expected by chance to lie within θ (measured in arcminutes) of an arbitrary point, with a surface density of Γ (per square degree); N is the number of objects surveyed. If we put $\Gamma = 20$, $N = 300$, and $\theta = 1$, we get $\langle n \rangle = 5$. Thus, to find three pairs if all of the fields of the radio galaxies had been searched would not be unlikely. However, only a fraction of them, perhaps 50, have been searched. If this is the case, $\langle n \rangle \simeq 1$, and the significance of the three cases is marginal. On the other hand, two of the three lie along the radio axis, and the third is a radio source of comparable strength only 10″ away.

We may ask how likely it is that two 3CR radio sources lie within 10″ of each other, as is the case for 3CR 435A and 3CR 435B, by chance. To determine this, we put $\theta = 1/6$, $N = 300$, $\Gamma = 1/90$; then $\langle n \rangle = 2.7 \times 10^{-6}$! Thus it is very unlikely that these two radio sources are *not* associated.

We now consider the other four pairs of 3CR radio galaxies and QSOs listed at the beginning of this section. The separations in these cases are $\theta \simeq 3', 7', 17'$, and $20'$. Using the same expression for $\langle n \rangle$, and again putting $N = 300$, and $\Gamma = 20$, we find that for $\theta = 3', 7', 17'$, and $20'$, $\langle n \rangle \simeq 4.5$, 25, 140, and 200, respectively.

These would be the expected numbers if all of the QSOs over that part of the sky containing the 3CR radio galaxies had been cataloged. Since only ~5000 are cataloged, the values of $\langle n \rangle$ must be reduced by a factor $\sim 5000/540{,}000 \simeq 10^{-2}$, so that more realistic values of $\langle n \rangle$ range from 0.05 to 2.

We have included these rather untidy and inconclusive results at the suggestion of the referee, since they may give the reader some idea of the real uncertainties involved in this part of the discussion.

Finally, in this section we wish to add a special comment about 3CR 435A and 3CR 435B (McCarthy, van Breugel, and Spinrad 1989). The object is unique in that, according to McCarthy *et al.*, the two radio sources 3CR 435A and 3CR 435B, despite their comparable radio fluxes, lie within 10″ accidentally on the sky. This peculiar feature is further compounded by the fact that the optical center of 3CR 435A is accidentally occulted by a Galactic star. This is the only way in which McCarthy *et al.* can explain the existence of three objects with very different redshifts ($z = 0$ in absorption, $z = 0.461$, $z = 0.865$, both in emission) lying within 10″ of each other, with one pair with redshifts of 0 and 0.461 being coincident. We simply do not believe that this is an accident. In our opinion, one object (with apparently two redshifts), is a QSO physically associated with a radio galaxy with $z = 0.865$. For the present we do not understand the two redshifts in a single object.

IV. EVIDENCE FOR SIGNIFICANT EXCESSES OF PAIRS OF GALAXIES AND QUASI-STELLAR OBJECTS

In an earlier analysis of the bright galaxy–QSO pairs listed in the paper of Hewitt and Burbidge (1980), Burbidge (1981) showed by studying the pairs with separations less than 10′ that there was a significant excess of QSOs around bright galaxies out to about 3′ over the numbers expected by chance, and that for QSOs farther out the effect disappears. The significance of such associations is discussed extensively by Arp (1987). Stocke *et al.* (1987) have found a similar result from a sample of X-ray–emitting QSOs (which are contained in Table 2) near faint galaxies.

With the very much larger number of pairs now available from Table 2, the effect can be tested further. To do this, we have plotted in histograms shown in Figures 1 and 2 the numbers of QSO–galaxy pairs as functions of their angular separations out to 10′, and also out to linear projected separations of 200 kpc.

The material is all taken from Table 2. As was stated earlier, we have excluded those pairs in which galaxy and QSO have the same redshifts. By restricting the separations to 10′, we have also excluded the very widely separated pairs in Table 2 which arise either because the galaxies are very close by or because the separations are so large as not to be statistically significant, as is the case for most of the 3CR radio galaxies (cf. § III.).

Figure 2 contains some of the QSOs found at large angular separations from nearby galaxies, but it excludes all of the QSO–galaxy pairs for which no galaxy redshift is available. Figure 1*a* contains 300 pairs, and Figure 2 contains 278 pairs. In every case, the redshift of the QSO is large enough so that whether or not the redshift of the galaxy is measured, we know that $z_Q \gg z_G$.

Plotting the histograms of N against θ and N against l (the linear separation) enabled us to show all of the pairs whether or not the redshifts of the galaxies have been measured, and whatever the magnitude of the galaxy is. From both histograms it is clear that there is a large excess of galaxies near to QSOs, within about 2′ in angular measure, or out to 40–60 kpc in projected metric separation.

The result shown in Figures 1*a* and 2 is exactly what was found from the earlier samples (Burbidge 1979), which involved only 73 pairs. In that paper it was shown that the number of pairs at the extreme separation of 600″ was significantly below that expected from chance juxtapositions based on the assumed surface density of QSOs.

It could be argued that the effect may be artificial where pairs have been discovered by careful searches near galaxies, especially faint ones. To see whether the effect persists, we have

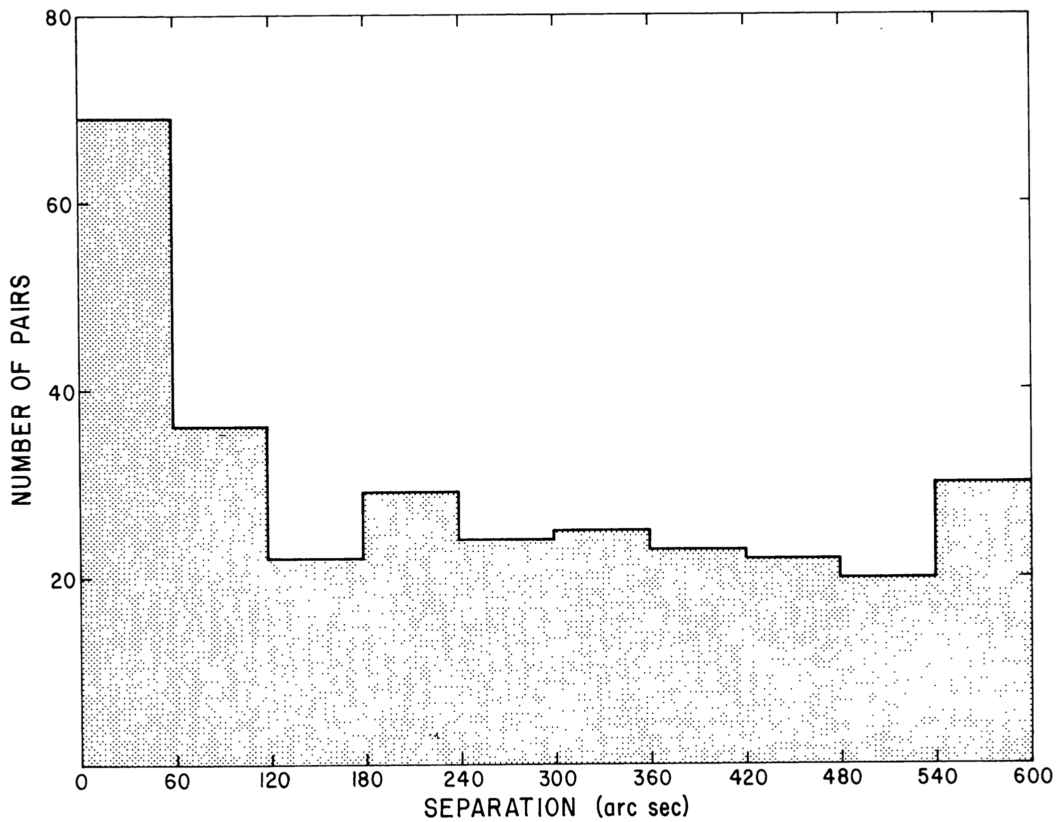

FIG. 1*a*

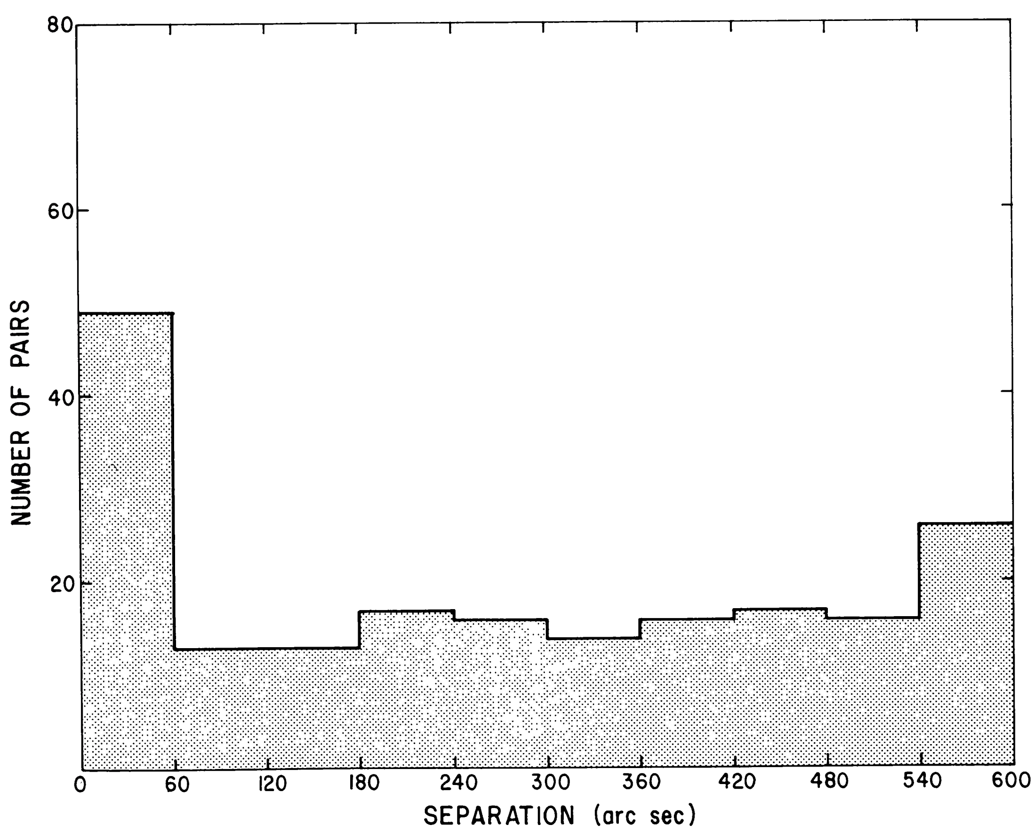

FIG. 1*b*

FIG. 1.—(*a*) Histogram of the distribution of separations of 300 QSO–galaxy pairs for $\theta \leq 600''$ taken from Table 2. (*b*) Histogram of the distribution of separations of 197 QSO–galaxy pairs for $\theta \leq 600''$ taken from Table 2. The difference between this histogram and that shown in (*a*) is that we have left out any pairs which were found by deliberate searches around galaxies.

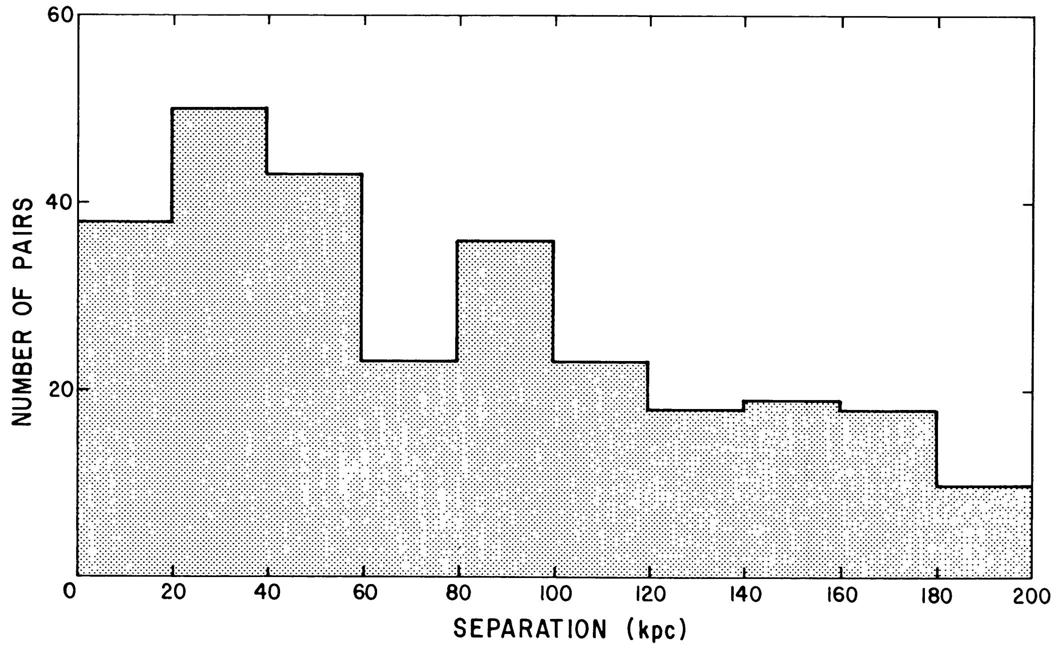

FIG. 2.—Histogram of the distribution of separations of 278 QSO–galaxy pairs for $l \leq 200$ kpc taken from Table 2.

therefore constructed in Figure 1*b* another histogram of numbers of pairs with different separations found only by the random search method (and not through deliberate searches). There are 197 such pairs, and it is clear to the eye that Figure 1*b* shows the same bunching effect at close separations as is seen in Figure 1*a*.

