M31 and Local Group QSO's

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ABSTRACT

Previous analyses have shown companion galaxies aligned along the minor axis of M31. The alignment includes some galaxies of higher redshift than conventionally accepted for Local Group members. Here we look at the distribution of all high redshift objects listed in a 10 x 10 deg. area around M31. We find not only galaxies of higher redshift but also quasars along the minor axis of this brightest Local Group galaxy. Some are an unusual class of low z, quasar-galaxy. Previously observers had noted radio sources aligned along the minor axis of M31. The ejection directions of quasars from active galaxy nuclei is also along the minor axis within a cone of about 20 deg. opening angle. It is shown here that the quasar-like and higher redshift objects associated with M31 are relatively concentrated along this axis.

M33 also falls closely along the minor axis of M31 and the famous 3C48 and similar redshift galaxy/quasars are seen along a line coming from this Local Group companion of M31. What appears to be dusty nebulosity has also been shown to exist along this extended line in the sky.

Subject headings: galaxies:individual (M31) - quasars: general

1. INTRODUCTION

Considerable evidence has by now been published showing quasars and high redshift galaxies associated with active galaxies (Burbidge et al 2003; Arp 1998a; 2003; Arp and E.M. Burbidge 2005). The question then arises: Do some galaxies show these associations even though they are at low levels of activity? To address this question we investigate M31, which is considered to be a prototype, normal Sb galaxy. Being the closest large galaxy to us, we can also observe to low luminosity possible objects belonging to M31.

To our surprise, as soon as we plotted the quasars in the area, there emerged a striking example of alignment of high and low redshift objects along the minor axis stretching across the Local Group from M31.

2. QSO’s around M31

Fig. 1 shows the result of plotting all quasars (z ≤ 2.4) listed in NED inside a 10 x 10 deg square around M31. The 10 innermost quasars group closely around M31 and are noticeably aligned along its minor axis. Then there are 9 quasars about 3 degrees distant which are distributed in an arc. Unrelated background objects would not be expected to form such configurations. In addition the apparent magnitudes written next to each quasar are noticeably brighter than quasars normally found in other areas of the sky.
2.1. Completeness of the NED Catalog

In the 44 years since their discovery many quasars have been measured all over the sky and it is interesting to see now what is known about those that happen to fall near M31. Table 1 here lists 37 NED quasars within 5 degrees of M31. It is apparent that many of them have been discovered more than once, e.g. as radio sources, in Hamburg objective prism, 2MASX infrared, X-ray surveys and occasionally from color. These are measures made over the large region in the direction of the Local Group center but not necessarily specifically on or near M31. An exception consists of 5 quasars identified from CFHT slitless spectrum observations of M31 (Crampton et al. 1997) and one near M31 by van den Bergh (1966). They are marked UV in Table 1, and excluded from numerical calculations. The rest of Table 1, as recorded between 1 and 5 degrees, should have no selection bias associated with the position of M31.

But in fact we see that there is an excess of quasars within about 1 to 4 degrees around M31. We independently verify this by sampling 84.8 square degrees of control fields outside the 5 degree circle. As an additional test of association we show that within this 5 deg. circle the quasar density diminishes away from M31 (Fig. 2).

Finally, and most importantly here, we show (Figs. 3 and 7) that the quasars nearest M31 define almost exactly the ejection cones along the minor axis which were empirically obtained from superposing data from previous quasars associated with active galaxies (Arp 1998a p.87).

Note: The quasars in Table 1 tend to be bright for their redshift as expected if there is any physical association with M31. (Most of the apparent magnitudes are in V wavelengths as in Véron and Cet Véron but we have added four in r (mag.) from USNO-A 1.0 positional identifications. Homogeneity in magnitude systems is to be wished but quasars are variable and for current purposes approximate values are adequate.)

Note also: Table 1 prints out what NED designates as QSO’s. In five cases a G is further noted for type. Upon investigation it is found the object has been classified once as a QSO and once as a galaxy. The reason for the QSO designation is usually radiation characteristics or the bright absolute magnitude the object would have at its conventional redshift distance. As the remarks following indicate, however, the absolute magnitude definition of a quasar is not empirical but depends on an assumption concerning redshift.

