EVIDENCE FOR NON-VELOCITY REDSHIFTS

HALTON ARP

Hale Observatories, Carnegie Institution of Washington, California Institute of Technology, Pasadena, Calif., U.S.A.

Abstract. Evidence for non-cosmological redshifts is reviewed. It is shown that all current statistical tests favor association of QSRs with galaxies close by, in distance, to our own. It is possible that all QSRs originate from galaxies of much lower redshift. It is shown that in the four cases where QSRs fall projected closest to bright galaxies, that in all four cases the galaxies show evidence of physical interaction. Evidence for high redshift, compact and peculiar companion galaxies is reviewed. From the individual associations of high redshift QSRs and companions, an empirical continuity of observed characteristics is shown between compactness (youth) and excess redshift. Some theoretical explanations for intrinsic redshifts are mentioned.

1. Introduction

Today I would like to present evidence for large redshifts in extragalactic objects which are not caused by recessional velocities in an expanding universe. One consequence of this is that, in these cases, the distances and the luminosities of the objects cannot be computed by the conventional application of the Hubble constant. An additional and even more important consequence is that if such nonvelocity redshifts do exist, then there is no ready explanation for them in conventional physics and they would therefore present the greatest challenge to cosmological theories.

In the short time available to me I cannot cover all that I wish to say on this subject nor even mention very much of what E. M. Burbidge, G. R. Burbidge, and F. Hoyle might want to say if they were here. Therefore, I will restrict myself to a very schematic summary of the evidence and one or two examples. But I would like to emphasize to you that the evidence I will now discuss represents only the tip of the iceberg of observational evidence which has accumulated in the last seven years on the existence of nonvelocity redshifts.

2. Association of QSRs With Nearby Galaxies

It is possible to take the position that Rowan-Robinson and others have taken about QSRs, namely, that there are some at cosmological distances and others nearby which have spurious redshifts (for references see reviews by Arp, 1973, 1974). That situation would be much harder to prove or disprove than if they were all at cosmological or all at local (10–100 Mpc) distances. Therefore, in the interests of simplicity I will investigate whether the proposition can be supported that 'all QSRs are associated with nearby (<100 Mpc distance) galaxies.'

2.1. Statistical Evidence

The initial investigations by Arp showed the QSRs to be associated with bright galaxies

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and peculiar galaxies, including those galaxies in our own Local Group. Later Burbidge *et al.* (1971) showed that four radio bright (3CR) QSRs fell very close ($<7'$) to moderately large spiral galaxies. The probability of this occurring by chance was extremely small. Some investigators reasoned that if these QSRs were physically associated with these galaxies, it should be possible to find additional cases by considering associations at greater distances, that is, fainter QSRs around fainter galaxies. So radio-fainter QSRs (Parkes 2700 MHz survey) were examined with respect to fainter galaxies (the Zwicky *Catalogue of Galaxies and Clusters of Galaxies* which reaches to $m_{pg} = 15.7$ mag.). No significant associations of fainter QSRs with fainter galaxies were found. Should we conclude that the association of QSRs and galaxies has not been supported by this result? Apparently not, because the most recent investigation by Browne and McEwan (1973) has turned up two new QSRs within $1.7'$ and $2.1'$ of faint galaxies. The probability of chance association now becomes only 5%. As it stands, this may be only marginally significant, but it can only be a lower limit to the real significance for the following reasons.

The original Arp (1970) associations showed:

Associations

Galaxies (m_{pg})	QSRs (V)
Arp: 9 to 11 mag.	17 to 19 mag.
implies: 13 to 15 mag.	21 to 23 mag.

Since we do not optically identify many QSRs in the 21 to 23 mag. range, we would not expect to find many QSRs around 13 to 15 mag. galaxies.

Looked at another way, the original paper showed that QSRs with quite low redshifts as well as those with very high redshifts were distinctly less luminous than QSRs of intermediate redshift. The luminosity function must look something like the following (see Figure 1 on p. 63).