If, further, we eliminate from the sample all galaxies fainter than 15 mag, the number distribution does not change its character. There are now 94 pairs left, and their numbers in the angular separations lying in the ranges $\theta \leq 60''$, $60'' < \theta \leq 120''$, $120'' < \theta \leq 300''$, and $300'' < \theta \leq 600''$ are respectively 7, 8, 24, and 55 as opposed to 0.94, 2.82, 19.74, and 70.5 expected by chance. The χ^2 for this distribution is 52.9, whereas the probability of its exceeding ~ 11.3 by chance is 0.01. Thus the observed number distribution could not have arisen from a purely random distribution of QSOs and galaxies.

There is another way of looking at the bright galaxy sample from Table 2 obtained by taking only those galaxies which are brighter than 15 mag. From the number-magnitude relation for galaxies (cf. Shane 1975 and § V) we find that the surface density of galaxies brighter than 15 mag is about 0.35 per square degree.

Thus, in a circle of radius $2'$ around an arbitrary point, we expect to find a bright galaxy with a probability $\sim 12.2 \times 10^{-4}$. Assuming that each of the ~ 5000 QSOs known today is one such arbitrary point, we would expect, by chance, about six QSO–bright galaxy pairs with separation less than $2'$. In Table 2 the number of such pairs already found is 38. In all of these, the galaxy is 15 mag or brighter, and in fact the average galaxy magnitude is 13.7 mag.

These results suggest that many more galaxies will be found very close to QSOs when the fields are studied in more detail. It should be remembered that faint galaxies have not been looked for around most of the QSOs now contained in the catalogs.

The referee has pointed out that, in addition to looking at the pairs presented in this way, we could have carried out a statistical study of nearest-neighbor distances using our updated QSO catalog (Hewitt and Burbidge 1987, 1989) with the catalog of galaxies. This test has already been performed, albeit with smaller samples of QSOs, by Seldner and Peebles (1979) and by some of us (Chu *et al.* 1984; see also Nieto and Seldner 1982). Both Seldner and Peebles and Chu *et al.* obtained positive results showing statistical evidence for the association of QSOs at all redshifts with bright galaxies having $z \leq 0.05$. It is our intention to carry out a similar analysis with an even larger sample of QSOs in the future.

V. A CORRELATION BETWEEN ANGULAR SEPARATION AND REDSHIFT

In the early 1970s, Burbidge, O'Dell, and Strittmatter (1972) plotted the angular separation θ between the two members of a QSO–bright galaxy close pair against the redshift z of the galaxy, for the five known cases. On the log θ–log z plot the five points fell very close to a straight line of slope -1, implying an empirical relation

$$\theta z = \text{constant} . \qquad (1)$$

If the redshift of the galaxy is an indicator of distance, the above relation suggests a fixed metric distance (projected perpendicular to the line of sight) for all five cases. If the QSO redshifts are cosmological, such a relation cannot exist and the above result must be entirely accidental. Indeed, if the result were accidental, then discoveries of further close pairs would wipe it out.

In 1979, Narlikar (cf. Burbidge 1979) found that the log θ–log z plot for 94 QSOs close to 65 galaxies had a considerable scatter but an unmistakable trend similar to that indicated in equation (1). The slope of the best-fit line was -1.17 with a correlation coefficient of 0.68.

On the hypothesis that the two members of a close pair are physically associated with a linear separation distance l of the order of 100 kpc, some scatter is certainly to be expected in the $\log \theta$–$\log z$ plot. The scatter in θ comes partly from a scatter in l and partly from the projection effect. It is interesting, therefore, to reexamine the data as they stand today. Figures 3*a* and 3*b* respectively illustrate the θ-z distributions of data points included in the 1980 study (Hewitt and Burbidge 1980) and those added subsequently. The total is plotted in Figure 3*c*. It is clear that the trend has persisted even though the data points have multiplied by a factor of 4 since 1980, and a hundred fold since 1972.

To test the similarity of the pre-1980 and post-1980 θ-z distributions, we have used the following adaptation of the Kolmogorov-Smirnov (KS) test. In the post-1980 data there are 316 pairs. These were used to generate a "parent" probability distribution. From this distribution 1000 samples were generated by the Monte Carlo technique, each sample having 76 pairs (corresponding to the number in the pre-1980 data).[1]

The KS statistic DN can be calculated for each of the 1000 samples by the formula

$$\mathrm{DN} = \sqrt{76} \times \max_{1 \le i \le 76} \{ |\mathrm{Obs}(z_i, \theta_i) - \mathrm{Theory}(z_i, \theta_i)| \} , \quad (2)$$

where $\mathrm{Obs}(z_i, \theta_i)$ denotes the fractional number of pairs in the sample, with $z \le z_i$, $\theta \le \theta_i$. $\mathrm{Theory}(z_i, \theta_i)$ is the probability distribution given by the parent population.

Thus a distribution of the statistic DN is obtained against which one can test the value of DN obtained for the actual pre-1980 sample, which is 1.638. What is the chance that this value is exceeded in the DN distribution? This works out as 3.2%. This probability, however, increases to 6.3% if the pair NGC 1298 (galaxy) and 0317−023 (QSO) is omitted. Thus, at the 1% level ($2.56\,\sigma$) the hypothesis that the pre- and post-1980 distributions are drawn from the same population cannot be rejected.

To minimize the effect of scatter in Figure 3*c*, it is instructive to plot the median angular separation against the redshift. Accordingly, in Figure 3*d* we have binned the data points in several relatively narrow redshift bins and plotted the log of the median angular separation in a given bin against the mean of the logs of the maximum and minimum redshifts of the bin. The dotted line of slope -1 is drawn in Figure 3*d* for comparison. In Figures 3*c* and 3*d*, it is clear that the most discrepant points come from pairs where the galaxy redshifts are very small and the angular separations are very large. Nearly all of these pairs come from the studies of Pocock *et al.* (1984) and Monk *et al.* (1986, 1988), who looked for QSOs around nearby galaxies. The angular separations are so large that statistical arguments suggest that these are not real pairs but chance configurations. They are not used in constructing the histograms shown in Figures 1*a*, 1*b*, and 2.

[1] When the earlier analysis was done (cf. Burbidge 1979), 94 pairs were used because duplicates in the sense of the discussion in § II were not removed.

For the dotted line the median projected separation in a close pair corresponds to 50–100 kpc for $H_0 = 50$ km s^{-1} Mpc^{-1}. We may consider this figure as characteristic of the range of influence of the galaxy on the QSO or vice versa.

It is necessary at this stage to review the possible selection effects that might have influenced the trend apparent in the above θ-z plots. These were earlier discussed by Arp (1983). We discuss them briefly in terms of the two zones of avoidance shown by hatched sections in Figure 3*c*.

The lower section basically comes from the difficulty of detecting a QSO against the luminous disk of the galaxy. For a typical disk of radius $R \sim 10$ kpc located at redshift z, the angular radius is $\theta \simeq RH_0/cz$. Allowing for the projection effect of the galactic disk, the lower zone of avoidance may be set at

$$\theta z \le 0''.16 . \quad (3)$$

Notice that very few of the pairs lie within the above zone, and the median separation of the pairs is several times the above galactic limit.

To understand the upper zone of avoidance, consider the following scenario. Suppose a search is made for QSOs brighter than apparent magnitude m in the neighborhood of a galaxy of redshift z. Let $N(m)$ denote the surface density of QSOs brighter than magnitude m. Then the chance of finding a QSO within an angular separation θ of the galaxy is given by

$$p = \pi\theta^2 N(m) . \quad (4)$$

There are several surveys of optical QSOs down to different magnitudes. The slope $d \log N/dm$ is super-Euclidean at the bright end and progressively flattens at fainter magnitudes. Schmidt and Green (1983) find 92 QSOs over 10,714 square degrees down to an average limiting magnitude $B = 16.16$. They estimate the number per square degree at $B = 21$ to lie between 30 and 60. The average slope over the magnitude range 16.16–21, therefore, lies between 0.73 and 0.79. For the computation that follows we take this value as 0.8. Thus we have

$$\log N(m) = \alpha m + \mathrm{constant} , \quad (5)$$

with $\alpha = 0.8$. Thus, for the same value of p, the value of θ decreases as m increases.

Consider now QSOs of the same absolute magnitude M associated with galaxies observed at varying redshifts z. The apparent magnitudes of these QSOs would vary with z as

$$m = M + 5 \log z + \mathrm{constant} . \quad (6)$$

Therefore, for this class of QSOs,

$$\log N(m) = 5\alpha \log z + \mathrm{constant} , \quad (7)$$

and for a fixed p,

$$2 \log \theta + 5\alpha \log z = \mathrm{constant} . \quad (8)$$

The constant in the last equation can be calculated as follows. Set $N(m) = 20$ per square degree for $m = 20$, and calculate θ

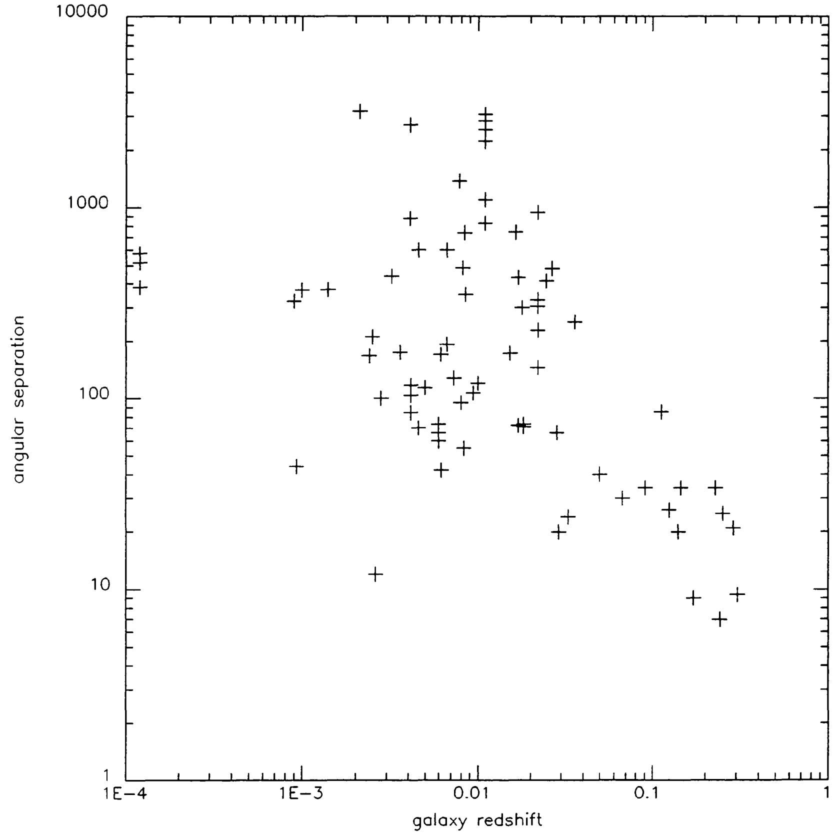

FIG. 3*a*

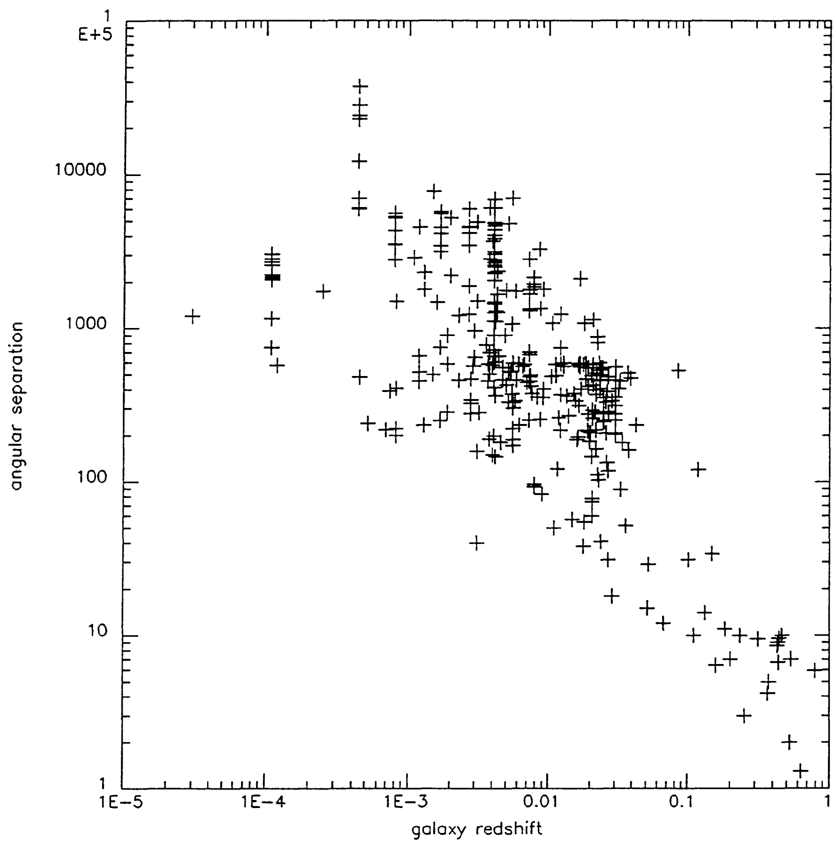

FIG. 3*b*

FIG. 3.—(*a*) Plot of the angular separation θ against z_G for the 76 QSO–galaxy pairs listed by Hewitt and Burbidge (1980). (*b*) Plot of θ against z_G for the 316 QSO–galaxy pairs in Table 2 which have been found since 1980. (*c*) Plot of θ against z_G for all 392 QSO–galaxy pairs given in Table 2. (*d*) Median angular diameter–redshift relation for 392 QSO–galaxy pairs. For comparison the relation $\theta \propto \bar{z}_G^{-1}$ = constant is plotted.