The two lowest redshift objects stand out in Fig.1 because at z = .120, .134 they have strikingly low redshifts to be catalogued as quasars. The reason they are so catalogued is that they have bright apparent magnitudes. But if they belonged to a more distant galaxy than M31, they would have fainter apparent magnitudes and not fit the definition of a quasar as having a luminosity of M ≤ -23 mag. Hence they would not be listed as quasars. At their redshift distance they would be near the upper luminosity for galaxies.

The preceding comment raises a difficulty in the definition of quasars. It has been a definition depending on a theory that the redshift means distance. The definition should preferably be an empirical criterion of morphology and spectroscopic characteristics which admits of a continuous transition of properties between quasars and galaxies.

To emphasize the unusual finding of QSO’s between z = .120 and .189 we note that we get a density of 1.1/sq.deg. close to M31. But in the control areas off the three corners of Figs. 1 and 3 we get only .01/sq deg. The mean apparent mag. of those near M31 is 17.4 mag. whereas in a 2dF sample in the -30 deg. strip the average magnitude at such redshifts is 19.0 mag.

If we wait until complete optical surveys such as 2dF and SDSS are done in our Local Group area we would expect more quasars but they would be fainter and probably predominantly background objects. As
of now the Hamburg objective prism survey covers the Local Group area ($|b| > 20$, Dec.$> 0$) to almost 18.0 mag. Note 18.0 and 18.4 mag. in Table 1. It would seem that the quasars down to about 18.0 mag. were reasonably complete. It is not useful to refer to quasar densities in other areas of the sky because in the direction of the Local Group quasars are very different. For example quasars of $z > 1.0$ are 6 times their average density in the direction of the Local Super Cluster (Sulentic 1988a,b). The quasars in the M33 direction are much different in magnitude and redshift than in the Virgo Cluster direction (Arp 1984b). In any case it is unlikely that there are a large number of unmeasured QSO’s in the 17 to 18 mag. range which could erase the concentration around M31.

![Fig. 1.— Quasars with $z < 2.40$ in a square 10 x 10 deg. around M31.](image-url)
| Object       | r(arc min.) | z  | mag. | Remarks                      |
|--------------|-------------|----|------|------------------------------|
| B3 0037+405  | 38.5        | .  | 19.3 | Radio, X-ray, BL Lac        |
| B3 0035+413  | 53.0        | 1.353 | 19.9 | Radio, X-ray, var           |
| NGC 224 E R  | 64.9        | .  | 20.5 | UV                           |
| MLA93 0034   | 68.9        | .  | 17.2 | Obj. Prism, red             |
| NGC 224 E J  | 71.4        | 2.400 | 20.2 | UV                           |
| NGC 224 E A  | 84.3        | 1.600 | 18.9 | UV                           |
| NGC 224 C29 U| 104.4       | 1.400 | 18.9 | UV                           |
| HB89 0045+395| 105.3       | .  | 17.4 | Radio, IR, r =16.5          |
| HB89 0034+393| 114.1       | 1.938 | 18.0 | Radio                       |
| B3 0037+405B | 130.2       | .  | 18.8 | Radio, IRS, 15.5 I.D.:      |
| NGC 224 C29 D| 131.1       | 2.400 | 19.3 | UV                           |
| HB89 0043+388| 131.2       | .  | 18.4 | UV                           |
| RX J0049+3931| 132.7       | .  | 18.3 | X-ray, HS                   |
| HS 0033+4300 | 139.7       | .  | 17.2 | Obj. Prism                  |
| HS 0036+3842 | 143.0       | 2.360 | 18.4 | Obj. Prism, IRS             |
| NGC 224 C29 B| 143.1       | 2.900 | 20.2 | UV                           |
| B2 0027+39   | 172.2       | 1.388 | 18.5 | Radio                       |
| HS 0035+4405 | 193.0       | 2.710 | 17.0 | Obj. Prism, IRS             |
| GB6 J0052+4402| 198.3     | .  | 18.3 | Radio                       |
| 4C +37.03    | 211.5       | 1.700 | 18.5 | Radio                       |
| B2 0022+39A  | 213.3       | 1.983 | 20.0 | Radio                       |
| HS 0026+3824 | 220.4       | 1.380 | 17.5 | Obj. Prism, IRS             |
| HS 0058+4213 | 222.2       | .  | 16.0 | Obj. Prism, IRS, blue       |
| B2 0027+38   | 228.6       | 1.066 | 19.3 | Radio                       |
| B2 0022+39B  | 229.7       | 1.946 | 18.6 | Radio                       |
| HS 0042+3704 | 236.1       | 2.410 | 17.6 | Obj. Prism, IRS             |
| B3 0027+377  | 239.8       | 1.450 | 17.4 | Radio, X-ray                |
| HS 0029+3725 | 246.2       | 1.850 | 17.6 | Radio, IRS                  |
| GB6 J0034+3712| 260.0    | .  | 18.9 | Radio                       |
| 87GB 0100+4306| 262.6     | .  | 16.6 | Radio, IRS, red             |
| 4C 36.01     | 263.4       | .  | 18   | Radio, X-ray, IRS           |
| HS 0058+3820 | 265.4       | 1.920 | 18.0 | Obj. Prism                  |
| 4C +43.01    | 267.1       | 1.050 | 19.4 | Radio, IRS                  |
| RGB J0042+366| 275.0       | .  | 17.5 | Radio, X-ray, HS            |
| 87GB 0025+4458| 289.8     | 1.050 | 17.6 | Radio, X-ray                |
2.2. Density of Quasars

