EVIDENCE FOR NON-COSMOLOGICAL REDSHIFTS - QSOs NEAR BRIGHT GALAXIES AND OTHER PHENOMENA

G. Burbidge
Kitt Peak National Observatory*, Tucson, Arizona U.S.A.

All of the speakers at this meeting except me have assumed, or will assume, without question that redshifts are measures of distance. This reflects a point of view which is not borne out by all of the evidence. I shall attempt to give you some of the flavor of the evidence which so many wish to ignore. It comes from individuals who perhaps not surprisingly, have not been invited to speak.

We would all agree that patterns of redshifts, or very different redshifts associated with objects which appear to be physically associated provide direct evidence for non-cosmological redshifts. We start briefly with recent investigations by Tifft on galaxies. For some years he has shown that there appears to be correlation between the nuclear magnitudes of galaxies and their differential redshifts in clusters. He has found that there appears to be a "quantized" value of $c\Delta z$ = 72.5 km sec^{-1}.

In a recent paper Tifft[1] has found a similar effect by plotting the redshift differences between pairs of galaxies in close binary systems. In Fig. 1, I reproduce his results from one sample--pairs of galaxies whose redshifts have been accurately measured using the 21 cm line. When the distribution of redshifts is divided into boxes which are multiples of 72.5 km sec^{-1}, the number deduced from his earlier and very different investigations, a strong effect is seen. I see no way of explaining this away by selection effects. The implications are profound.

I now turn to associations between QSOs and bright galaxies. The first investigation of this effect using properly chosen samples was that involving the QSOs in the 3CR catalogue and the galaxies in the Shapley Ames Catalogue[2,3]. A highly significant effect was found, with five out of 50 QSOs lying very close to bright galaxies, and even more remarkable, a plot of log θ for these five QSOs (θ is the angular separation between

*Operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation.

G. O. Abell and P. J. E. Peebles (eds.), Objects of High Redshift, 99–105.

the galaxy and the QSO) against log z galaxy showed a slope of -1 suggesting that the QSOs are all at approximately the same projected distance from their (parent?) galaxies.

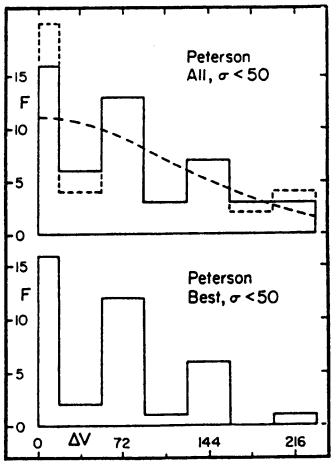

Fig. 1 The distribution of redshift differences for double galaxies with redshift differences less than 250 km s^{-1} and σ < 50 km s^{-1} according to Peterson. The upper histogram includes all pairs, the lower histogram includes corrections for optical pairing and overlapping signals in close pairs. From Tifft (1979).

Even earlier than this Arp[4] had argued that many radio sources, some identified with QSOs, were aligned across bright galaxies and were thus physically associated with them.

In the last decade many more QSOs have been found to lie close to bright galaxies. Arp has found a large number and others have been found by a variety of individual studies. Recently, Hewitt and Burbidge[5] have compiled a list of all of the cases known. They comprise at present (September, 1979) 94 QSOs close to 65 galaxies. Of these 68 QSOs lie within 10' of 54 galaxies.

I have attempted to look at the statistical significance of this latter sample. Following the review by Wills[6] I have taken as the surface density of QSOs derived from several surveys 10 per square degree $\leqslant 20^m$, $3 \leqslant 19^m$, $1 \leqslant 18^m$, $0.3 \leqslant 17^m$. These are very conservative values especially at the bright end. On the assumption that at most 200 fields near bright galaxies have now been surveyed, we can calculate the number expected by chance $\langle n \rangle$ and compare it with the total number found, N_O, and the total number found by Arp designated by N_{OA}. The results are shown in Table 1. It can be seen that for very small separations the result is highly significant, while for very large separations the total number seen is less than we would expect to find by chance.

https://doi.org/10.1017/S007418090006839X Published online by Cambridge University Press

This latter result may be due to the fact that Arp and others have not searched extensively enough at distances $\geqslant 5'$ from the galaxies. Alternatively it may be that QSOs are rarer than we have assumed in using the values of the surface densities given above. In this case the significance of the close associations is enhanced.

Table 1. A comparison between the number (N_O and N_{OA}) of QSOs found near bright galaxies and the number $\langle n \rangle$ expected by chance.