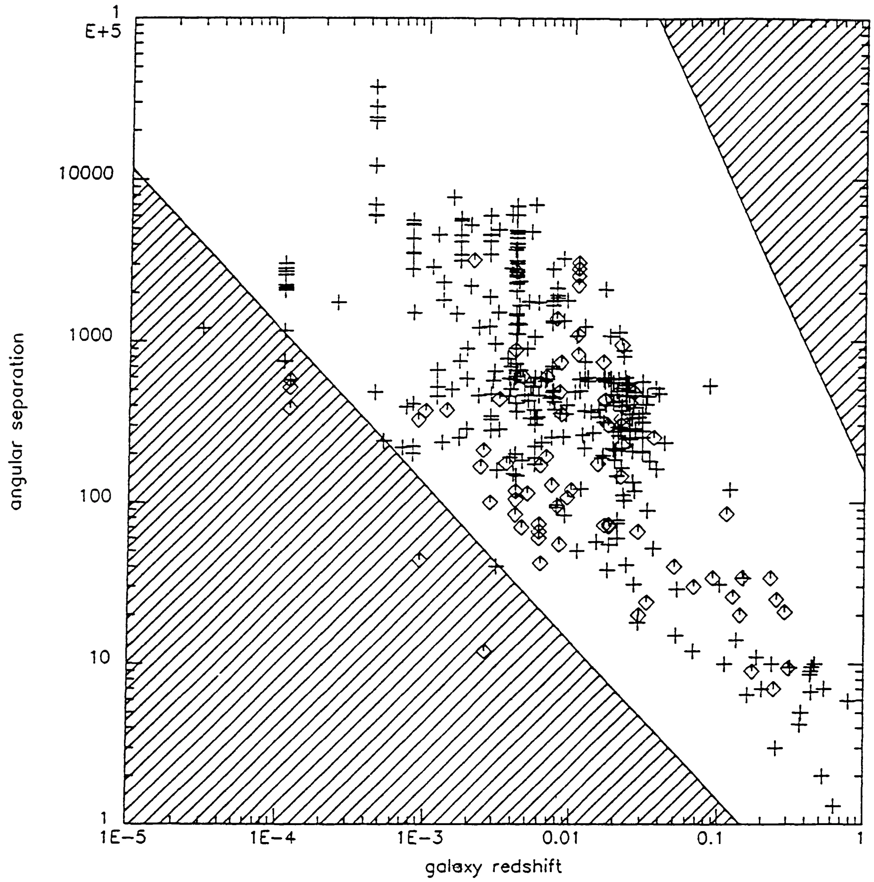
1 E+5
10000
1000
100
10
1
angular separation
1E-5
1E-4
1E-3
0.01
0.1
1
galaxy redshift

FIG. 3*c*

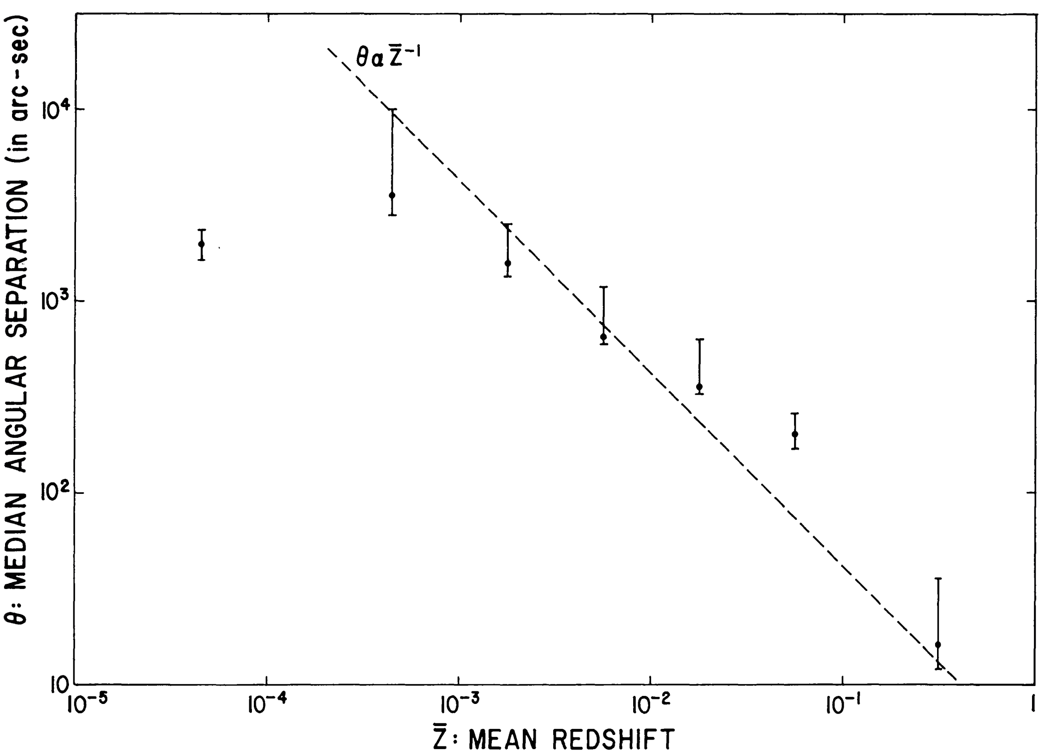
θ α Z̄⁻¹
10⁴
10³
10²
10
θ: MEDIAN ANGULAR SEPARATION (in arc-sec)
10⁻⁵
10⁻⁴
10⁻³
10⁻²
10⁻¹
1
Z̄ : MEAN REDSHIFT

FIG. 3*d*

for $p = 0.1$. We get $\theta \cong 140''$. Set $z = 1$ in the above relation for $\theta = 140''$. For $\alpha = 0.8$, this gives the straight line

$$\log \theta + 2 \log z = 2.15 . \quad (9)$$

The upper shaded region lies above this straight line in Figure 3*c*.

The rationale behind this zone of avoidance is as follows. The permitted zone for the effect must be such that the probability of finding a QSO within it by pure chance should not be appreciable. The shaded part has $p \geq 0.1$. It is also apparent that the QSOs looked for near very bright and nearby galaxies (z small) tend to be brighter (low m) than those looked for near fainter, more distant galaxies.

It is clear from Figure 3*c* that the scattered distribution of points lies well away from this forbidden zone. In other words, the trend seen appears not to be a consequence of the way QSOs are selected.

It could be argued that the upper limit to the distribution of Figure 3*c* is a consequence of the increasing surface density of galaxies at fainter magnitudes (and higher redshifts). In a Euclidean universe with a uniform distribution of galaxies, the number of galaxies out to a distance r is proportional to r^3. These are projected against the sky with a mean angular separation $\Delta\theta \propto r^{-3/2}$. Thus the galaxies would tend to "crowd" together at higher redshifts with the mean angular separation $\Delta\theta \propto z^{-3/2}$ for $z \ll 1$. A more exact relation can be worked out at higher redshifts for any specified cosmological model.

This dependence of $\Delta\theta$ on $z^{-3/2}$ is, however, different from the dependence $\theta \propto z^{-1}$ observed in Figure 3*c*, and could not be responsible for it. However, it is possible that for large enough z, $\Delta\theta$ becomes smaller than θ, and thus the above upper bound does become the main cause of the observed decrease of θ with z.

To test whether this actually happens in the present case, it is necessary to know how the number density of galaxies changes with redshift. To date no such information is available. The best that can be done is to use the data on the number density of galaxies as a function of galaxy magnitude, and to see whether a relation of the above kind could have come from the increasing closeness of fainter and fainter galaxies as they are projected on the sky.

While we undertake such an exercise, we feel it necessary to mention a point of caution. In Figure 3*c* we have plotted the median value of θ, *as a function of z*. While Hubble's law implies increasing faintness with increasing z for galaxies, the relatively large scatter of the m-z relation *even for galaxies* shuffles the bins used for computing the median values. Also, while Figure 3*c* contains those data points for which (θ, z) values are known, the present data do not contain magnitudes for all galaxies, as is evident from Table 2. Thus, to look for the above effect the median values of θ from the different *magnitude ranges* should be compared with the value of $\Delta\theta$ for galaxies within the same magnitude ranges. The following calculation shows that, with increasing faintness, both the median θ and $\Delta\theta$ decrease, but the former stays well below the latter.

The number-magnitude relation $N(m)$ for galaxies follows the slope

$$\frac{d \log N(m)}{dm} = 0.57\text{–}0.59 \quad \text{for} \quad 12 \leq m \leq 15 , \quad (10)$$

giving, on an average, say

$$\log N(m) = 0.58m + C \quad (11)$$

(cf. Shane 1975). The constant C can be fixed by comparison with the counts in Zwicky's catalog and/or the Lick catalog. Taking an average value between the two, we get for equation (11)

$$N(m) = \text{dex}\,(0.58m - 9.15) \text{ per square degree} . \quad (12)$$

For fainter magnitudes ($m > 15$) one may consider the counts given by Tyson and Jarvis (1979). Based on these figures, we arrive at Table 1. The first two columns of Table 1 list the magnitude limits for the galaxies in the QSO-galaxy pairs. There are 263 pairs for which the galaxy magnitudes are known. The third column lists the median separation θ_{med} between the pairs, while the fourth column lists the average separation $\Delta\theta$ of galaxies on the sky within the same magnitude range. It is evident from this table that $\Delta\theta$ exceeds θ_{med} by a considerable factor. Thus the observed relation could not have been driven by the increasing closeness of fainter and fainter galaxies.

Figure 3*c* has a number of galaxies at redshifts greater than 0.1, and it is expected that the bulk of their magnitudes would lie in the range ~18.5–22 mag. However, as is seen from Table 2, these magnitudes are not known in most cases. Nevertheless, had we continued the exercise of Table 1 to the above magnitude range, then the data on galaxy counts (Tyson and Jarvis 1979) tell us that $\Delta\theta \sim 70''$. (It needs to be emphasized here that the galaxy counts at faint magnitudes are known to flatten with a slope of ~0.4 for $d \log N/dm$ as opposed to the Euclidean value, and so $\Delta\theta$ does not drop off with increasing m as rapidly as at the bright end.) Thus the last point on the θ-z relation of Figure 3*c* also could not have come from this effect.

There is one further test that we have carried out to test the reality of equation (1). In Figure 4 we plot the difference between the apparent magnitudes of the paired QSO and the galaxy against the redshift of the galaxy. If the QSOs were projected near their neighbor galaxies by chance, we should expect their magnitudes to be uncorrelated with the redshifts of the corresponding galaxies. As a result, allowing for the scatter, we should see the above plot mimic the Hubble plot for galaxies. On the other hand, if the QSOs are physically near to their neighbor galaxies, then the above difference in magnitudes should be uncorrelated with the galaxy redshifts. Figure 4 supports the latter alternative, except for the wide pairs at very

TABLE 1

COMPARISON OF θ_{med} WITH $\Delta\theta$ AT DIFFERENT GALAXY MAGNITUDES

m_1	m_2	θ_{med}	$\Delta\theta$
7	11.3	840″	72000″
11.4	12.7	580	30996
12.8	14.0	458	13176
14.1	15.0	336	7236
15.1	18.6	161	362

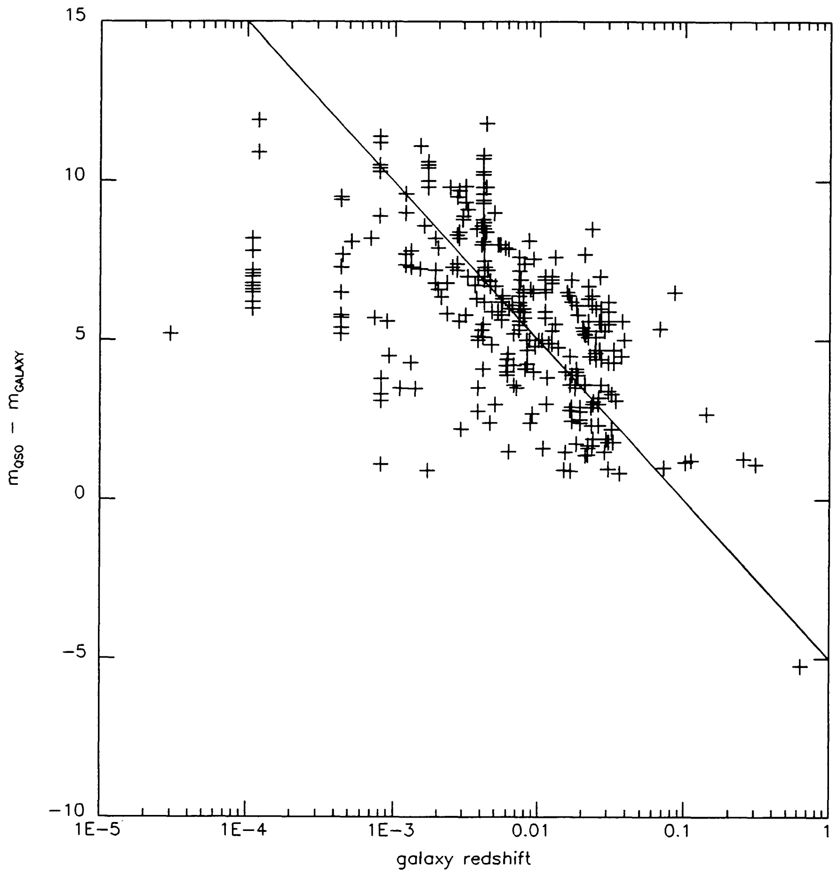

FIG. 4.—Plot of $m_{QSO} - m_G$ against z_G for all pairs used in Fig. 3c, with the Hubble relation plotted as a straight line.

small galaxy redshifts. (The correlation coefficient for the data points in Figure 4 is −0.54.)

VI. RESULTS AND POSSIBLE INTERPRETATIONS

As was stated in § I, the tendency for QSOs and galaxies to cluster together has been discussed for nearly 20 years. The results described in §§ IV and V from a much larger body of data than has ever been used before seem to show unambiguously that QSOs and galaxies with very different redshifts cluster together.

