THE RED SHIFT HYPOTHESIS FOR QUASARS: IS THE EARTH THE CENTER OF THE UNIVERSE?

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Abstract. It is shown that the cosmological interpretation of the red shift in the spectra of quasars leads to yet another paradoxical result: namely, that the Earth is the center of the Universe. Consequences of this result are examined.

> Einstein distinguishes between two main criteria [for a good theory]: (a) the *external confirmation* of a theory, which informs us in experimental checks of the correctness of the theory, and (b) the *inner perfection* of a theory which judges its 'logical simplicity' or 'naturalness'.
>
> G. Holton (1973)

A few years ago it was pointed out by G. Burbidge (1968) that a number of quasars have an absorption-line red shift of 1.95. He also drew attention to the fact that there are four quasars: namely, 3C 191, PKS 0119-04, PHL 938, and BSO 6, whose emission-line red shifts are extremely close to 1.955. The absorption-line red shift at 1.95 has been subsequently discussed by the Burbidges and by others in a number of papers.

It appears, however, that the significance of this coincidence of four emission-line red shifts at 1.955 has remained unappreciated. Also, it is perhaps not recognized that there are many other similar groups where the red shifts of two or more quasars lie very close together. In this paper we discuss a very serious consequence of these coincidences assuming the red shift hypothesis for quasar spectra.

In 1968 there were 20 QSOs with emission-line red shifts greater than 1.9. Burbidge calculated the probability for a chance coincidence of these four red shifts from the equation

$$P_k = \frac{r!}{k!(r-k)!}\frac{1}{n^k}\left(1-\frac{1}{n}\right)^{r-k}, \tag{1}$$

where P_k is the probability of the chance coincidence of k red shifts, where the total number of possible intervals is n=(total range in red shift measured)/(size of box determined by measurement errors or other effects) and the total number of red shifts is r. Burbidge took the size of box, Δz, to be 0.002. For the origin of Equation (1), reference may be made to Parratt (1961) and Piper (1968).

It may be argued, however, that Burbidge considered only a small range of z: namely, between z=1.93 and 2.36; and the number of QSOs in the population considered was also small. In the intervening years spectral data on a large number of

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quasars has become available. We shall consider all quasars for which spectral data for one or more emission lines have been published, except those for which the red shift $z<0.2$. In the region $z<0.2$, there are a few objects which have occasionally been listed as quasars. Some of these (for example, B234, B264, and Ton 256) are *N*-type galaxies or related objects, while some others are quasars. The total number of quasars with $z<0.2$ is quite small and will not have any significant effect on our numerical results. As of June 1975 there were 384 quasars in the category that we are considering. The range of z is 0.2 to 3.53. Using the same size of box as that used by Burbidge, we find that the probability of a chance coincidence of the red shifts of the same 4 QSOs is $P_k=9.24\times10^{-5}$. This value is about 50 times as large as the one calculated by Burbidge (1968). Although this is a small probability, the significance of this is possibly not appreciated.

Before proceeding further, we wish to make one point clear. The resulting low probability given above, in itself, does not confer any special status to the red shift of 1.955. We would have obtained the same result had the four QSOs been at any other red shift between $z=0.2$ to 3.53. A special status for 1.955 arises because of the assumed identifications of lines. We clarify this point further. The red shift 1.955 is obtained because the two strong lines observed in these QSOs are identified with C IV $\lambda1549$ and Lα $\lambda1216$. The ratio of these two wavelengths is 1.274. Another ratio close to this number is that of [O III] $\lambda4363$ to [Ne V] $\lambda3426$. If for some reason we identify the two observed lines with $\lambda4363$ and $\lambda3426$, we get $z=0.049$. The important point to note is that now the coincidence will occur at $z=0.049$, but the probability P_k will change only slightly. Similarly, if we were to identify the two observed lines with C III $\lambda977$ and N IV $\lambda765.1$, the corresponding red shift will be 3.69, but the probability P_k will be about the same.

There is, however, one more aspect of the problem. It is perhaps not realized that there are many other similar groups where red shifts of two or more quasars lie very close together. In Table I we list the quasars, together with their apparent emission-line red shift, belonging to 57 such groups. We wish to emphasize here that the table is based more on the similarities in the spectra of the quasars constituting a group, than on the nearness of their red shifts. As an illustration, in Figure 1, we show a diagrammatic representation of the spectra of quasars belonging to group 18 of Table I. Table I represents the first classification of QSOs on the basis of their spectra. As a matter of fact, some QSOs with very different red shifts belong to the same group, but this will introduce complications in our discussion, hence we shall not consider this point further in this paper.