This would predict that the QSRs seen at the greatest distance, falling closest to galaxies, and therefore singled out as associations, would be predominantly of intermediate redshift. Table I in the present paper shows all the QSRs presently believed to be most probably associated with galaxies. The first five cases are from B^2S^2 and the next seven are from my own compilation. A very significant result emerges when one examines the redshifts of these associated QSRs. All their redshifts fall between $z = 0.4$ and 1.8. If we take a normal distribution of QSR redshifts as in Barbierie *et al.* (1967), we see that the chance of accidentally selecting all the redshifts in Table I between $z = 0.4$ and 1.8 is less than 1%.

The earlier paper showed that the very high and very low redshift QRSs were associated with very nearby galaxies, including the Local Group of galaxies which is dominated by M31. (Our own Galaxy falls somewhere near the edge of the M31 Local Group.) These closest QSRs fall projected at large angular distances from their

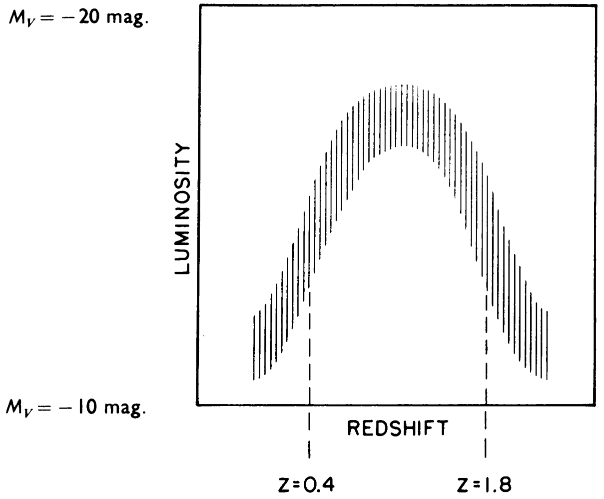

Fig. 1.

galaxies of origin. We can therefore answer the question: If all QSRs are associated with nearby galaxies why does not every QSR fall close to a galaxy? The answer would then be that a number of QSRs belong to very close-by galaxies and fall projected at considerable distance from them on the sky.

2.2. Individual Evidence of Association of QSRs with Galaxies

We list below the four closest cases of quasars adjacent to galaxies (excluding the two additional and as yet uninvestigated cases reported by Browne and McEwan, 1973):

(1) PKS 2020–37 falls 21″ from small spiral galaxy.
(2) 3C 455 falls 23″ from NGC 7413.
(3) Mark 205 falls 42″ from NGC 4319.
(4) PHL 1226 falls 55″ from IC 1746.

In the first case the QSR falls very close to a very distorted spiral arm, which might be taken as evidence of interaction. In the second case the Galaxy shows an unusual perturbation of its luminous isophotes in the general direction of the QSR. (See review by Arp, 1974 for details of the previous and the following two cases) In the third case Markarian 205 shows a luminous connection back to NGC 4319. In addition, investigation of the interior regions of NGC 4319 shows perturbations of the inner isophotes, which appear to be associated with the ejection of a radio source in one direction and the ejection of Markarian 205 in the other direction from the nucleus of NGC 4319. This ejection is computed to have taken place at approximately 3000 km s^{-1} about 10^7 yr ago. (It should be noted that an ejection velocity of about 3000 km s^{-1} is about what is needed to construct clusters of galaxies by fissioning and ejecting from central objects.) In the fourth case there is evidence for interaction between IC 1746 and the QSO-peculiar galaxy double that lies just off the southeast edge of the Galaxy. There also appears to be a luminous filament connecting the QSO with the peculiar galaxy. Although the redshift of the Galaxy is not known, it would be