Let us look at other results concerning this effect and how they have been interpreted. We first consider QSOs and faint galaxies which lie at the same redshifts. The many studies of these low-redshift QSOs have led to the conclusion that these QSOs have more companion galaxies than would be expected in the general field. Sometimes it is stated that low-redshift QSOs are usually situated in groups or clusters of galaxies (cf. Gehren *et al.* 1984), or, as Yee (1987) has put it, the frequency of finding close companions to these low-redshift QSOs is ~6 times that expected for field galaxies. In addition to this, Dahari (1984, 1985) and Byrd, Sundelius, and Valtonen (1987) have concluded that Seyfert galaxies are much more likely to have companions than normal galaxies. At the other extreme, Webster *et al.* (1988) have found an excess concentration of high-redshift QSOs within 6″ of lower redshift galaxies, and Fugmann (1988) has found a similar effect.

With the heterogeneous sample described here, we have demonstrated that this same affinity of high-redshift QSOs for lower redshift galaxies is present all the way from the famous cases of comparatively nearby galaxies with QSOs some few arcminutes distant (in the original 3C sample of Burbidge *et al.* 1971) to pairs with much smaller separations, with galaxies at appreciable (cosmological) redshifts.

The general conclusion is that QSOs tend to lie in the vicinity of galaxies much more often than would be expected by chance, *whether or not* the galaxies and QSOs have the same redshifts.

This result may also have a bearing on the anomalies involving smaller redshifts. For many years it has been known that there is a significant number of close groups of galaxies—pairs, triplets, quartets, quintets, etc. (cf. Burbidge and Sargent 1971)—in which one galaxy has a highly discrepant excess redshift, and in which statistical or morphological arguments suggest that only one physical system is involved. Here again we are seeing a (comparatively) high-redshift galaxy with low-redshift companions far in excess of what would be expected by chance.

What explanations are available for this remarkable effect? In principle, there are two possibilities. The first is that QSOs lie at the distances implied by their redshifts and the reason for their probability of discovery close to galaxies is not well understood. Alternatively, they are physically associated with galaxies, so that the bulk of their redshifts are of noncosmological origin.

The conservative position is that perhaps after all the cosmological redshift hypothesis is correct, and because of uncertainties in the surface density of faint QSOs and the content of galactic halos, it may be possible to explain the results in terms of gravitational microlensing.

The alternative, which we favor, is that these results are further direct evidence for noncosmological redshifts. Why do we believe this? For low-redshift QSOs it has sometimes been argued that the companion galaxies trigger by tidal activity the activity in the "host galaxy" which gives rise to the QSO (Byrd, Sundelius, and Valtonen 1987). However, for the high-redshift QSOs associated with low-redshift galaxies, it has sometimes seemed that acceptance of the reality of the effect hinged on the availability of an explanation for it within the conventional framework of Hubble's law. An explanation that has been attempted on several occasions involves statistical gravitational lensing (Canizares 1981; Schneider 1987). Although, prima facie, this idea looks attractive, bearing in mind the reservation made above, its quantitative application to the actual data appears to encounter severe difficulties.

As concluded by Linder and Schneider (1988), there is now a general agreement that gravitational lensing by compact foreground objects is not likely to generate a statistically significant overdensity of QSOs around galaxies containing these objects. The difficulty (also highlighted by Arp 1990) is that the fractional density enhancement is significant only if the number of QSOs increases sharply as the magnitudes become fainter and one is dealing with large enough numbers to start with. The counts of QSOs are indeed steep at the bright end, but the numbers are too small to make a significant contribution to the observed overdensity. Also, at fainter magnitudes the number counts of QSOs flatten considerably, so that lensing cannot be very effective in augmenting their surface densities.

Can the observed overdensity of galaxies near QSOs be explained by statistical microlensing? Again, Linder and Schneider (1988) have pointed out that some detectable effect is possible, but its amplitude is smaller than observed.

Webster *et al.* (1988) have tried to argue for microlensing to explain their finding of an excess concentration of high-redshift QSOs within 6″ of low-redshift galaxies. However, the amount of lensing matter required for the observed effect turns out to be excessive compared with the dynamical estimates of M/L for galaxies and clusters (Hogan, Narayan, and White 1989).

In any case, the lensing scenario cannot work for the effect highlighted in §§ IV and V where the angular separations are as high as 2′, and the galaxies concerned are very close by.

VII. POSSIBLE THEORETICAL INTERPRETATIONS

The general result described in § IV requires that some part, ranging from a very small increment in Δz in low-redshift QSOs to the dominant component Δz in high-redshift objects, is due to effects other than the expansion of the universe. It appears that this result may apply to all classes of active objects (sometimes called AGNs).

As is well known, the alternatives to the cosmological redshift include a local Doppler effect, gravitational redshifts, a tired-light mechanism, a variable-mass hypothesis, etc. (for a review see Narlikar 1989). The apparent lack of blueshifts is a problem with the Doppler hypothesis, although this could be explained if the ejected QSOs radiate preferentially in the backward direction (Narlikar and Subramanian 1983). The gravitational redshift or the tired-light theory cannot explain why QSO–galaxy pairs should exist. The variable-mass hypothesis (Narlikar 1977; Narlikar and Das 1980) holds out a possible explanation. In this theory the QSO is made of newly created matter ejected from the parent galaxy. The excess redshift, however, does not arise from a high speed of ejection but from the low mass of the newly created matter. It was shown by Narlikar and Das (1980) that the ejected QSO can be bound to the parent galaxy with a typical separation of the order of ~100–200 kpc.

Our ideas so far are fragmentary, but we do believe that the existence of this widespread effect requires a new approach to the cosmogony of violent nonthermal events wherever they may occur.

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G. Burbidge and A. Hewitt: Center for Astrophysics and Space Sciences, C-011, University of California, San Diego, La Jolla, CA 92093

P. Das Gupta and J. V. Narlikar: Inter-University Centre for Astronomy and Astrophysics, Poona University Campus, Pune 411 007, India

TABLE 2

PAIRS OF GALAXIES AND QUASI-STELLAR OBJECTS

QSO	Galaxy	Separation arcsec	kpc	Galaxy	Separation arcsec	kpc	Galaxy	Separation arcsec	kpc	REF
0001-121(UT) 1.30 18	N 7813 – 15.0	582	–							1
0002-422 2.758 17.21	N 55(Sc) 0.00044 7.8	12180	148	N300(Sc) 0.00044 11.3	38820	350				2
2319-383 0.37 17.3	"	37200	450							2
0048-396 0.478 17.8				"	7020	64				2
0053-384 0.379 18.9				"	–	17				2
0056-363 0.162 16.7				"	6060	56				2
0056-394 1.409 18.6				"	6000	55				2
0059-361 0.901 18.3				"	–	76				2
0122-380 2.181 16.5				"	22920	209				2
0125-400 1.39 17.1				"	24000	219				2
0130-403 3.03 17.02				"	28140	256				2
0003+158(4C15.01) 0.450 15.95	ANON(S) 0.119 –	120	415	N7814(S) 0.0042 12.4	2352	239	faint galaxies(88)			2
0007-000(UM280) 2.31 17	ANON – –	–	–							3
0007+106 0.089 15.4	IIIZw2-B(E) 0.0856 17.66	50	124	IIIZw2-C(S) 0.0906 16.25	250	659	faint galaxies(88)			4,70 26
0007+332(4C33.01) 0.743 18.8	N29 (S) – 13.5	570	–							1

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0013-004(UM224)	N60(S)									1
2.086	–									
17	15.5	320	–							
0014+166(PG)	faint									
0.100	galaxies(88)									
16.23										
0015+162	ANON									26,86
0.553	0.541									
18.2	–	60	900							
0017+257(4C25.01)	ANON									90
0.248	–									
15.4	–	10	–							
0017+154(3CR9)	ANON									98
2.012	0.254									
18.21	20.5	11	81							
0021-017	ANON									84
1.35	–									
–	–	3.5	–							
0025-018(UM245)	N120(S0)									5,70
(1.46)	–									
18	14.8	240	–							
0026+129(PG)	ANON(S)			faint						2
0.142	0.0058			galaxies(88)						
15.41	–	336	57							
0027+018(UM247)	N132(SBb/Sc)									5,70
2.35	0.0179									
18.9	13.8	300	156							
0027-289(QSO1)	ANON1(S)			ANON2(S)						6
0.28	–			–						
17.1	–	11	–	–	23	–				
0027-289(QSO2)	”			”						6
1.6										
19.36		26	–		45	–				
0032-086(BSO1)	N157(Sc)			ANON(S pec.)						7,70
0.756	0.00583			–						
19	11.1	1740	306	–	119	–				
0034+024(UM52)	N164									1
(2.27)	–									
18	16	497	–							
0038+327(1E)	3CR19									1
0.197	0.482									
18.06	20	716	>1000							
0038-020(PKS)	UGC439(Sa)			N227(E)						9,10
1.178	0.017			0.017						70
18.5	14.4	430	213	13.7	1784	882				

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0038-019(PKS)										8,9,11
1.690	”			”						10,12
16.86		72	36		1313	649				70
0040-017(UM268)										5,70
(1.66)				”						
18					431	213				
0040+005(UM269)	N223(Pec)									1
(2.00)	0.0179									
18	14.5	582	288							
0039-265	N253(Sc)									2
1.803	0.0008									
17.5	7.0	5580	84							
0041-261										2
2.501	”									
17.4		3480	52							
0042-248										2
0.807	”									
17.3		3540	53							
0048-261										13
2.249	”									
18.2		2790	42							
0049-272										13
2.484	”									
18.4		5320	80							
0050-253										2
0.626	”									
15.9		4320	65							
0051-253										2
1.444	”									
17.5		5220	78							
0041+119(MC2)	galaxies									
0.228	nearby(90)									
19										
0043+039(PG)	faint									
0.384	galaxies(88)									
15.88										
0044+030(PKS)	faint									
0.624	galaxies(88)									
16										
0044-209(PHL6625)	N247(Sc)									14
0.380	0.00052									
18.8	10.7	240	3.7							
0045-384	N264									1
0.40	–									
18.0	–	382	–							

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0048-071(PKS)	N273									1
1.974	0.0158									
19.5	13	338	156							
0050+124(IZw1)	ANON									88
0.061	–									
14.07	–	–	–							
0051-274	ANON(Pec)									15
0.65	–									
18.90	–	–	–							
0052+251(PG)	ANON			faint						16
0.155	–			galaxies(88)						
15.42	20.5	10	23							
0055-277(CT250)	UGC554(S)									1
2.186	–									
18.77	15.6	185	–							
0100-351	ANON									17
1.413	–									
19.0	–	10	–							
0101-353	N365									1
2.20	–									
17.3	–	228	–							
0104+318(1E)	ANON			N383/3CR31(E)						8,18
2.027	0.111			0.0167						1
18.72	17.5	10	33	13.5	985	478				
0106+013(PKS)	ZW									19,70
2.107	0.0067									
18.39	14.8	192	37							
0107-356	N415									1
2.19	0.0218									
20.1	–	286	182							
0109+200(UT)	ANON									77
0.746	0.535									
17	–	7.0	102							
0110+318(4C31.03)	N420(S0)									1
0.603	0.0165									
18	13.5	578	277							
0112-014	N442(Pec)									1
2.20	0.0187									
20.3	14.5	589	321							
0112-017(PKS)	N448(E)			N450(SC)						19,2
1.365	0.0067			0.0062						70
17.41	13.2	600	61	12.5	2118	189				
0112+329(1E)	N447(SB)			N449(SB0/SBa)						1
0.764	0.0187			0.0160						
18.9	15.0	467	254	14.0	542	252				

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0114+074(PKS)	ANON									20
0.861	–									
18	18.	30	–							
0117+213(PG)	ZW459.034(S)			faint						2
1.493	–			galaxies(88)						
16.05	–	336	–							
0117+031g(57)	N470(S)			N474(S0)						21
1.902	0.0079			0.0078						
18.79	12.5	2430	624	12.9	2133	548				
0117+031g(68D)										21
1.533	”			”						
18.2		96	25.2		300	77				
0117+031g(D5)										21
1.609	”			”						
19.4		2160	555		1933	497				
0117+031g(D8)										21
2.090	”			”						
18.9		2160	555		1867	480				
0117+031g(68)										21
1.875	”			”						
19.9		93	24.4		264	68				
0118+034(PKS)	N479(Sb)									19,70
0.765	–			”						
18.09	15.1	518	–		1380	355				
0117-340	N491A									1
1.87	0.0119									
19.9	–	261	96							
0119-341	N491(SB)									1
2.22	0.0130									
18.5	13.0	595	219							
0119-341										1
1.47	”									
20.6		564	207							
0119-046(PKS)	ANON									78
1.948	0.133									
16.47	20	14	44							
0120+092	N505(S0)			N509(S0)			N516(S0)			1,14
0.176	0.0185			0.0076			0.0081			
18.2	15.1	590	318	14.7	375	82	14.3	530	125	
0121+108(MC2)	ANON(S)									22
0.510	–									
18	–	40	–							
0122+035g(31)	N520(Amorph)									21
0.633	0.00728									
18.59	12.4	1330	308							

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0122+035g(53)										21
0.923	"									
18.78		670	155							
0122+035g(79)										21
1.341	"									
18.38		2800	650							
0122+035g(46)										21
0.221	"									
19.57		1800	418							
0122+035g(192)										21
2.000	"									
20.0		450	104							
0122 +035g(D1)										21
1.468	"									
19.0		1670	387							
0122+035g(D2)										21
0.311	"									
18.5		700	162							
0122+035g(30)	"									21
1.405										
17.88		1300	302							
0122+035g(40)										21
1.202	"									
17.73		482	112							
0122+035g(D9)										21
1.670	"									
18.0		1770	411							
0121+034(48)										14,21
0.336	"									
18.5		251	58							
0121+108(MC2)	ANON									22,70
0.51	0.05									
18	–	40	58							
0122-003(PKS)	faint									
1.070	galaxies(88)									
16.70										
0122-353	N526			N527						1
1.67	0.0191			0.0192						
20.6	14.48	363	201	13.94	216	121				
0123-021(UM322)	N558									5,70
1.93	0.0165									
18.6	15.0	744	359							
0124-021(UM324)				N560			N564			1
0.35	"			0.0181			0.0192			
17.8		196	94	14.41	298	157	14.02	584	327	