Catalogued quasars of all $z$ values are pictured in Fig. 3. We measure their density in concentric annuli around M31. As Table 2 shows, the maximum occurs about $N = (0.42 - 0.45)/\text{sq.deg.}$ between 1 and 4 degrees from the galaxy. By about 5 degrees radius the density has fallen to around $N = 0.11/\text{sq.deg.}$ We note that this is a minimum over-density because there are three candidate QSO’s at 38.5’, 68.9’ and 132.7’ whose redshifts have not yet been measured (although control fields also contain QSO’s missing redshifts).

In the histogram in Figure 2 we would like a sample of background density even further outside the 5 degree radius we have used for the extent of M31. We take four circular areas of 3 deg radius off the four corners of the square in Fig. 3. The R.A. and Dec. of these 28.27 sq.deg. areas are listed in Table 2.

The 01h 12m +34d 00m density of $N = 0.32$ seemed disturbingly large until it was realized that sample fell directly in the extended alignment of M31 companions along the SE minor axis. We find the quasar density along the full extent of the minor axis alignment to be $N = 0.25/\text{sq.deg.}$ This density is 2.3 times the density off the axis all the way to 3C120. The density for the three fields away from this axis was $(0.14 + 0.18 + 0)/3 = 0.11/\text{sq.deg.}$

One way to estimate the significance of the excess quasars around M31 is to calculate the ratio of the numbers of quasars within the 0 to 5 degree radius to the numbers expected from the fields well separated from M31. Since the effect is maximum in the brighter quasars we take quasars with magnitudes $<19$ and omit 3 UV quasars in Table 1 (equaling 21). We then average the three control fields from Table 2, only for mag.$<19$ which yields $(0.14 + 0.11 + 0) = 0.083/\text{sq.deg.}$ Then the significance for the excess around M31 is:

$$(21 - 6.52)/\sqrt{6.52} = 5.7\text{sigma}$$
But if we take all QSO’s, bright and faint, without UV QSO’s, we get a background density of .11/sq.deg. and a 5.6 sigma result. So this is not so sensitive to the magnitude limit adopted. Moreover as we note in Section 2.5 absorption in M31 raises the significance of the excess. We only emphasize here that we find a significant over density of quasars between 1 and 4 deg. from M31 as is visually apparent from the absence of quasars toward the outer edges of Figs. 1 and 3. Note also the apparent ring of 6 quasars $2.4 \leq z \leq 2.7$ around M31 in Fig.3. The low z galaxies also show association with M31, however, and since they are unusual it is interesting to investigate them in more detail.
Table 2: Quasar Density Around M31

| Annulus      | Area(sq.deg.) | N (QSOs) | N/sq.deg. | Remarks                       |
|--------------|---------------|----------|-----------|-------------------------------|
| 0 to 1 deg.  | 3.142         | 1        | .32       | obstructed by M31             |
| 1 to 2 deg.  | 9.425         | 4        | .42       |                               |
| 2 to 3 deg.  | 15.71         | 4        | .25       |                               |
| 3 to 4 deg.  | 21.99         | 10       | .45       |                               |
| 4 to 5 deg.  | 28.27         | 6        | .21       |                               |
| r = 3 deg.   |               |          |           |                               |
| 00h08m+34d00m| 28.27         | 4        | .14       | off corners of M31 square     |
| 00h08m+46d00m| 28.27         | 5        | .18       | “ “                           |
| 01h12m+46d00m| 28.27         | 0        | .00       | “ “                           |
| 01h12m+34d00m| 28.27         | 9        | .32       | M31 minor axis alignment      |
| NGC 404      | 28.27         | 7        | .25       | “ “                           |
| NGC 918      | 28.27         | 7        | .25       | “ “                           |
| 3C120        | 28.27         | 7        | .25       | “ “                           |