For each of these groups, we have calculated P_k and the results are shown in the third column of Table I. It was assumed that the uncertainty in the reported z values is ±0.001 and thus the red shift width of a group was $=z(\text{highest})-z(\text{lowest})+0.002$. From the multiplicative law of probability, the probability of these 57 sets of coincidences occurring in this system of 384 QSOs is $\simeq3\times10^{-85}$. We hope this number will be convincing evidence that the coincidences are real and cannot be attributed to

TABLE I

Probabilities of Coincident Red Shifts by Chance

Group number	Quasars (red shift)	P_k
1	PHL 1093 (0.262), 3C 323.1 (0.264)	6.704×10^{-2}
2	4C 31.63 (0.297), 4C 9.35 (0.299), PHL 1194 (0.299)	1.027×10^{-2}
3	3C 249.1 (0.311), 1355–41 (0.313)	6.704×10^{-2}
4	PKS 2059+034 (0.370), 4C 37.43 (0.370), 3C 351 (0.371), 4C 27.38 (0.372)	1.176×10^{-3}
5	PKS 0812+02 (0.402), PHL 1226 (0.404)	6.704×10^{-2}
6	3C 215 (0.411), PKS 1546+027 (0.412)	4.230×10^{-2}
7	1049+616 (0.422), 4C 10.30 (0.423), 3C 47 (0.425)	1.788×10^{-2}
8	4C 9.72 (0.432), 4C 21.35 (0.433)	4.230×10^{-2}
9	3C 275.1 (0.557), 1634+26 (0.561)	1.199×10^{-1}
10	0403–13 (0.571), OR 103 (0.572), PKS 0404–12 (0.574)	1.788×10^{-2}
11	2353–68 (0.716), PHL 923 (0.717)	4.230×10^{-2}
12	3C 454.3 (0.860), NAB 0107–15 (0.861)	4.230×10^{-2}
13	PKS 2340–036 (0.896), 0922+14 (0.896)	2.109×10^{-2}
14	0957+00 (0.907), 3C 309.1 (0.908), PHL 892 (0.911)	2.755×10^{-2}
15	TON 157 (0.960), 3C 288.1 (0.961), 0350–07 (0.962)	1.027×10^{-2}
16	PKS 0906+01 (1.018), 3C 311 (1.022), TON 153 (1.022), 3C 184.1/140 (1.022)	4.737×10^{-3}
17	2346+38 (1.032), CTA 102 (1.037), 3C 2 (1.037)	3.901×10^{-2}
18	1055+20 (1.110), 3C 208 (1.112), 3C 204 (1.112), 4C 05.46 (1.115), NAB 0024+22 (1.118)	5.295×10^{-3}
19	1508–05 (1.191), 2329–384 (1.195)	1.199×10^{-1}
20	3C 268.4 (1.400), DA 406 (1.401), 4C 18.34 (1.401), 3C 446 (1.404)	4.737×10^{-3}
21	1126+101 (1.515), 3C 270.1 (1.519), PKS 1801+01 (1.522)	6.592×10^{-2}
22	4C 06.40 (1.699), TON 155 (1.703)	1.199×10^{-1}
23	4C 29.64 (1.753), 4C 11.32 (1.754), 1221+114 (1.755), 3C 454 (1.757), MARKAR 132 (1.758), 1334+119 (1.760)	6.0×10^{-4}
24	3C 432 (1.805), PKS 2354+14 (1.810)	1.454×10^{-1}
25	4C 13.39 (1.875), B 194 (1.876), 2121+053 (1.878)	1.788×10^{-2}
26	LB 9612 (1.901), 1548+115b (1.901), RS 23 (1.908), PHL 1222 (1.910)	3.020×10^{-2}
27	PKS 0119–04 (1.955), PHL 938 (1.9552), 3C 191 (1.956), BSO 6 (1.956)	4.171×10^{-4}
28	LB 8755 (2.010), 3C 9 (2.012)	6.704×10^{-2}
29	NAB 0348+06 (2.058), PHL 1305 (2.064), PKS 0229+13 (2.065)	6.592×10^{-2}

Table I (Continued)