TABLE 2—*Continued*

		Separation			Separation			Separation		
QSO	Galaxy	arcsec	kpc	Galaxy	arcsec	kpc	Galaxy	arcsec	kpc	REF
0127+059(UM109)	3CR44									1
(2.30)	0.66									
18.9	21.0	1514	>1000							
0130+242(4C24.02)	faint									
0.457	galaxies(88)									
16.8										
0132-075g(UB1)	N615(Sb)									23
1.64	0.0062									
18.5	12.50	235	45							
0133+004g(UB1)	N622(SB)									7,70
0.91	0.0183									
18.5	14.10	71	35.5							
0133+004g(BS01)										7,70
1.46	"									
20.2		73	36.5							
0134-376	N633									1
2.493	0.0172									
18.2	–	402	201							
0134+329(3CR48)	ANON			ANON			faint			24,2
0.367	–			0.368			galaxies(88)			
16.06	23	12	–	–	3	32				
0135+056(PHL1072)	N632(S0)									1
0.615	0.0105									
18.3	13.50	486	149							
0137+060(PHL1092)	ANON									25,2
0.396	0.2303									70
17.0	–	34	228							
0137+012	faint									
0.258	galaxies(88)									
17.07										
0146+056(PKS)	N676(S0)									1
2.345	0.0050									
19	10.50	427	63							
0147+089(PHL1186)	ANON									26,85
0.27	0.2688									
17.4	–	4	28							
0148-097(UM674)	N701(Sc)									1
2.848	0.0061									
18.6	13.03	585	109							
0149-166	N725									14
0.399	–									
19.3	14.0	1320	–							
0151+045(PHL 1226)	IC1746(Sb)			ANON			ANON			27,28
0.404	0.0260			0.1602			–			70,79
17.5	14.5	54	41	–	6.4	30	–	10.9	39	77

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0154+316(4C31.06)	V ZW150			V ZW147			ANON			1,29
0.373	–			–			0.372			26
18.9	–	320	–	–	340	–	–	4	42	
"	ANON									1,29
	0.372									26
	–	4	152							
0156+187	N770			N772(Sb)						9,10
2.61	0.0085			0.0085						70
19.43	14.2	–	–	11.3	352	90				
0157+001(MKN1014)	N768(Sb)			ANON			faint			2,26
0.163	0.0211			0.163			galaxies(88)			16
15.69	14.3	1140	700	–	5.5	13				
0159-117(3C57)	IC1767									10,27
0.669	–									70
16.66	15.0	2340	–							
0200-089(1E)	ANON									8
0.77	0.015									
16.52	17.4	57	25							
0205+024(NAB)	UGC1621(Sc)									2
0.155	–									
15.39	16.5	144	–							
0208-018(UM407)	N850									1
0.56	0.0272									
18.4	14.0	285	225							
0210+860(BSO)	ANON 1			ANON 2			ANON 4			30,70
0.184	0.180			0.188			0.113			
19	–	12	3.1	–	85	22	–	85	22	
"	ANON 5									30
	0.186									
	–	85	22							
0219+428(3C66A)	3CR66B(E)			UGC1832(S0)			UGC1837(E)			2,31
(0.444)	0.0215			0.0206			0.0226			70
15.58	19	390	243	15.4	146	87	15.2	222	146	
"	N891(Sb)									2,31
	0.0024									
	10.8	2502	190							
0225-014(PKS)	N936(SB0)			N941(S)						19,1
2.037	0.0046			0.0054						70
18.15	11.3	600	88	13.4	539	90				
0226-106(UT)	ANON			N948(SB)						8,1
0.62	0.036			0.0150						
18.32	17.5	52	54	14.0	583	255				
0235+164(AO)	ANON									71
0.94,0.524	0.524									
15.5	20	2	30							

TABLE 2—*Continued*

		Separation			Separation			Separation		
QSO	Galaxy	arcsec	kpc	Galaxy	arcsec	kpc	Galaxy	arcsec	kpc	REF
0239-154(UM677)	N1065									1
2.782	0.02465									
18.6	14.0	548	393							
0240-011(BSO1)	N1073(SBc)									7,33
1.945	0.00415									34,70
19.8	11.3	104	13.2							
0240-011(BSO2)										7,33
0.599	"									34,70
18.8		117	15.0							
0241-011(RSO)										7,33
1.411	"									34,70
20		84	10.8							
0238-315(QSO2)	N1097(SB)									35
2.153	0.0041									
19.5	9.7	6068	756							
0238-301(QSO3)										35
2.265	"									
19.9		4642	579							
0238-310(QSO6)										35
2.034	"									
19.0		4804	599							
0240-309(QSO7)										35
0.374	"									
18.5		3134	391							
0241-316(QSO9)										35
1.588	"									
19.5		4850	604							
0241-302(QSO10)										35
0.359	"									
19.5		2563	319							
0242-310(QSO12)										35
0.874	"									
19.0		2688	335							
0242-310(QSO13)										35
1.985	"									
19.5		2674	333							
0242-305(QSO14)										35
1.042	"									
19.0		1111	138							
0242-301(QSO15)										35
2.269	"									
20.0		1442	180							
0242-301(QSO16)										35
0.783	"									
19.5		1477	184							

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0243-294(QSO17)										35
1.683	"									
18.5		3824	476							
0243-297(QSO18)										35
1.577	"									
19.5		2570	320							
0243-291(QSO19)										35
2.163	"									
18.5		4799	598							
0243-318(QSO21)										35
1.875	"									
18.5		4868	607							
0243-297(QSO22)										35
2.063	"									
20.0		2503	312							
0243-302 (QSO23)										1,36
0.89	"									
19.1		720	90							
0244-302(QSO25)										1,36
3.103	"									
19.3		660	82							
0244-302(QSO26)										1,36
1.00	"									
17.8		900	112							
0244-303(QSO27)										1,36
0.528	"									
18.3		600	75							
0245-302(QSO28)										1,36
0.34	"									
18.2		1260	157							
0245-301(QSO29)										1,36
(1.10)	"									
20.5		1440	179							
0245-294(QSO30)										35
1.663	"									
19.5		4012	500							
0245-297(QSO31)										35
1.004	"									
20.0		3026	377							
0245-294(QSO33)										35
2.141	"									
19.5		4028	502							
0245-298(QSO34)										35
1.862	"									
19.5		2771	345							

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0246-308(QSO35) 1.093 18.5	"	2046	255							35
0246-300(QSO36) 1.775 19.0	"	2319	289							35
0247-304(QSO37) 1.646 19.0	"	2272	283							35
0247-294(QSO38) 2.193 20.0	"	4372	545							35
0249-290(QSO42) 2.204 19.5	"	6898	860							35
0243-007(UB1) 2.147 19.16	N1087(Sc) 0.00615 11.3	170	27							7,70
0244-003(US3146) 1.815 18.99	N1090(SBc) 0.00912 12.5	353	97							1
0245-004(US3167) 2.118 18.68	N1094 0.0211 13.5	427	263							1
0248+430(S4) 1.316 18.0	ANON 0.0512 –	15	22							37,78
0302-223(1E) 1.400 16.0	N1232(Sc) 0.0055 10.2	7020	1208							2
0304-392 1.965 17.6	N1217 0.0208 13.99	294	178							1
0306+169 2.14 20.3	3CR79(N) 0.2559 18.5	930	>1000							1
0307+172 2.28 19.2	"	1344	>1000							1
0308-420 0.581 17.6	N1291(S) 0.0027 10.2	4580	209							38
0309-403 1.729 18.5	"	4160	190							38

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0312-409										38
0.864	"									
17.6		1880	86							
0316-417										38
0.538	"									
19.7		1230	56							
0320-407										38
0.374	"									
18.5		3460	158							
0321-421										38
1.807	"									
17.4		4510	206							
0321-397										38
1.088	"									
17.6		5980	273							
0317-198(1E)	ANON									8
1.00	0.101									
18.56	17.4	31	91							
0317-023(4C02.15)	NGC1298(E)									19,70
2.092	0.0221									
19.50	14.2	228	144							
0318-196	N1300(SBb)									1
0.104	0.0047									
14.86	11.0	555	82							
0323+022	3CR88									1
Cont.	0.0302									
16.5	13.95	1597	>1000							
0331-053(1E)	N1358(SBa)									1
0.139	0.0136									
17.26	12.5	362	145							
0335-353	N1399(E1)									14
1.002	0.0049									
19.8	10.8	900	132							
0405-123(PKS)	ANON									39
0.574	0.568									
14.82	–	13	188							
0413-116	ANON			faint galaxies						95
3.853	(0.28)			(Abell 483)						
22.0	–	73	(610)							
0446-208(MC1)	ANON(S0)									2,80
1.896	0.0669									
17	–	12	23							
0454+039(PKS)	faint									
1.345	galaxies(88)									
16.53										

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0506-612(PKS)	N1796(SBc)									2
1.093	0.00025									
16.85	–	1740	126							
0537-441(PKS)	ANON(S)									75
0.894	0.186									
15.5	–	11	57							
0721+690	N2366(Irr)									14
0.111	0.00003									
16.8	11.6	1200	21							
0735+178(PKS)	faint									
–	galaxies(90)									
14.85										
0736+017(PKS)	faint									
0.191	galaxies(90)									
16.47										
0742+318(4C31.30)	faint									
0.462	galaxies(88)									
16										
0804+761(PG)	ANON			faint						26,16
0.100	0.100			galaxies(88)						
15.15	–	24	70							
0809+558g(U1)	N2534(Pec)									23
2.40	0.0117									
18.7	13.8	121	41							
0812+020(PKS)	ANON(E)									83
0.402	0.40									
17.10	22	–	–							
0814+578g(BSO1)	N2549(S0)			ANON(S pec)						23,40
2.40	0.0038			0.0263						
18.9	12.5	410	48	–	134	103				
0832+251(PG)	N2611			faint						1
0.320	–			galaxies(88)						
–	15.5	156	–							
0834+250(OJ259)	N2620(S)			N2621			N2622			1
1.122	0.0261			–			0.0285			
18	14.8	208	158	15.5	320	–	15.0	499	414	
0835+580(3CR205)	ANON									78
1.534	0.236									
17.62	22	10	68							
0837-120(3C206)	ANON			faint						87
0.198	0.2			galaxies						
15.76	–	10	52	(88,90)						
0840+499(UI)	N2639(Sa)			ANON(Pec)						41,40
1.177	0.0110			0.0056						70
18.8	12.4	1730	556	–	188	31				

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0840+499(U2)										41,40
1.105	”			”						70
19.5		1770	569		221	36				
0840+499(U3)										41,40
1.522	”			”						70
19.1		1550	498		302	49				
0840+499(U4)										41,40
(0.78)	”			”						70
18.7		1790	575		329	54				
0841+498(U5)										41,70
(1.494)	”									
18.3		2220	713							
0842+498(U7)										41,70
2.00	”									
19.3		2500	803							
0840+501(U8)										41,70
2.80	”									
19.4		830	267							
0838+501(U10)										41,70
0.305	”									
18.1		1100	353							
0841+495(U14)										41,70
2.132	”									
19.0		3070	986							
0837+497(U15)										41,70
1.535	”									
19.3		2830	909							
0841+449	ANON									42
2.17	–									
20.9	–	13	–							
0842+449	ANON(S)									42
2.30	–									
19.1	–	32	–							
0844+319(4C31.32)	IC2402									43,70
1.834	0.0675									
18.87	13.5	30	59							
0846+100(4C09.31)	faint									
0.366	galaxies									
19.20	(90,91)									
0846+513(W1)	ANON(S)			N2681(Sa)						44,40
1.860	0.072			0.0026						70
17.0	16.0	12	25	10.4	35	16				
0847+190(LB8741)	N2677									1
0.568	–									
16.6	15.0	559	–							

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0849+336g(U1)	N2683(Sb)			UGC4658(Sc)						40
0.621	0.0012			0.0143						
17.4	9.7	3200	124	14.9	517	215				
0849+336g(U2)										40
1.262	"			"						
18.7		2817	109		453	270				
0849+336g(U3)										40
1.252	"			"						
19.3		2783	108		658	180				
0851+142(3CR208.1)	ANON									93
1.011	0.159									
19.26	20.85	3.9	18.5							
0853+515(UB1)	N2693(E)			N2694						40,1
2.31	0.0162			0.0168						
19.5	13.1	188	92	15	–	92				
0855+539g(UB1)	N2701(Sc)			ANON						23
0.243	0.0075			–						40
19.4	12.5	420	99	–	110	–				
0902+186	N2744(SB)			N2747			N2749(E3)			1
(0.465)	0.0114			–			0.0137			
17.53	13.8	491	163	15.5	133	–	13.5	509	206	
0903+169(3CR215)	ANON									26
0.411	0.41									
18.27	–	8	100							
0903+175	ANON									45
2.756	–									
17.3	18.0	3.9	–							
0907+072g(U1)	N2775(Sa)			ANON						40
1.442	0.0044			–						
18.8	11.5	661	77	–	121	–				
0911+053(4C05.38)	faint									
0.303	galaxies									
17.43	(88,90)									
0911+402(U1)	N2782(Sa pec)			UGC4872(SBb)						1,14
0.936	0.0850			–						
19.0	12.5	529	132	16.0	180	–				
0918+511g(UB1)	N2841(Sb)			UGC4932(Sb)						23,2
2.028	0.0023			0.00082						
18.5	10.17	1284	89	15.4	407	28				
0918+511g(UB2)										23,2
0.120	"			"						
18.7		1614	111		200	14				
0918+511g(UB3)										
0.553	"			"						23,2
16.5		1284	89		222	15				