2.3. Note on low z, quasar-like objects

It has already been noted that some of the objects near M31 have unusually low redshifts and are only classified as quasars because of their bright apparent magnitudes. If they were slightly fainter they would be calculated to be fainter than the conventional quasar limit of -23 mag. In fact there are other objects near M31 which fall slightly below this arbitrary cut off but which have spectra and morphology very much like quasars. Two examples are shown as small open circles in Fig. 3. One has z = .149 and a listed magnitude of 18.8 mag. But its DSS magnitudes are r = 15.5, b = 17.3 mag. On a luminosity definition it could, paradoxically, be a QSO in the red and galaxy in the blue. It is listed as strong emission (Djorgovski et al. 1995) and there are extremely straight radio ejections coming from the central object (B3 0050+401). The other is B3 0045+395 at z = .252. At apparent mags. r = 16.5 and b = 17.4 mag., and a designation BL Lac?, it certainly is in the conventional quasar category although classed as Sey 1. With these two added to the previously mentioned very low redshift quasars one can see that there is an indication of an unusual kind of quasar associated with M31, the kind of an object that would not be classed as a quasar in a more distant galaxy. On the other hand, the z = .189 object, though usually called a quasar, fails the absolute magnitude criterion.

In the 3 deg. field around NGC 404 (also along the M31 minor axis to M33) there is a z = .107 object at 15.5 mag. (2MASX J01174564+3637145) which is labeled QSO in VCV 2001 (Véron-Cetti and Véron 2001). Actually these kind of low redshift quasars are noticeable around large nearby galaxies. Two at z = .215 and .216 are shown to be associated with the active, ejecting NGC 3079 (Arp and Burbidge 2005). It could be a worthwhile exercise to study just this interval around nearby galaxies versus more distant galaxies where the objects belonging to the galaxy drop in apparent magnitude below the quasar definition.
2.4. Low Luminosity Quasars

If some of the low redshift objects near M31 fall just marginally brighter than the conventional quasar criterion of luminosity, then the question arises: What about objects that are just slightly fainter than this level? Are there more galaxies listed near M31 which resemble quasars in their radiative characteristics? Surprisingly, Fig. 4 shows there are indeed many galaxies, \(0.05 < z < 0.25\), which fall close to the \(M = -23\) mag. line. It suggests that there would be more quasars listed around M31 if their definition did not depend on an arbitrary luminosity which in turn is based upon an inapplicable redshift/distance criterion.

![Fig. 4. -- z/m for galaxies ≤ 5 deg. of M 31. NED redshifts .05 < z < .26. Low z quasar properties marked with plus signs.](image)

**Suggested New Definition of QSO:** A quasar is a compact (high surface brightness) object which shows appreciable non thermal radiation. This would make the spectroscopic or multi wavelength classification be entirely empirical and enable one to study the quasar/galaxy continuity over a range in luminosities. This is already being done for very high redshift galaxies which have just as extraordinarily high redshift as some of the highest redshift quasars but show an underlying stellar spectrum.

Independently of their possible quasar-like properties, however, the important result shown in Fig. 5 is that 40 objects classified as galaxies by NED are physically associated with M31 despite their mean redshift being \(z \sim 0.1\). They are even more strongly concentrated around M31 than the quasars in Figs. 1 through 3.

Question: How do we know the concentration of galaxies around M31 in Figs. 5 and 6 is not a background
Fig. 5.— All galaxies with NED redshifts $0.05 < z < 0.26$. Low z quasar pair labeled $z = 0.12$ and $0.13$.

cluster of galaxies?