TABLE I

Close association between quasars and galaxies

Object pair	m	z	r(min)
3C 455	19.7	0.543	0.4
NGC 7413	15.2	0.033	
3C 232	15.8	0.534	1.9
NGC 3067	12.7	0.005	
3C 268.4	18.4	1.400	2.9
NGC 4138	12.1	0.004	
3C 275.1	19.0	0.557	3.5
NGC 4651	11.3	0.003	
3C 309.1	16.8	0.904	6.2
NGC 5832	13.3	0.002	
2020-370	–	–	0.3
Spiral galaxy	–	1.1	
PHL 1226	–	0.404	0.9
IC 1746	14.5	–	
3C 270.1	18.6	1.519	5.1
pec ring galaxy	(17)	–	
0159-11	16.4	0.68	39
IC 1767	(15)	–	
Mark 132	15	1.75	45
NGC 3079	11.9	0.041	
3C 254	18.0	0.734	126
Mayall's pec object	(15)	0.035	

unprecedented for this fairly bright and diffuse object to have the redshift of the quasar, which is $z=0.404$.

We can summarize this section on individual connections with the statement that, in the four cases where quasars lie closest to bright galaxies, in every case we see evidence for interaction between the quasar and the Galaxy.

3. Association of High Redshift Galaxies with Low

By now the most famous case of discordant redshift is Stephan's Quintet (see for review, Arp, 1974). It has been proposed by Arp that the whole of Stephan's Quintet is associated with the bright, $cz=800$ km s^{-1} spiral NGC 7331, which is about 30′ northeast of the Quintet. That means that four members of the Quintet with redshifts between $cz=5700$ km s^{-1} and 6700 km s^{-1} are really about 8 times closer in distance than their redshifts would indicate. In support of this picture a number of lines of evidence can now be cited:

(a) The H II regions are almost exactly the same size in both the low redshift member of the Quintet (NGC 7320) and the one high redshift which contains H II regions (NGC 7318).

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(b) There is interaction between the high and low redshift members of the Quintet.

(c) There are excess numbers of radio sources in the region between NGC 7331 and the Quintet.

(d) There is a system of very faint, luminous optical filaments between NGC 7331 and the Quintet.

Now, independently, hydrogen measures by Heidmann with the Nancay radio telescope (report this symposium) give a distance, independent of redshift to NGC 7319 which is much closer to the low redshift distance of NGC 7331 and NGC 7320 (about 10 Mpc) than the Hubble distance of NGC 7319 (which would be about 120 Mpc with $H = 55$ km s^{-1} Mpc^{-1}).

In addition, it has been recently shown by Arp (in press) that other systems like Stephan's Quintet (e.g., VV 150 and the Burbidge chain northwest of NGC 247) *characteristically* occur near bright, relatively low redshift galaxies. Therefore, we see that Stephan's Quintet is not a unique, isolated phenomenon, but this effect happens in other cases where multiple interacting galaxies appear to have strong components of nonvelocity redshift.

I would like to show a photograph that illustrates one case of a bridge or luminous filament connecting a high redshift galaxy to a low redshift galaxy. Figure 2 shows a peculiar companion of $cz = 16900$ km s^{-1} connected to a main galaxy (NGC 7003),