Apparent Magnitude	$\theta \leq 60''$			$61'' \leq \theta \leq 120''$			$121'' \leq \theta \leq 180''$			$181'' \leq \theta \leq 300''$			$301'' \leq \theta \leq 600''$		
	N_O	$\langle n \rangle$	N_{OA}	N_O	$\langle n \rangle$	N_{OA}	N_O	$\langle n \rangle$	N_{OA}	N_O	$\langle n \rangle$	N_{OA}	N_O	$\langle n \rangle$	N_{OA}
≤ 17	1	0.05	0	1	0.16	0	1	0.24	1	1	0.82	0	4	3.9	1
≤ 18	5	0.17	0	6	0.52	4	1	0.86	1	2	2.8	0	9	13.0	2
≤ 19	9	0.52	1	12	1.55	9	4	2.4	2	4	8.2	0	15	39.1	8
≤ 20	12	1.73	3	16	5.2	12	6	8.6	4	7	27.6	2	18	129.6	10

Apparent Magnitude	$\theta \leq 180''$			$\theta \leq 600''$		
	N_O	$\langle n \rangle$	N_{OA}	N_O	$\langle n \rangle$	N_{OA}
≤ 17	3	0.46	1	8	5.2	2
≤ 18	12	1.56	5	23	17.3	7
≤ 19	25	4.62	12	42	51.9	20
≤ 20	34	15.5	19	59	173	31

No attempt has been made to assess the statistical significance of the fact that in cases recently found by Arp[7] [8] QSOs with similar redshifts are aligned across bright galaxies. One example of this kind (Arp, 1979) is shown in Fig. 2. An even more striking case not involving a bright galaxy has recently been found by Arp and Hazard[9] where six QSOs with three similar pairs of redshifts close to 0.5, 1.6 and 2.1 are aligned in two triple systems. If lines joining the pairs with similar redshifts are drawn they appear to have a common origin (Fig. 3).

It seems to me that examples of this kind make an almost overwhelming case for the reality of large non-cosmological redshifts.

https://doi.org/10.1017/S007418090006839X Published online by Cambridge University Press

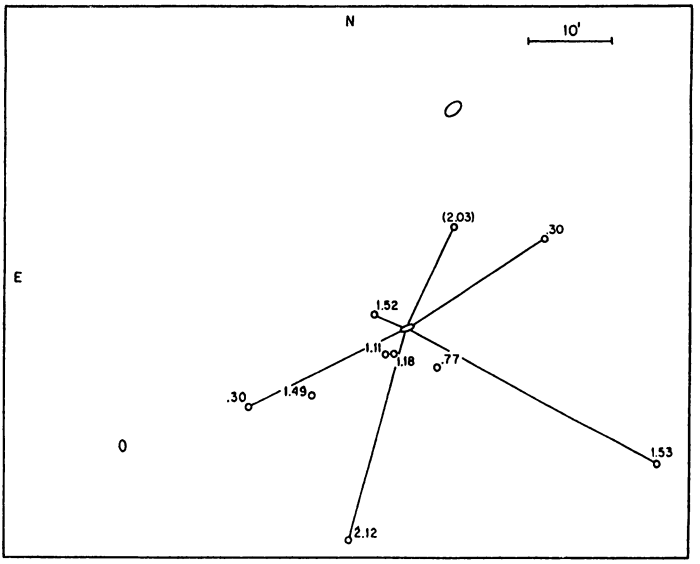

Fig. 2

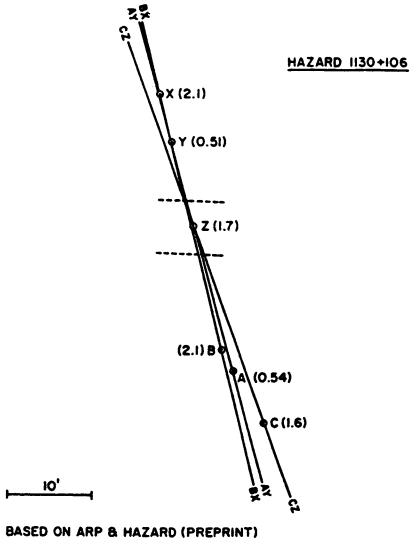

Fig. 3

https://doi.org/10.1017/S007418090006839X Published online by Cambridge University Press

Finally, there is another test that we can make for physical association. In Fig. 4 we show a plot of log θ against log z galaxy for all of the 94 QSOs close to 65 galaxies listed by Hewitt and Burbidge[5]. This is an update of the original plot of Burbidge, O'Dell and Strittmatter[3]. The equation of the line shown is

$$\log \theta = -1.17 \log z_{galaxy} + \text{constant}.$$

The range of slope for this line at the 99% confidence level is between -0.93 and -1.56. The correlation between log θ and log z is significant with a correlation coefficient of 0.68.