Answer: These 40 galaxies are spread out within a diameter of about 8 degrees on the sky. They have an apparent diameter of the order of the Virgo Cluster but a mean redshift about 30 times greater! As a single cluster it would be too large and the internal range in redshifts would be too large. As for multiple clusters in just this line of site there is no evidence for groups of redshifts at discrete values. Finally there is their strongly increasing density toward the center of M31.

It is informative to note that 22 out of the 40 galaxies plotted in Fig. 5 are infrared sources from the all sky, 2MASX survey. Then there are 5 radio galaxies, 4 MCG, 2 Zwicky, 1 Mrk etc. In addition to the size of the association, signs of activity in these galaxies around M31 are already becoming evident.

Fig. 6 shows the increase in galaxies per sq. deg. as annuli closer to the center of M31 are measured. Table 3 gives the numerical densities in the rings.

If we take the outermost ring reading as the density of galaxies unrelated to M31, then we can compute the chance of getting 40 within a 5 degree radius (78.54 degree area) from M31. The calculation gives:

$$\frac{40 - 11}{\sqrt{11}} = 8.7\sigma$$

Even this extremely large sigma is an underestimate of the significance of the association because it does not take into account the monotonic increase in density as the annuli approach M31. Neither does it allow for the obscuration of the background from dusty absorption from M31. The latter could be considerable
Table 3: Density of \(0.05 < z < 0.26\) Galaxies Around M31

| Annulus   | Area (sq.deg) | N (QSOs) | N/sq.deg | Remarks             |
|-----------|---------------|----------|----------|---------------------|
| 0 to 1 deg.| 3.142         | 6        | 1.91     | obstructed by M31   |
| 1 to 2 deg.| 9.425         | 15       | 1.59     |                     |
| 2 to 3 deg.| 15.71         | 8        | 0.51     |                     |
| 3 to 4 deg.| 21.99         | 7        | 0.32     |                     |
| 4 to 5 deg.| 28.27         | 4        | 0.14     |                     |

considering the apparent size of M31.

2.5. Absorption from M31

The disk of M31, in which the dusty absorption is concentrated, is tilted within about 9 deg. of edge on to the observer. One can see from the image of M31 (e.g. Fig. 1) that the near side of the disk is on the NW edge of the ellipse as we see it. This means that the minor axis to the NW is more obscured than the minor axis to the SE. Is this reflected in the number and apparent magnitude of the objects shown in Figs. 3 and 5? Yes. Approximately 5 objects NW in Fig. 3 have average mag. 18.9 while 8 along the SE minor axis have 18.4 mag. The imbalance of galaxies NW re SE is also visually apparent in Fig. 5.

![Fig. 6.— All galaxies with NED redshifts \(0.05 < z < 0.26\). Density in N/sq.deg. in annuli centered on M31.](image)

If the cloud of galaxies under discussion were at its redshift distance it would contain of the order of a dozen galaxies in the \(M_{abs} = -23\) mag. range (See Fig. 4). This is quite unprecedented since the brightest central galaxies we know are in the -21, -22 mag. range. On the other hand, at the distance of M31 the galaxies would be extreme dwarfs in the -7 tp -9 mag. range. (For systematic evidence on the association of
clusters of galaxies with bright, nearby galaxies see Arp and Russell 2001). One suggestion would be that they may represent quasars (which are underluminous to start with if associated with nearby galaxies) that have broken up in the ejection from the interior of M31 and are evolving to, perhaps, globular clusters as they approach the age of the Local Group galaxies. At \( z = .1 \), a late stage in their evolution, these still somewhat active objects have no where to evolve except possibly to clusters which have a range of absolute magnitude with recent star forming medium having been stripped out by various encounters with clouds along the line of exit from the nucleus of the parent galaxy.

Fig. 7.— All quasars from Fig.3 with superposed ejection patterns from previous active galaxies.

2.6. Quasars along the minor axis

In addition to the over density of quasars and near quasars around M31 there is also the point that they are elongated in their distribution and that elongation is markedly along the well defined minor axis of M31. Fig. 7 shows the empirically defined ejection cones from combined data on active galaxies.