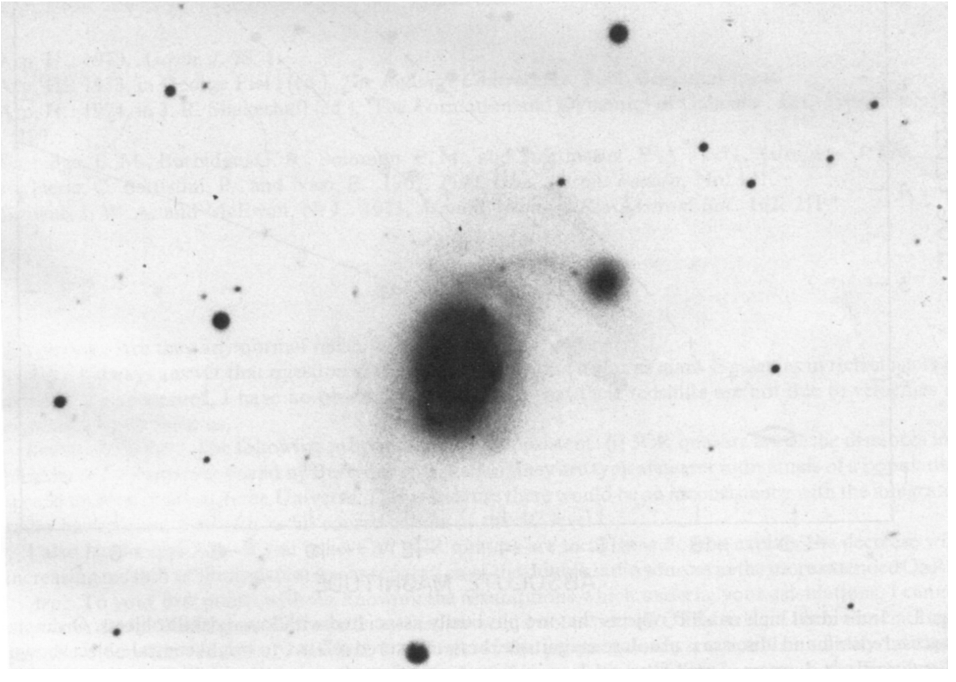

Fig. 2. NGC 7603. A light print to show disturbance of inner parts of main galaxy. Darker prints show strong bridge between main galaxy at $cz = 8800$ km s^{-1} and companion galaxy at $cz = 16900$ km s^{-1}.

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which has a redshift of $z = 8\,800\ \mathrm{km\ s^{-1}}$. Aside from all the arguments originally made as to the physical association of this discordant pair of redshifts, we can now add the argument shown in this figure. The photograph shown here is a lighter print than usual, and rather than emphasizing the bridge shows the extremely distrubed interior regions of the larger galaxy. The argument now becomes the simple but powerful one: 'If the action of the high redshift companion has not distrubed the central galaxy, then what has?'

Finally, I would like to mention that all the cases of discordant redshifts, where individual high redshift objects have been associated with low redshift objects of known or estimated distance, can be combined in a diagram. Figure 3 shows how the excess redshift of an object is associated with its lower absolute magnitude. I believe that this diagram represents an evolutionary sequence in which a compact object or quasar is ejected from a large galaxy. It has initially high intrinsic redshift, but the compact object evolves into a compact galaxy, then into a disturbed young spiral, then spiral, and finally into a relaxed type II population system. I believe the intrinsic redshift decays along this evolutionary sequence leaving, eventually, only the true Doppler redshift due to the space motion of the object.