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	kpc	Galaxy	Separation arcsec	kpc	Galaxy	Separation arcsec	kpc	REF
0918+511g										23,2
0.297	"			"						
19.2		2310	160		1500	104				
0921+348g(U1)	ANON(Pec)			N2859(SB)						40,46
0.23	0.006			0.0056						70
19.2	15.3	60	10	12.2	574	88				
0921+348g(U2)	ANON									40,46
2.25	0.006			"						70
19.7	15.7	66	12		1320	203				
0921+344(U3)	ANON(S pec)									40,46
1.46	0.006			"						70
20.3	(15.9)	73	13		1440	222				
0921+348										47
0.487				"						
18.6					596	97				
0923+201(PG)	N2903(Sc)			ANON			faint			2,26
0.190	0.0015			0.190			galaxies(88)			16
16.04	9.8	7740	353	–	9	48				
0929+218										1
2.53	"									
20.9		500	23							
0924+301	B2									10,70
2.02	0.0266									
21.0	14.0	480	371							
0931+437(PG)	faint									
0.456	galaxies(88)									
16.3										
0932+219g(UB1)	N2916(S)									40,23
0.238	0.0123									
19.2	12.3	216	77							
0932+219g(UB2)										40,23
0.793	"									
17.6		370	132							
0932+219g(UB3)										23
1.279	"									
18.2		1234	442							
0932+219g(UB4)										40,23
1.868	"									
19.3		586	208							
0932+219g(UB5)										23
0.732	"									
19.1		746	118							
0935+417(PG)	faint									
1.980	galaxies(88)									
16.25										

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0936+396(PG) 0.458 17.40	3CR223.1 0.1075 16.36	1696	>1000	faint galaxies(88)						1
0937+121 2.7 19.0	N2958(SB) 0.0221 13.9	217	140							1,48
0938+120 2.00 19.5	"	164	106							1,48
0938+120 2.4 20.2	"	398	256							1,48
0941-200(MC) 0.715 18.2	N2983(SBa) 0.0067 13.0	580	99							1
0946+301(PG) 1.216 16.00	faint galaxies(88)									
0947+396(PG) 0.206 16.40	ANON 0.207 –	8	48	faint galaxies(88)						16,26
0950+080(1E) 1.45 17.69	UGC5304(S) 0.023 14.8	103	69							8
0952+179(AO) 1.472 17.23	faint galaxies(96)									
0952+698(Hoag1) 2.053 20	N3034(Amorph) 0.00012 9.1	384	6.6							7,40 70
0953+698(Hoag2) 2.058 21	"	516	8.9							7,40 70
0953+698(Hoag3) 2.033 21	"	576	10							7,40 70
0951+699(M82-4) 0.85 20.2	"	576	10							1
0953+414(PG) 0.239 14.5	ANON – 21.00	–	–	faint galaxies(88)						16,88
0955+326(3C 232) 0.533 15.78	N3067(Sb) 0.0050 12.8	114	16	faint galaxies(88)						19,70

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0956-073(1E) 0.327 16.5	N3115(E/S0) 0.002 9.9	5256	223							2
0959-075 1.559 17.8	"	2200	93							38
0957+558g(UB1) 1.53 18.8	N3073(S0) 0.0038 13.8	190	23	N3079(Sc pec) 0.0041 11.9	725	86				23
0957+558g(UB2) 2.091 17.3	"	693	82	"	1077	128				23
0957+558g(UB4) 1.154 17.4	"	933	111	"	199	24				23
0957+561(A/B) 1.405 17.0				"	880	105				10,70
0958-551(MKN132) 1.751 16.0				"	2700	321				10,70
0957-055 1.810 18.0	A1008-04(Irr) 0.00011 –	3040	175							38
0958-042 0.497 18.1	"	2570	148							38
0959-028 1.816 18.7	"	2710	156							38
1000-037 0.143 17.6	"	2170	125							38
1000-032 0.526 19.4	"	2220	128							38
1001-033 0.458 19.8	"	2070	113							38
1003-026 2.871 18.2	"	2140	123							38
1006-023 0.687 18.6	"	2070	119							38

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1006-050										38
1.169	"									
18.8		750	43							
1008-055										38
2.109	"									
18.3		1160	67							
1010-072										38
0.640	"									
17.8		2830	163							
1001+291(TON28)	3CR234									1
0.329	0.1848									
15.5	17.27	1794	>1000							
1002-248	N3109(SB)									38
2.437	0.0013									
17.7	10.4	2310	76							
1004-256										38
1.876	"									
18.2		1790	59							
1004+130(PKS)	ANON			ANON			faint			25,70
0.241	0.2423			0.2400			galaxies(88)			
15.15	–	34	237	–	45	314				
1008+133(PG)	faint									
1.287	galaxies (88)									
16.24										
1011+250(TON490)	faint									
1.631	galaxies(96)									
15.4										
1011-282(PKS)	faint									
0.253	galaxies(90)									
16.88										
1012+008(PG)	ANON			ANON			faint			26,88
0.185	0.186			0.187			galaxies(88)			16
16	17.6	3	12	18.4	–	30				
1012+736g(U1)	N3147(Sb)			ANON(S pec)						40
1.055	0.0092			–						
19.0	11.45	1800	508	–	60	–				
1015+416g(UB1)	N3184(Sc)			ANON(S pec)						23,40
0.152	0.0019			–						
17.7	10.9	284	17	–	797	–				
1015+416g(UB3)										23,40
(0.92)	"			"						
19.1		584	34		339	–				
1015+416g(UB4)										23,40
2.029	"			"						
18.1		900	53		278	–				

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1016+359(CSD 259)	ANON									94
1.552	0.055									
17	–	45	72							
1017+280(TON34)	N3204(SBb)									1
1.928	0.0167									
15.69	14.8	314	152							
1020-103(OL-133)	faint									
0.197	galaxies(90)									
16.11										
1021-006(PKS)	ZW									19,70
2.547	–									
18.22	15.5	126	–							
1031+583(1E)	3CR244.1									1
0.248	0.428									
18.66	19	595	>1000							
1037-270(TOLOLO19)	ANON									49
2.18	–									
17.4	–	40	–							
1038+064(4C06.41)	ANON			faint						77
1.27	0.441			galaxies(88)						
16.81	–	9.6	123							
1039+140g(UB1)	ANON(S pec)			N3338(Sbc)						7,1
(2.04)	–			0.0043						70
20.4	15.5	218	–	11.5	–	–				
1039+140g(UB2)	ANON(S dstb)									7,1
2.14	–			”						70
19.7	13.8	251	–		–	–				
1038-272(TOLOLO22)	ANON									49
2.331	–									
17.8	–	95	–							
1045+350	N3381(SB)									1
0.923	0.0054									
20.8	12.8	518	82							
1045+128g(UB1)	N3379(E0)			N3384(SB0)			N3389(Sc)			50,1
1.111	0.00297			0.0024			0.0042			70
19.4	11.0	584	43	10.8	250	18	12.5	146	11	
1045+128g(UB2)										50,1
1.28	”			”			”			70
19.8		960	71		710	52		365	27	
1045+128g(UB4)										50,1
1.107	”			”			”			70
19.9		647	48		668	49		1043	77	
1045+128g(UB5)										50,1
1.192	”			”			”			70
19.2		960	71		1064	78		1440	106	

TABLE 2—*Continued*

QSO	Galaxy	Separation		Galaxy	Separation		Galaxy	Separation		REF
		arcsec	kpc		arcsec	kpc		arcsec	kpc	
1045+128g(UB8)										50,1
1.134	"			"			"			70
18.7		1189	88		795	59		657	48	
1045+128g(UB13)										50,1
(0.497)	"			"			"			70
20.6		600	44		167	12		417	31	
1045+128g(UB14)										50,1
(0.52)	"			"			"			70
20.5		1649	122		1461	108		1106	82	
1045+128g(UB15)										50,1
1.131	"			"			"			70
19.7		1878	138		1607	118		1294	95	
1048+342(CSO294)	ANON			ANON			faint			16,26
0.167	0.167			–			galaxies(88)			88
15.81	19.7	–	11	20.2	–	50				
1048-090(PKS)	ANON			ANON			faint			25,70
0.344	–			0.1255			galaxies			
16.79	–	23	–	–	26	95	(88,90)			
1049-005(PG)	IC653(Sa)			faint						2
0.357	0.0182			galaxies(88)						
15.95	14.2	1074	569							
1049+616(4C61.20)	N3407(E/S0)			N3435(Sb)						9,70
0.422	0.0153			0.0174						
16.48	15.0	173	85	12.8	1062	520				
1058+110(4C10.30)	ANON(S)			faint						2
0.423	–			galaxies(90)						
17.1	–	120	–							
1059+730	N3516(SB0)									2
0.089	0.0087									
14.7	12.3	1344	339							
1104+728(W1)										1
2.10	"									
18.9		255	64							
1100+772(3CR249.1)	faint									
0.311	galaxies(88)									
15.72										
1100-264	ANON			ANON			ANON			97
2.145	0.18			0.297			0.370			
16.02	–	17	89	–	60	520	– 65	700		
1103-006(PKS)	N3521(Sb)			faint						19,70
0.426	0.0021			galaxies(88)						
16.46	10.1	3180	193							
1104+167(4C16.30)	faint									
0.634	galaxies(88)									
15.7										

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	kpc	Galaxy	Separation arcsec	kpc	Galaxy	Separation arcsec	kpc	REF
1107+036(OTL) 0.963 18.9	ANON 0.0291 17.0	20	17							73,70
1108+289 2.192 20	N3550(Pec) 0.0351 14.2	532	543	N3552 – 15	389	–	N3553 – 15	389	–	1,51
"	N3554 0.0291 15.5	327	277	N3558 0.0299 15.0	574	501	N3561 0.0285 14.7	66	55	1,51 70
1109+357(1E) 0.91 18.1	N3569(S0) 0.027 14.5	31	24							8
1112+431(PG) 0.302 17.89	faint galaxies(88)									
1113+183 2.20 18.6	N3599(E/S0) 0.0028 13.0	326	26							1
1113+182 1.9 19.5	N3605(E/S0) 0.0023 12.7	458	37							1
1114+183 1.9 19.7	"	600	48	N3608(E) 0.00399 11.7	574	46				1
1114+184 2.20 20.3	N3607(E) 0.0033 10.2	507	41	"	150	12				1
1114+445(PG) 0.144 16.05	faint galaxies(88)									
1115+080 (A/B) 1.722 15.84	ANON(S) – –	101	–	UGC6312(S) – 14.9	369	–	faint galaxies(88)			2
1116+215(PG) 0.177 15.17	faint galaxies(88)									
1117+137 2.15 19.7	N3628(Sb dstb) 0.0028 11.5	278	19							1
1117+139 2.06 19.9	"	468	33							1
1118+138 2.43 21.2	"	341	24							1

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1117-248(PKS)	faint									
0.466	galaxies(90)									
17.07										
1117+535(SBS)	N3631(Sc)									1
1.921	0.0038									
18.0	11.0	503	60							
1121+423(PG)	faint									
0.224	galaxies(88)									
1123+356(CSO 340)	faint									
1.285	galaxies(94)									
17										
1124+571(OM540/4)	N3683									1
2.89	0.0056									
19.0	12.7	172	30							
1127-145(PKS)	ANON									
1.187	0.313									
16.9	–	9.5	86							
1128+315(B2)	ANON			ANON			ANON			25,70
0.289	0.2896			–			0.2920			
16.6	–	7	59	–	28	–	–	35	294	
1130+473g(BSO1)	ANON(Pec)			N3726(Sc)						9,1,70
1.13	0.0320			0.0028						
18.4	15.1	100	93	10.95	987	87				
1131+350(CSO 352)	ANON									94
0.204	–	5	–							
17	–									
1137+660(3CR263)	faint									
0.646	galaxies(88)									
16.32										
1138+040(PG)	faint									
1.877	galaxies(88)									
16.05										
1141+202g(QSO1)	N3837(E)			N3840(Sa)			N3841			52,1
0.335	0.0208			0.0246			0.0212			
18.5	14.2	199	126	14.7	470	299	15.0	113	72	
"	N3862(3CR264)			N3842(E)			N3844(SD)			52,1
	0.0208			0.0208			0.0228			
	12.74	1557	940	13.3	78	47	14.9	290	184	
"	N3845			N3851						52,1
	0.0188			0.0216						
	15	205	130	15	307	195				
1141+202g(QSO2)	N3837(cont)			N3840(cont)			N3841(cont)			52,1
0.946										
18.5		292	186		457	290		108	69	

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
"	N3862(cont)	1522	920	N3842(cont)	60	36	N3844(cont)	259	165	52,1
"	N3845(cont)	124	78	N3851(cont)	178	113	N3861B – 15.0	592	376	52,1
1141+202g(QSO3) 2.205 21	N3837(cont)	216	137	N3840(cont)	542	344	N3841(cont)	176	112	52,1
"	N3862(cont)	1450	880	N3842(cont)	74	45	N3844(cont)	346	220	52,1
"	N3845(cont)	218	139	N3851(cont)	236	150				52,1
1146-037(PKS) 0.341 16.9	faint galaxies(88)									
1146+562(W1) (0.958) 19.2	N3898(Sa) 0.0037 11.7	453	49							1
1148+549(PG) 0.969 15.82	N3992(SBb) 0.0038 10.7	6060	670							2
1150+497(4C49.22) 0.334 17.10	ANON 0.2889 –	21	176							1,70 90
1151+117(PG) 0.176 15.51	ANON – –	–	–	faint galaxies(88)						16
1153+534(W1) 1.75 20.3	ANON(S dstb) – 14.1	280	31							25,70
1156+295(4C29.45) 0.729 14.41	faint galaxies(88)									
1158-187(POX42) 2.448 16.93	N4038(SB) 0.0055 11.3	1064	143							38
1200-051(PKS) 0.381 18	faint galaxies(90)									
1202-262(PKS) 0.789 19.5	N4087 0.0111 13.0	50	16							1