The half opening of the cone angle for quasars ejected from active galaxies was observed initially as
\[\pm 20 \text{ deg. with } \pm 35 \text{ deg. for companion galaxies (Arp 1998a, p87). Most recently López Corredoira and Gutiérrez (2007) have confirmed a similar angle of emergence along the minor axis from large survey samples of quasars near galaxies. It is striking that the M31 data here further support these previous results. It is also important for models of evolution from high redshift quasars to low redshift galaxies. Note also the evidence for ejection of radio material along the M 31 minor axis in section 4 of this paper.}\]

**2.7. Pairing of quasars across M31**

While Fig. 1 omitted quasars with \(z \geq 2.40\), Fig. 3 shows all QSO’s including the highest redshifts. Lines connecting apparent pairs have been dashed and emphasize the equal and opposite ejection events which are hypothesized to account for this pervasive property of quasars associated with galaxies.(Arp 2003).

Table 4: Quasar Pairs across M31

| \(z\) | mag. | \(z\) (ave) | Remarks |
|------|------|-------------|---------|
| .120 | 17.2 | .127        | close alignment |
| .134 | 16.5 |             |         |
| 2.623| 18.3 | 2.49        | \(z_K = 2.64\) |
| 2.360| 18.4 |             |         |
| 2.710| 17.0 | 2.56        | \(z_K = 2.64\) |
| 2.410| 17.6 |             |         |
| 1.588| 18.3 | 1.644       |         |
| 1.700| 18.5 |             |         |
| 1.600| 18.9 | 1.500       | \(z_K = 1.41\) |
| 1.400| 18.9 |             |         |

It is impressive to note the similarity of the redshifts and apparent magnitudes of the quasars in the pairs. Some are listed in Table 4. They also tend to be brighter in apparent magnitude than average quasars observed over the sky. (Note the pair of \(z = 2.710\) and 2.410 at the very bright 17.0 and 17.6 mag. There is also a tendency for the average redshift in the pair to fall close to two of the Karlsson preferred redshift peaks at 1.41 and 2.64 (Arp et al. 1990).

Perhaps of greater importance it is clear that the pairs of quasars align within a cone extending in both directions along the minor axis. We will see in the following sections that the accepted companions, higher redshift companions and quasars, extend in the SE minor axis direction far across the across the sky in this Local Group direction.
3. ALIGNMENT ALONG M31 MINOR AXIS

Extensive early studies of edge-on disk galaxies showed concentrations of companions along their minor axes (Holmberg 1969, p.317). Later a very conspicuous alignment of smaller galaxies along the minor axis of M31 was reported (Arp 1990, p.434, 1998b, p.662). As Fig. 8 here shows, the alignment consists of all the brightest conventional members of the Local Group.

![Diagram showing alignment of galaxies along M31 minor axis](image)

Fig. 8.— Conventional members of the Local Group (-86 ≤ \(v_0\) ≤ +140 km/sec) are filled symbols. All galaxies known with 300 ≤ \(v_0\) ≤ 700 km/sec are shown by crosses for spiral, open symbols for dwarfs. Some higher redshift, peculiar galaxies are plus signs SE of M33. See Arp 1990.

If we take galaxies with slightly higher redshifts than accepted for the Local Group, say 300 ≤ \(cz\) ≤ 700 km/sec, we see in Fig. 8 that they all fall along the same minor axis alignment from M31. This establishes some important points:

1) Bright companions to M31 are almost exclusively distributed along a narrow line along the SE minor axis.

2) These companion galaxies have distinctively small redshifts but are systematically redshifted with respect to M31 (Arp 1994, 1998b).

3) 12 galaxies SE of M33 extend back to M31 accurately along the line of the M31 minor axis. These galaxies have redshifts of \(v_0\) = 647, 1625 and the rest 4116 through 5163 km/sec. They are almost all of peculiar, non equilibrium morphology. (Arp 1990, p. 435)

4) The terminus of the line from M31 is 3C120 and UGC 3066 (\(v = 9.896\) and 4640 km/sec). This terminus is accurately at p.a. 125 deg. - the same as the minor axis of M31. 3C120 is a much studied, quasar-like, strong radio source.

In general the distribution of companion galaxies around minor axes tended to be, as Holmberg had
pointed out, about $\pm 35$ deg. This is the opening angle of the ejection cone defined by the objects in Figs. 3 and 7. But why then is the alignment of galaxies so narrow over a longer extent in the Local Group?