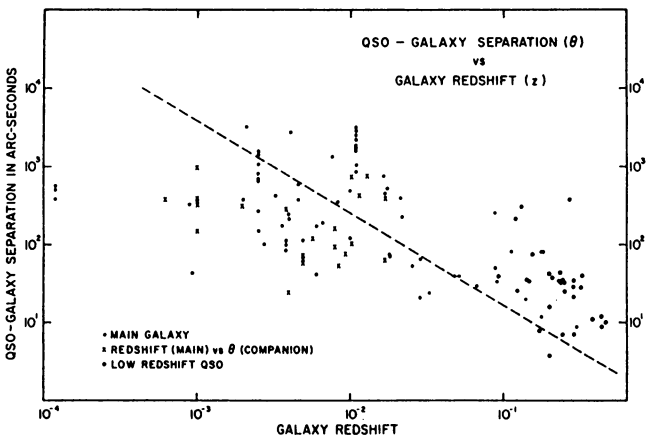

Fig. 4

I have left out many other pieces of evidence. For example, the existence of 3 QSOs within 2' of the center of NGC 1073[10] with "magic" redshifts of 0.599, 1.411 and 1.945[11] is most significant.

I believe that however much many astronomers wish to disregard the evidence by insisting that the statistical arguments are not very good, or by taking the approach that absence of understanding is an argument against the existence of the effect, it is there and many basic ideas have to be revised.

A revolution is upon us whether or not we like it.

I am indebted to H. C. Arp, A. Hewitt, J. V. Narlikar and W. Tifft for giving me access to material not yet published and for much help in preparing this paper.

REFERENCES

1. Tifft, W. 1980, Ap.J. in press.
2. Burbidge, E.M., Burbidge, G.R., Solomon, P.M. & Strittmatter, P.A. 1971, Ap.J. 170, p. 230.

3. Burbidge, G., O'Dell, S.L. and Strittmatter, P.A. 1972, Ap.J., 175, p. 601.
4. Arp, H.C. 1966, Science 151, p. 1214.
5. Hewitt, A. and Burbidge, G. 1980, Ap.J.Suppl. in press.
6. Wills, D. 1978, Physica Scripta 17, p. 333.
7. Arp, H. 1979, Proc. 9th Texas Symposium on Relativistic Astrophysics, Munich (Ann. NY Acad. Sci.) in press.
8. Arp, H. 1979 preprint.
9. Arp, H. and Hazard, C. 1979 preprint.
10. Arp, H. and Sulentic, J.W. 1979, Ap.J. 229, p. 496.
11. Burbidge, E.M., Junkkarinen, V., and Koski, A.T. 1979 preprint.

DISCUSSION

Tyson: You have given many examples of associations involving several combinations of angular distance, redshift, lines, and other patterns. I think I counted eight separate "games." I am reminded of the origin of constellations. Although we probably ought to remain open-minded when searching through the "noise" of stars, galaxies, and redshift, the statistical significance of any discovery of some single kind of association is considerably reduced if we allow the rules of the game to change during the search.

G. Burbidge: There is really only one "game," namely the collection of evidence for physical association of QSOs with large redshifts with galaxies with small redshifts. We can test by looking for luminous bridges by finding QSOs very close to galaxies using complete samples and working out probabilities of chance effects or by finding alignments and pairing of reshifts.

I agree that the game is not being played always according to a list of rules generally agreed on, but in practice, while statistical arguments are important, every scientist will evaluate evidence in his own way. All I ask is that people do have open minds, that they look at the data and are not too thoroughly influenced by current beliefs and convictions to ignore their data or unfairly criticize the methods of those who present them.

Arp: It is so rare to hear a really unprejudiced speaker in this subject that I listened with great interest. I would only like to remark that in the preprint of the paper by Arp and Hazard, the group of quasars that form a small cluster is a little more than 2 degrees away from the two triplets that are in the same paper. Saslaw and Hazard described in this cluster from the preprint two more triplet alignments which had not been seen before. As before, both those triplets had exact alignment, within the 2 arc sec image sizes on the photograph. One of the triplets had extremely similar redshift to redshifts in the first two triplets discovered.

Rees: It's still, of course, difficult to assess the quantitative significance of the various alignments and associations involving quasars. (In fact, the argument is reminiscent of another long-running controversy -- the astronomical significance of stone alignments in megalithic sites.) However, even if one accepts these effects as real, it's important to emphasize that this doesn't necessarily force us to invoke "new physics." The irregular collapse of a massive system in a galactic nucleus could, quite plausibly, lead to "slingshot" ejection of compact objects at high speed. Also, there is now increasing evidence for production of beams and jets in galactic nuclei, and the analogous galactic object SS433 shows that jets can consist of cool material coasting along at well-defined relativistic speed. It is by no means a wild extrapolation from this evidence to suppose that the material in such jets can sometimes condense into compact objects.

G. Burbidge: I agree. The first step is to gain acceptance of the evidence that there is a generic connection between QSOs with high redshifts and galaxies with low redshifts, for astronomers to realize that large (and small) non-cosmological redshifts exist and may be commonplace. At that point we would look for an explanation and exhaust all other possibilities contained within conventional physics before we consider "new physics."

https://doi.org/10.1017/S007418090006839X Published online by Cambridge University Press