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1203+109(4C10.34)	N4082									1
1.088	0.0233									
17.32	15.0	595	403							
1205-008(PKS)	ANON									54,70
1.007	0.306									
18.6	17.5	9.4	84							
1205+644(1E)	3CR268.3									53
0.105	0.371									
17.70	20	762	>1000							
1206+459(PG)	N4144(Sc)			N4258(Sb)						2
1.158	0.0011			0.0018						
15.79	12.3	2886	88	9.6	8526	431				
1206+439(3CR268.4)	N4138(S0)									19,70
1.40	0.0036									
18.42	12.1	174	18							
1207+399	N4145A									1
2.4	0.0029									
17.5	15.5	567	57							
1207+397(W4)	N4151Sa/SBb			N4156(SB)						55,1
Cont.	0.0032			0.0224						
20.3	11.2	283	27	14.3	290	190				
1208+322(B2)	ANON									25,70
0.388	0.1494									
16.0	–	34	148							
1209+107(KP9)	ANON			ANON						71,72
2.191	0.3922			0.629						
17.76	21.9	7	80	23	1.3	24				
1210+134(4C13.46)	N4193(Sb)									1
1.137	0.0083									
18.09	13.4	357	86							
1213+132	N4216(Sb)									1
2.562	0.00045									
18.9	11.2	481	51							
1216+069(PG)	faint									
0.334	galaxies(88)									
15.68										
1216+695	N4236(SB)									14
0.627	–									
17.0	10.7	1200	21							
1217+151(A3 12)	N4262(SB0)									1
0.564	0.0046									
19.0	12.3	181	19							
1217+023(PKS)	faint									
0.240	galaxies									
16.53	(88,90)									

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1218+753(1E)	ZW1210.9+7520									8
0.645	–									
18.16	15.4	94	–							
1219+047	N4303(SBc)			N4292(S0)			N4294A			1,14
0.094	0.0052			0.0075			–			
16.8	10.9	331	35	14.1	441	97	15	531	–	
1219+755(MKN205)	N4319(SB)									56,70
0.07	0.0062									
14.5	13.0	42	4.5							
1219+285(W Com)	N4295									1
Cont	0.0285									
16.5	15	336	279							
1219+116	N4294(Sc)			N4299(Irr)						1
2.178	0.00119			0.00074						
18.5	12.6	491	52	12.8	389	41				
1220+160	N4321(Sc)			N4328						14,1
0.081	0.0052			0.0017						
15.9	10.6	546	58	15.0	250	26				
1221-113(MC2)	N4352(S0)									1
1.755	0.0070									
18	14.5	443	47							
1222+216(4C21.35)	faint									
0.435	galaxies(90)									
17.5										
1222+131	N4374(3CR272.1)			N4387(E)						1
1.250	0.0031			0.0019						
18.5	8.67	158	17	13.2	534	57				
1222+135(RMB98)										74
1.792	"									
18.0		1505	161							
1221+758(W1)	N4386(S0)									1
1.632	0.0055									
18.8	12.6	374	40							
1222+102(WDM6)	N4380(Sa)									10,70
cont.	–									
17.6	13.4	88	9.3							
1222+228(Ton1530)	faint									
2.040	galaxies(88)									
15.49										
1223+252(Ton616)	ANON									25,70
0.268	0.0911									90
16.0	–	34	90							
1223+338g(UB1)	ANON(Sc)			N4395						7,27
1.265	0.0220			0.0010						70
18.7	17	145	93	10.5	–	–				

TABLE 2—*Continued*

QSO	Galaxy	Separation		Galaxy	Separation		Galaxy	Separation		REF
		arcsec	kpc		arcsec	kpc		arcsec	kpc	
1223+338g(B6)										7,27
1.038	"			"						70
18.4		329	211		–	–				
1223+338g(U3)										7,27
(1.677)	"			"						70
18.7		946	602		–	–				
1223+338g(UB1)										34,70
0.77				"						
19.2					370	108				
1218+339(3CR270.1)										27,70
1.519	"									
18.61		303	194							
1226+023(3CR273)	ANON			N4420(Sc)						57,2
0.158	0.1575			0.0052						70
12.86	20.3	75	345	12.7	4770	506				
1226+136(1E)	N4458(E)			N4473(E)						1
0.150	0.0023			0.0074						
17.19	13.3	535	57	11.2	493	52				
1226+126	N4476(S0)			3CR274(M87)						1
2.279	0.0065			0.0043						
19.4	13.3	565	60	8.7	1213	129				
1226+130										1
2.502				"						
20.5					2350	251				
1227+122				"						1
2.178										
18.5					1662	177				
1228+123(1E)										1
0.116				"						
17.10					1270	135				
1229+117	N4497(S0)									1
(2.23)	0.0037									
20.1	13.8	586	62							
1229+645(1E)	N4510(E)									8
0.17	0.009									
16.89	14.2	83	22							
1229+204(TON1542)	UGC7697(Sc)									2,89
0.064	–									
15.3	15.3	672	–							
1232+125(WDM8)	N4550(E)			N4551(E)						10,1
0.723	0.00093			0.0040						70
17.21	12.7	44	4.7	13.1	218	23				
1233+268	ANON									42
1.82	–									
19.8	–	30	–							

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1233+268	N4555(E)									1
1.99	0.0221									
20.2	13.5	372	239							
1233+260	N4562(Sc)			N4565A(Sc)						1
2.04	0.0047			–						
20.5	14.6	463	49	14.5	463	296				
1233+262							N4565(Sb)			1
2.09	"			"			0.0041			
21.0		587	62		587	376	10.3	411	47	
1233+264	N4565B			N4565C						1
2.40	0.0210			0.0210						
19.1	15.5	260	166	15.5	326	209				
1233+266										1
2.10				"						
21.6					582	372				
1241+166(3CR275.1)	N4651(Sc)									27,70
0.557	0.0025									
19.0	11.3	210	22							
1241+176(PG)	faint									
1.273	galaxies(88)									
15.38										
1246-057	N4697(E)			N4731(SB)						2
2.236	0.0036			0.0045						
16.73	10.6	780	83	11.60	2280	242				
1247+267(PG)	N4725(Sb)			faint						2
2.038	0.0040			galaxies(88)						
15.53	10.2	3690	391							
1248+401(PG)	N4736(S)			faint						2
1.030	0.0012			galaxies(88)						
16.06	8.7	4566	152							
1253+104(MC2)	ANON									12,70
0.824	–									
18.2	14.0	90	–							
1254+047(PG)	N4765(S)			faint						2
1.024	0.0023			galaxies(88)						
15.84	13.0	1212	74							
1254+278	N4824									1
(2.05)	–									
21.0	–	79	–							
1255+278	N4839(E)			N4840(E)			N4842(E)			1
1.52	0.0245			0.0202			0.0250			
19.4	13.6	305	195	15.0	346	221	15.0	278	178	
1254+279										1
2.65	"			"			"			
20.4		499	319		209	133		327	209	

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1255+278										1
1.98	"			"			"			
20.1		385	246		380	243		353	226	
1254+282	N4828			N4850						1
1.88	0.0204			0.0199						
20.8	15.5	491	314	15.5	561	359				
1255+282										1
2.11				"						
20.8					184	118				
1256+278	N4854			N4853						1
1.62	0.0269			0.0251						
20.6	15.0	479	307	14.0	246	157				
1256+280							N4869			1
2.66	"						0.0226			
21.0		482	308				15.0	490	314	
"	N4875			N4876						1
	0.0263			0.0222						
	15.5	572	366	15.0	572	366				
1256+280	"			"			N4894			1
2.30							0.0153			
21.1		512	328		512	328	15.5	583	373	
"							N4898			1
							0.0229			
							14.5	527	337	
1256+281	"			"						1
0.384										
19.5		254	163		254	163				
"	N4864			N4867			N4869(cont)			1
	0.0226			0.0158						
	15.0	320	205	15.5	371	237		111	71	
"	N4871			N4872			N4873			1
	0.0237			0.0239			0.0188			
	15.0	300	192	15.5	309	198	15.5	352	225	
"	N4974(S0)									1
	0.0239									
	13.5	350	224							
1258+281	N4906			N4911A			N4911(S dstb)			1
1.92	0.0249			–			0.0267			
21.0	15.0	251	161	15.0	285	182	13.7	324	207	
"	N4919(S0)			N4921(S)			N4894(cont)			1
	0.0270			0.0182						
	14.9	438	280	13.7	432	276		558	357	
"							N4898(cont)			1
								523	335	

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1258+280 (1.93) 20.4	N4906(cont)	563	360	N4911A(cont)	151	116	N4911(S)(cont)	249	159	1
"	N4919(S0)(cont)	118	81	N4921(S)(cont)	299	191	N4923 0.0182 14.5	266	170	1
1259+281 0.243 18.5				N4911A(cont)	427	273	N4911(S)(cont)	524	335	1
"	N4919(S0)(cont)	231	148	N4921(S)(cont)	144	76	N4923(cont)	55	29	1
1256+284 2.16 19.2	N4881(E) 0.0223 14.5	455	291	N4858 0.0313 15.5	479	307	N4860 0.0264 14.5	387	248	1
"	N4865(E) 0.0162 14.5	520	333							1
1258+285(US136) 1.355 17.4	N4896(E/S0) 0.0194 15.0	419	268							1
1258+287(5C4.105) 0.648 17.9	"	553	354							1
1257+286(XComae) 0.092 17.5	"	213	136							1
1258+286(W61972) 1.922 17.75	"	277	177							1
1259+593(PG) 0.472 15.60	ANON(S) 0.0225 –	876	561	faint galaxies(88)						2
1300+284(US189) 1.302 17.6	N4943 0.0182 15.5	590	378	N4944(S) 0.0237 13.5	456	289				1
1302-102(PKS) 0.286 14.92	ANON 0.1458 –	34	144	ANON 0.0940 –	39	107	N4939(Sbc) 0.0099 –	1746	503	25,2 70,88
1303+291 2.07 22.5	N4966(S) 0.0234 14.0	555	355							1
1304+293 2.10 20.1	"	498	319							1

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1304+293										1
0.26	"									
20.4		462	296							
1305+069(3C281)	faint									
0.602	galaxies(88)									
17.02										
1306+276(US323)	3CR284									1
0.462	0.2394									
18.5	18	1841	>1000							
1307+085(PG)	ANON									16
0.155	–									
15.28	–	–	–							
1307+298	N5004C									1
(1.81)	0.0238									
18.5	15.5	553	354							
1308+297										1
1.85	"									
17.4		534	342							
1308+286	ANON									42
2.39	–									
21.5	–	25	–							
1309+355(PG)	N5033(Sbc)			faint						2
0.184	0.0031			galaxies(88)						
15.45	–	4902	426							
1313+422g(UB1)	ANON(S pec)			N5055(Sb)						7,70
0.91	–			0.0016						
18.3	15.5	315	–	9.7	1477	79				
1317-122(1E)	ANON									8
0.33	–									
18.3	16	10	–							
1319+388g(UB1)	N5112(SB)			N5107						1
0.949	–			0.0031						
19.5	12.5	760	74	13.7	40	3.6				
1322+659(PG)	ANON									16
0.168	–									
15.86	–	–	–							
1327-206(PKS)	ESO1327-2041(S)									58
1.169	0.0180									
17.04	–	38	20							
1328-173	N5170(Sb)									38
0.329	0.0050									
18.6	11.9	1760	220							
1325-289	N5236(SB)									38
1.412	0.0017									
18.5	8.5	4530	152							

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1325-298										38
1.963	"									
19.1		4150	139							
1329-287										38
2.089	"									
19.0		3140	105							
1333-298										38
1.906	"									
18.9		750	25							
1343-281										38
2.274	"									
18.3		5560	186							
1345-301										38
1.438	"									
18.9		5710	192							
1329+412(PG)	faint									
1.935	galaxies(88)									
16.30										
1331+025(PKS)	3CR287.1(N)									1
1.228	0.2159									
18.85	18.27	1373	>1000							
1332+552(4C55.27)	ANON A			ANON B						59
1.249	0.373			0.373						
16	–	5	54	–	14.6	158				
1333+176(PG)	ANON(E)			ANON(S0)			faint			2
0.554	0.0227			0.0231			galaxies(88)			
15.64	–	804	536	–	1008	671				
1333+035(1E)	ZW1333.8+0335									8
0.85	0.024									
17.98	14.9	41	29							
1338+416(PG)	faint									
1.219	galaxies(88)									
16.08										
1342+440g(BS01)	N5296(Sc)			N5297(Sc)						9,70
0.963	0.0083			0.0086						
19.26	15.0	55	13	12.3	144	35				
1348+384(UT)	N5325A			N5325B						1
1.39	0.0113			–						
18.0	15.0	579	191	16.0	427	141				
1351+318(B2)	3CR293									1
1.326	0.0452									
17.4	14.37	1559	>1000							
1352+183(PG)	faint									
0.152	galaxies(88)									
15.5										