We comment that if a high intrinsic redshift (Narlikar and Arp 1993) proto quasar comes out exactly along the rotation axis it can travel a long distance while it is evolving to more mass and lower intrinsic redshift i.e. becoming a well aligned galaxy. If the ejection is somewhat off the exact rotation axis of the ejecting nucleus then it encounters medium and clouds which slow, deviate and break up the proto quasar/galaxy plasmoid. These products are small and stay close to the ejecting galaxy as in the picture of M31 in Fig. 7. But it also implies that the ejection axis in M31 has operated over a period of time comparable to the evolution from compact proto quasars to normal, only slightly redshifted companion galaxies.

4. RADIO SOURCES ALONG THE M31 MINOR AXIS

Early searches for a radio halo around M31 revealed instead point sources concentrated along the M31 minor axis. To quote Wielebinski (1976): “By a strange chance of nature there are groupings of rather strong sources in nearly symmetrical positions on opposite sides of the nucleus along the minor axis.” (See also Wielebinski 2000). The importance of this finding lies in the accepted origin of radio sources as ejections from centers of galaxies. Since we have seen companion galaxies along this M31 minor axis as well as higher redshift galaxies and quasars it is reasonable to conclude this is an ejection path for material which evolves into normal companion galaxies.

Confirmation of this ejection of radio sources can be seen in the 408 MHz, 3.9 x 2.7 deg. map of M31 (Gräve 1981). In their Fig. 3 just laying a straight edge at p.a. 125 deg. shows that essentially all of the sources lie along the M31 minor axis.

5. NEBULOUS DUST ASSOCIATED WITH M31 EJECTION

Finally we come to the aspect which could most shake conventional beliefs about the Local Group and the nature of near space. Deep prints of a red sensitive schmidt plate (Arp and Sulentic 1991) show unmistakable filamentary dust features reaching back along the minor axis direction toward M31. This filament is repeated in the blue photographs and 100 the hundred micron infra red scans. They have to be real. Although no one has cared to take a spectrum there is no hint of gaseous emission.

The ejection path across the whole Local Group sky from M31 to 3C120 (Note the well known but little attended nebulosity just north of 3C120) must have carried material either dusty or capable of forming dust from the ejecting M31. But that means dust and obscuration within the Local group of galaxies - a point which has never before been seriously advanced. But how can one escape the multiwavelength evidence and the detailed discussion of Arp and Sulentic (1991)?

The most provocative object in the M31 minor axis line is NGC 918 at $v_0 = 1640$ km/sec redshift. The nebulous dust is most concentrated at the position of the galaxy but a region has been cleared on either side of the minor axis of the galaxy. Higher resolution images would give invaluable information on the process whereby ejections come out along the minor axis of galaxies.

In addition the nebulosity is of such long extent across the sky and so coincident with the alignment along the M31 minor axis that it must be in the Local Group. Therefore interaction with the dust filament
would represent direct evidence for a distance much smaller than NGC 918’s conventional redshift distance.

Fig. 9 shows a 29 x 29′ region around NGC 918. It is taken with the 40cm reflecting telescope of D. Carosati at the Armenzano Observatory in Assisi, Italy, with 50 summed exposures in the R band totaling 150 minutes.

The filamentary features surrounding NGC 918 are well shown in this image. The outer features appear to be dust illuminated by the galaxy. Immediately around the galaxy the dust appears to cleared away. By either outflow of matter or radiation pressure from the galaxy.

If further imaging confirms that the galaxy is actually interacting with the faint surface brightness material then we have a galaxy of $cz = 1640$ km/sec redshift at the same distance of nebulous matter as the Local Group of Galaxies which is essentially $cz \sim 0$ km/sec.

If the galaxy is not interacting with the nebulosity but just shining through a serendipitous hole we still have the remarkable inference that material has been ejected along the minor axis of M31 into the middle of the Local Group of galaxies. The question then arises as to how many other nearby galaxy groups contain intergalactic material and what this would do to our view of purportedly more distant galaxies.

Fig. 9.— Faint surface brightness features around NGC918 (29 x 29′).
6. Remarks on NGC 404 and M33

NGC 404 falls approximately midway between M31 and M33 and almost exactly on the minor axis line back to M31. It is an unusual galaxy in that it has a presumably old halo of red stars but at the center has a compact, high surface brightness nucleus. Its redshift is +228 km/sec greater than M31.