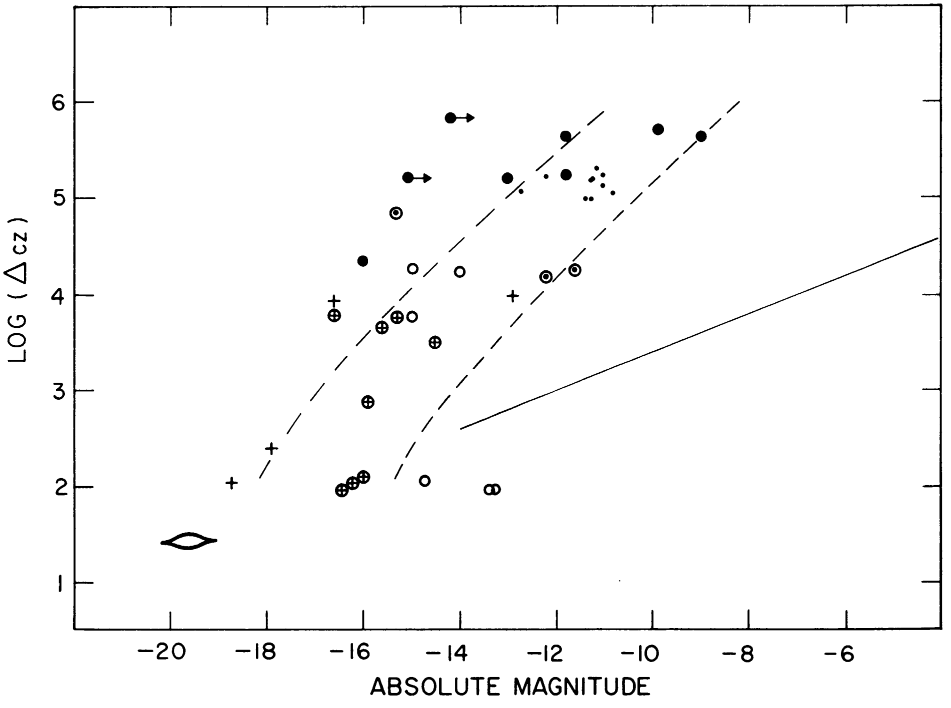

Fig. 3. Individual high redshift objects that are physically associated with low redshift objects. Ordinate is excess redshift and abscissa is absolute magnitude, both measured relative to bright central object shown schematically in diagram. Small filled cricles represent Local Group quasars; large filled circles represent quasars associated with individual galaxies. Remaining symbols represent individual compact galaxies, peculiar interacting systems like Stephan's Quintet, and companions to large nearby spirals like companions to NGC 7603, M82, M32, etc.

Among the astronomers and physicists who accept the reality of nonvelocity redshifts, about four kinds of explanations are being worked on. They are in order of my judgement of their likelihood: (1) gravitational redshifts; (2) difference between proper and coordinate time at large space-time distances; (3) photon-photon scattering; and (4) creation of low-mass matter. I will not go further into any of these explanations, but instead refer the reader to my review (Arp, 1974).

One final comment. I would like to describe the very exciting discovery by Joseph Wampler, communicated to me by telephone recently. The discovery consists of two quasars, 5″ apart, which have redshifts of $z=1.90$ and $z=0.43$. There is a luminous, diffuse object on the other side of the bright quasar, directly across from the faint quasar, and a radio source somewhere on the same side as the nebulous object. This triple configuration, or pairing across a bright object, is a common finding in the discordant redshift and ejection phenomenon. Aside from the improbability of accidentally finding two quasars this close together on the sky, I would like to stress the extreme improbability of also finding this triple configuration.

In conclusion, I would like to point out that, of course, as is true of the earlier examples discussed in this paper, we need only one established case of a discordant redshift to force a crucial confrontation between observation and the current physics on which cosmology is based.

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DISCUSSION

Zel'dovich: Are they any normal redshifts?

Arp: I always answer that question very carefully. I say that as far as giant E galaxies in rich clusters of galaxies are concerned, I have no observational evidence that their redshifts are not due to velocities of expansion away from us.

Rowan-Robinson: The following propositions are inconsistent: (i) 3CR quasars are at the distances implied by the associations found by Burbidge *et al.* and (ii) they are typical nearer individuals of a population spread uniformly through the Universe. This is because there would be an inconsistency with the integrated radio background and with radio source counts at the 5C level.

I also have a question. If you believe *all* 3CR quasars are local, how do you explain the decrease with increasing redshift of the apparent linear separation of the double radio sources in the more extended QSRs?

Arp: To your first point: without knowing the assumptions which underlie your calculations, I cannot answer in detail. But in general, I would say that we would not expect all QSRs to be in these associations – just those between redshifts of 0.4 and 1.8. Some of the parent galaxies are spirals and may be closer than commonly assumed. There is also an unknown degree of hierarchical structure in the distribution of galaxies. As for the question: I believe the evidence indicates that the luminosities of QSRs decrease rapidly as we go towards and past $z=2.0$. Therefore it would be reasonable to expect the intrinsic separation of their radio components to become smaller.