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1352+011(PG) 1.121 16.03	faint galaxies(88)									
1354+198(PKS) 0.720 16.02	faint galaxies(88)									
1354+048 1.234 17.8	N5364(S) 0.0046 13.2	–	–							2
1354+213(PG) 0.300 15.85	faint galaxies(88)									
1355-416(PKS) 0.313 15.86	N5408(Irr) 0.0017 –	3420	99							2
1358+043(PG) 0.427 16.31	faint galaxies(88)									
1359-058 1.996 17.8	N5426/7(Sbc) 0.0086 12.8/12.1	3270	794							38
1400+095 2.980 18.5	N5424(S0) 0.0201 14.3	542	317	N5431 0.0191 15.0	381	212	N5434B 0.0154 14.5	484	217	1
"	N5434A 0.0154 14.5	376	169	N5469 – 15.5	541	–				1
1400+162(4C16.39) – 16.37	faint galaxies(90)									
1401+098(1E) 0.441 16.2	N5436(S0) 0.0220 14.9	517	332	N5437 – 15.0	572	–	N5438 0.0235 14.5	404	277	1
1402+261(PG) 0.164 15.57	faint galaxies(88)									
1403+546 0.082 16.8	N5457(Sc) 0.0009 8.7	1080	40	N5477(Sc/Irr) 0.0013 14.5	235	8.6				14
1407+265(PG) 0.944 15.73	ZW162.065(S) – –	470	–	faint galaxies(88)						2
1409+524(1E) 1.29 22.03	3CR295 0.4614 20.20	110	>1000							1

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1415+254	N5548(Sa)									1
2.31	0.0169									
19.3	13.1	593	285							
1415+254(1E)										1
0.560	"									
20.0		561	269							
1415+259(1E)										1
cont.	"									
16		2100	1009							
1415+451(PG)	faint									
0.114	galaxies(88)									
15.74										
1416+067(3CR298)	faint									
1.436	galaxies(88)									
16.79										
1421+201(KP45)	3CR300									1
1.48	0.270									
19	18	1423	>1000							
1425+267(TON202)	ANON(S)									2
0.362	0.0141									
15.67	–	269	110							
1427+480(PG)	faint									
0.221	galaxies(88)									
16.33										
1428+498g(UB2)	N5660(Sc)									9,70
0.205	0.0082									
17.3	12.3	483	114							
1430+101g(UB1)	ANON			N5669(Sc)						7,70
0.766	0.0046			0.0046						
17.7	15.3	70	8.8	13.2	360	45				
1432+489(BSO1)	N5682(SBb dstb)			N5683			N5689			7,1
1.94	0.0080			0.0391			0.0072			70
19.2	15.1	95	21	15.5	158	180	12.7	490	108	
1441+522(3C303C)	3CR303									60,70
1.570	0.141									90
19.97	17.29	20	82							
1444+407(PG)	faint									
0.267	galaxies(88)									
15.95										
1458+718(3CR309.1)	N5832(Sb)			faint						27,70
0.905	0.0014			galaxies(88)						
16.78	13.3	372	16							
1505+559g(BSO1)	N5866(S0)									9,70
0.706	0.0032									
18.1	11.1	436	35							

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	kpc	Galaxy	Separation arcsec	kpc	Galaxy	Separation arcsec	kpc	REF
1510-089(PKS)	ANON									25,70
0.361	0.2536									
16.52	–	25	184							
1511+103(MC2)	ANON									77
1.546	0.4359									
17.73	–	6.7	85							
1512+370(4C37.43)	ANON			faint						25,70
0.371	0.3722			galaxies(88)						
15.5	–	11	118							
1518+201	3CR318									1
2.1	0.752									
19.2	20.3	1167	>1000							
1518+202										1
2.10	"									
19.9		748	>1000							
1525+159(1E)	UGC9846(Sc)									2
0.230	–									
17.24	14.7	2616	–							
1525+227(LB9743)	ANON			ANON						25,70
0.253	0.2519			–						
16.39	–	33	240	–	40	–				
1530+151(1E)	N5951(Sc)									1
0.090	0.0059									
18.0	13.8	460	70							
1537+595g(UB1)	N5981(S)			N5982(E)			N5985(Sb)			7,1,70
2.132	0.0094			0.0098			0.0084			
19.0	14.2	107	28	12.5	257	67	12.0	714	187	
1537+595g(UB2)										7,1,70
1.968	"			"			"			
19.0		743	194		1086	284		740	194	
1538+149(4C14.60)	faint									
–	galaxies(90)									
15.5										
1543+489(PG)	ANON(S)			ANON(S)			faint			2
0.400	–			–			galaxies(88)			
16.05	–	34	–	–	40	–				
1545+210(3CR323.1)	ANON			faint						43,70
0.264	0.270			galaxies(88)						
16.69	19.0	370	2906							
1548+114(A)	ANON			ANON						25,70
0.436	0.4338			0.4327						
17.23	–	9	113	–	12	151				
1548+114(B)										25,70
1.901	"			"						
19.0		9	113		12	151				

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	kpc	Galaxy	Separation arcsec	kpc	Galaxy	Separation arcsec	kpc	REF
1549+203(LB906)	3CR326			ZW107.051						1,2
0.250	0.0895			–						
17.4	17	527	>1000	–	534	–				
1552+085(PG)	ANON			faint						16
0.119	–			galaxies(88)						
16.02	–	–	–							
1602+178(CL4)	N6039			N6040			N6041(E)			1
3.003	–			0.0413			0.0342			
19.5	14.5	598	–	14.5	598	719	14.9	448	446	
"	N6042			N6043			N6044			1
	0.0347			0.0599			0.0331			
	15.5	394	398	15.5	132	23	15.5	411	396	
"	N6045(Sb)			N6047			N6050			1
	0.0330			0.0315			0.0319			
	14.8	89	86	15.5	117	107	14.9	263	245	
"	N6054									1
	0.0372									
	15.5	360	390							
1603+179(CL8)										1
(1.813)	"									
21.0		513	556							
1602+241(1E)	N6051(E)									1
0.087	0.0319									
17.1	14.9	403	375							
1603+183(CL7)	N6053			N6055(S0)			N6057			1
1.620	–			0.0377			0.0348			
20.0	15.5	447	–	15.4	161	177	15.5	247	250	
1603+181(CL9)	"			N6056						1
(2.066)				0.0388						
20.0		517	–	15.0	472	553				
1612+262(TON256)	ANON(S)			ANON			faint			61,70
0.131	0.1205			0.1318			galaxies			
15.41	–	210	764	–	300	1091	(88,90)			
1612+266(NAB)	N6096									1
0.395	0.0326									
17.3	15.5	453	431							
1613+658(PG)	N6140(SBc)			ANON(S)			faint			2,62
0.129	0.0038			–			galaxies(88)			
15.37	12.6	2820	312	–	20	–				
1614+051(PKS)	ANON									63
3.210	3.125									
19.5	–	–	–							
1617+175(PG)	ANON			ANON			faint			16
0.114	–			–			galaxies(88)			
15.46	–	–	–	–	–	–				

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1618+177(3CR334)	faint									
0.555	galaxies(88)									
16.41										
1630+377(PG)	faint									
1.471	galaxies(88)									
15.96										
1632+391(4C39.46)	ANON(S)									76
1.082	0.3662									
18	–	4.2	28							
1633+335	ANON									42
3.33	–									
20.6	–	17	–							
1634+628(3CR343)	3CR343.1									1
0.988	0.750									
20.6	20.71	1741	>1000							
1634+627(KP85)	"									1
1.49										
18.5		1479	>1000							
1634+706(PG)	faint									
1.334	galaxies(88)									
14.90										
1635+119(MC 2)	faint									
0.146	galaxies(90)									
16.50										
1640+396	MCG7-34-136									8
0.540	0.034									
18.3	15.2	180	178							
1640+401	MCG7-34-137(E)									14
0.986	–									
17.1	14.8	120	–							
1641+399(3CR 345)	faint									
0.595	galaxies(88)									
15.96										
1641+398	N6212									1
2.0	0.0302									
21.2	15	277	243							
1642+398										1
2.179	"									
20.5		559	491							
1641+399										1
0.704	"									
16.8		314	276							
1641+399										1
0.594	"									
19.3		356	313							

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
1642+397	"									1
2.3										
20.6		459	403							
1641+399(3CR345)										1,90
0.595	"									91
15.96		252	221							
1641+399										1
1.083	"									
18.4		204	179							
1641+399										1
2.0	"									
20.9		208	183							
1654+137(MG)	ANON									68
1.74	0.254									
20.93	18.66	3	23							
1700+518(PG)	ANON			faint						16
0.288	–			galaxies(88)						
15.43	–	–	–							
1700+642(HS)	ANON A			ANON B						92
2.72	0.086			0.19						
16.1	18.8	11	30	–	18	100				
1701+610	N6292(S)			ANON			ANON			1,64
0.164	0.0113			0.052			0.052			
17.0	14.4	333	110	–	29	44	–	38	57	
1704+608(3CR351)	N6306(Sab)			faint						2
0.371	0.0107			galaxies(88)						
15.90	14.3	1080	336							
1749+701(W1)	N6503(Sc)									10,70
cont.	0.0009									
16.5	10.9	324	9.5							
1821+642(E)	ANON									2
0.297	–									
14.1	–	90	–							
1828+487(3CR 380)	faint									
0.692	galaxies(88)									
16.81										
1912-550(PKS)	ANON									77
0.402	–									
16.49	–	–	–							
1953-325	ANON(E)									32
1.242	–									
20.5	–	32	–							
2020-370(PKS)	ANON			Klemola 31A(S)			Klemola 31B(E)			10,2
1.048	0.0290			0.0288			0.0285			70,81
17.5	–	21	18	–	18	15	–	45	37	

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TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
2112+059(PG)	faint									
0.466	galaxies(88)									
15.52										
2126+073[1](3C435B)	3C435A									69
0.0,0.865	0.461									
19.4	21	10	140							
2128-123(PHL1598)	ANON									65,77
0.501	0.430									
15.46	–	8.6	108							
2135-428	N7095									1
1.46	–									
17.91	–	309	–							
2135-147(PKS)	ANON			ANON			ANON			25,70
0.20	0.1997			0.2002			0.2008			77
15.91	–	6	35	–	16	93	–	43	250	
2141+175(PKS)	ANON									25,70
0.213	0.2106									
15.5	–	38	221							
2145+067(PKS)	ANON			faint						77
0.99	0.7897			galaxies(88)						
16.47	–	5.9	135							
2158-135(BSO1)	IC1417			N7171						10,1
0.71	–			–						70
17.6	–	76	–	12.5	790	211				
2200-205	N7188									1
(0.81)	–									
19.8	14.0	255	–							
2201+315	faint									
0.297	galaxies(88)									
15.47										
2203+292	3CR441			ANON						66
4.406	0.707			0.202						
22.0	21.0	51	1050	–	7	41				
2215-037	ANON									26
0.241	0.095									
17.2	–	27	74							
2216-038(4C–03.79)	faint									
0.901	galaxies(88)									
16.52										
2230+114(CTA102)	N7305									1
1.037	0.0260									
17.33	15.0	332	251							
2233+134(PG)	faint									
0.325	galaxies(88)									
16.04										

[1] If this is not a QSO, it is star superposed on source(69).

		Separation			Separation			Separation		
QSO	Galaxy	arcsec	kpc	Galaxy	arcsec	kpc	Galaxy	arcsec	kpc	REF
2237+030	ANON									82
1.695	0.0394									
16.78	15	0	0							
2247+140(4C 14.82)	faint									
0.237	galaxies(88)									
16.93										
2251+113(PKS)	ANON			ANON			ANON(S)			25,2
0.323	0.3228			0.3312			0.0360			70
15.77	–	28	260	–	41	382	–	252	264	
"	ANON(S)			ANON(Sd)						25,2
	0.0273			0.0285						
	–	624	496	–	660	547				
2251+158	faint									
0.859	galaxies(88)									
16.1										
2252+129(3CR455)	N7413(E pec)			N7414						19,1
0.543	0.0330			–						70
19.7	15.2	24	23	–	261	–				
2257+157g(UB1)	N7448(Sc)			N7465(SB0)			N7464			7,1,70
1.66	0.0073			0.0073			0.0063			
19.2	12.0	1930	465	13.3	128	31	14.50	190	40	
"	N7463									7,1
	0.0081									
	13.50	230	49							
2305+187(4C18.68)	ANON			ANON			faint			25,70
0.313	0.2427			0.2424			galaxies(88)			
17.5	–	7	49	–	35	247				
2308+098(4C09.72)	ANON			faint						25,70
0.432	0.1726			galaxies(88)						
16.0	–	9	45							
2315-049g(UB1)	N7576(S0)			N7592(S)			N7585			7,70
1.41	0.0119			0.0248			0.0112			
18.7	14.0	–	–	–	415	295	13.0	–	–	
2315-425	N7582(Sb)			N7590(Sa)						1
2.83	0.0052			0.0050						
20	12	525	80	12.5	551	79				
2326+167(MC 3)	faint									
0.284	galaxies(90)									
18.3										
2333+019(UB1)	N7714(S)			N7715(S)						67,1
1.871	0.0100			0.0092						70
18.0	13.0	120	33	15	202	55				
2334+019(UB2)										67,1
2.193	"			"						70
19.0		480	130		401	109				

TABLE 2—*Continued*

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
2344+092(PKS)	ANON(S)			faint						2
0.672	0.0426			galaxies(88)						
15.97	–	235	287							
2349-014(PG)	faint									
0.174	galaxies(88)									
15.33										
2355-329	N7793									1
0.071	0.0007									
18.2	10.0	218	4.4							

NOTE.—For most of the 3CR galaxy–QSO pairs in the table the angular separations are large, and the redshifts are comparatively large, so that the projected separations depend sensitively on the value of q_0 assumed. Since these pairs are not used in the analysis, we have simply put these separations higher than 1000 kpc.

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(Note added in proof follows)

Note added in proof.—The following table includes four pairs of galaxies which have been discovered since Table 2 was completed.

ADDENDUM TO TABLE 2

QSO	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	Galaxy	Separation arcsec	Separation kpc	REF
0119+115(PKS)	ANON									1,2
0.570	-									
19	-	2								
0838+770(PG)	UGC 04527									3
0.131	17									
16.30	-	130								
1228+397(B3)	ANON			ANON						4
2.217	18.0			18.0						
17.7	-	26		-						
1343+284	ANON									5
0.659	-									
18.0	-	5								

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