M33 is well known Local Group spiral galaxy. It also lies on the alignment of companions back to the nucleus of M31. It is considered a normal, prototype spiral galaxy and, as in M31, it is of interest to see if there are any associations with quasar-like objects. Considering all the known quasars within a region of about 7 x 10 degrees it is seen that there is a fairly clear region around M33 as in many active parents and a pair of very high redshift quasars on either side of the galaxy. (z = 4.532 nad 4.258) Such high redshifts are rare and it is noticed that their apparent magnitudes, like the quasars around M31, are quite bright. If these two had intrinsic redshifts at the Karlsson peak of z = 4.51 then their velocities of ejection would be $z_v = +.005$ and -.046. We note, however, a quasar with $z = 4.220$ further from M33 to the NW.

3C48 and M33

The most striking aspect of the neighborhood of M33 is that one of the closest quasars to M33 is the famous 3C48, in 1963 the first discovered quasar. See the three investigations in 1984 (Arp 1984a,b,c) of the Local Group direction in the sky. There it was shown that M33 was at the head of a line of radio quasars and galaxies of similar redshift ($0.27 \leq z \leq 0.47$) and apparent magnitude. The above three papers showed that this region in the SGH had extensive radio mapping and that a number of radio quasars had been identified. In fact, because of its nebulous image and strong radio emission the prototype quasar, 3C48, acted more like a member of a group of radio galaxies (albeit with large range in redshifts).

Ironically 3C48, the much publicized quasar that astronomers fiercely competed for in 1963, turns out to be just a compact radio galaxy (with an angular extent of 12") but with a redshift which conventionally would place it at great distance in back of M33. The redshift - magnitude plot for quasars in the Local Group vs those in the Local Supercluster direction should be studied, however, because they are very different (Arp 1984a).

Of course 3C48 was first discovered because of its strong radio emission and bright apparent magnitude. If quasars are associated with galaxies it would seem likely that 3C48 would be associated with one of the brightest galaxies in the sky. In the preceding paper we have now given evidence for quasars being emitted from M31, the central galaxy in the Local Group. It would seem supportive of that finding to find the second brightest galaxy in our Local Group also associated with higher redshift quasars.

If M33 were removed to distances of fainter galaxies its apparent separation between it and 3C48 would be smaller and its apparent magnitude would be fainter, about where we begin to observe such objects associated with more distant galaxies.
7. Summary

The evidence for association of higher redshift galaxies and quasars with M31 and the Local Group is:

1) Excess of quasars of bright apparent magnitude within 5 deg. radius of M31.
2) Increasing density of quasars from 5 to 1 degrees toward M31.
3) Unusual class of low redshift quasars.
4) Distribution of associated quasars in two cones along M31 minor axis.
5) Pairing of redshifts and magnitudes across nucleus.
6) Ejection of radio material and alignment of companion galaxies along M31 minor axis.
7) M33 located along minor axis of M31. M33 associated with line of quasars that are similar to the first-discovered 3C48.

Finally ejection along the minor axis of M31 appears to reach into the middle of the Local Group and may be involved with medium redshift galaxies and/or nebulosities.

8. Conclusions and Criticism

Excluding gravitational lensing on the basis of the wide separations, and properties listed above, there are only two possibilities in the region around M31. Either the catalogued quasars are physically associated with the galaxy and its aligned companions or there has been a special search around the galaxy compared to adjacent regions. In the latter case it would also be necessary to demonstrate a systematic bias to sample along minor axis directions or adjacent arcs. It would be necessary to find observers who said “I searched for high redshift objects by looking in the extended neighborhood of large, low redshift galaxies!

A quite opposite selection effect is more likely. Because of the almost universal belief in red shift distances local objects would have been avoided if anything. Criticisms about “completeness” or magnitude scales should not be allowed to postpone further checks with control fields such as have been started in the present paper.

In view of the importance for astronomy and physics it would seem that selection effects would have to be demonstrated otherwise the present observational results would need to be seriously considered and further investigated along with their consequences for the nature of redshifts.

Acknowledgement: In 1965 Allan Sandage published a paper in part titled “A Major New Constituent of the Universe: The Quasi-Stellar Galaxies”. In the ensuing years the QSO’s or quasars as they came to be known, truly developed into a constituent that embraced galaxies in many evolutionary stages. Still in controversy, the observations discussed here perhaps extend the importance and inclusive nature of the objects he and others at that time reported.

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168