Group number	Quasars (red shift)	P_k
30	1331+170 (2.081), BSO 11 (2.084)	9.338×10^{-2}
31	2320+079 (2.090), 2254+024 (2.090), PKS 0317–02 (2.092)	1.027×10^{-2}
32	LB 9743 (0.253), PHL 1033 (0.255)	6.704×10^{-2}
33	PHL 881 (0.321), PKS 2251+11 (0.323)	6.704×10^{-2}
34	LB 8948 (0.331), LB 2136 (0.334)	9.338×10^{-2}
35	1510–08 (0.361), PHL 1027 (0.363), 4C 29.2 (0.363)	1.027×10^{-2}
36	MSH 03–19 (0.614), PHL 1072 (0.615)	4.230×10^{-2}
37	OI 363 (0.630), 4C 16.30 (0.634)	1.199×10^{-1}
38	4C 29.45 (0.728), 4C 28.59 (0.731), 3C 254 (0.734)	5.193×10^{-2}
39	4C 26.48 (0.779), 0414–060 (0.781), 4C 09.37 (0.786)	6.592×10^{-2}
40	1253+104 (0.824), 4C 19.34 (0.828)	1.199×10^{-1}
41	1252+11 (0.871), 4C 20.33 (0.871), PHL 891 (0.874), 4C 27.52 (0.875)	4.737×10^{-3}
42	4C 37.45 (0.972), 4C 22.26 (0.974)	6.704×10^{-2}
43	LB 8991 (1.013), CTD 141 (1.015)	6.704×10^{-2}
44	1317+520 (1.060), 4C 30.25 (1.061), 3C 186 (1.063)	1.788×10^{-2}
45	0122–00 (1.070), LB 9388 (1.070)	2.109×10^{-2}
46	4C 10.34 (1.088), PHL 921 (1.088)	2.109×10^{-2}
47	BSO 1 (1.241), 4C 35.21 (1.241), PHL 847 (1.243)	1.027×10^{-2}
48	PKS 1454–06 (1.249), 4C 36.28 (1.254)	1.454×10^{-1}
49	5C 4.127 (1.373), B 201 (1.375)	6.704×10^{-2}
50	3C 298 (1.439), 4C 17.46 (1.444), 4C −04.6 (1.445), 4C 30.13 (1.446)	1.702×10^{-2}
51	3C 205 (1.534), 4C 21.59 (1.534)	2.109×10^{-2}
52	4C 19.31 (1.689), 1308+182 (1.689), 0038–019 (1.690)	4.857×10^{-3}
53	0922+005 (1.720), 1045+604 (1.722)	6.704×10^{-2}
54	4C 29.1 (1.828), 0844+31 (1.834)	1.693×10^{-1}
55	LB 9707 (1.924), 4C 29.50 (1.927)	9.338×10^{-2}
56	1148–00 (1.982), PHL 1127 (1.985), 4C 28.40 (1.989)	6.592×10^{-2}
57	PKS 0424–13 (2.165), 4C 11.45 (2.171)	1.693×10^{-1}

chance. As discussed earlier for $z = 1.955$, this calculation does not imply any special status to the red shifts at which these coincidences occur. These coincidences are to be clearly distinguished from the 'peaks' that some authors have claimed in the red shift distribution.

Next we must consider how these coincidences can be physically explained. First let us consider the conventional view that the red shifts of the QSOs are cosmological in origin. If we assume that the Universe is homogeneous and isotropic (the cosmological principle), it is well known that the most general expression for the line-element

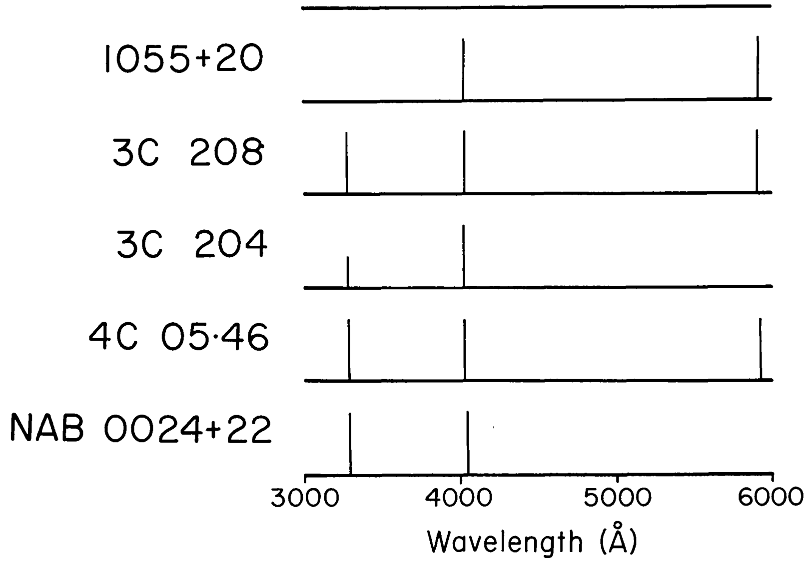

Fig. 1. Diagrammatic representation of the spectra of 5 quasars belonging to group 18 of Table I. The heights of the lines represent their strengths, except for 4C 05.46, for which the observers have not given the strengths of lines. $\frac{2}{3}$rd height indicates medium strength, $\frac{1}{3}$rd, weak. The spectrum of the quasar 1055+20 has not been investigated below 4000 Å, and that of 3C 204 has not been investigated above 4950 Å.

is the Robertson-Walker line element, which has the form

$$ds^2 = c^2\,dt^2 - \frac{R^2(t)}{(1 + \frac{1}{4}kr^2)^2}\{dr^2 + r^2(d\theta^2 + \sin^2\theta\,d\phi^2)\}, \tag{2}$$

where $R(t)$ is the scale factor (also called the expansion parameter), k is the curvature index, and r, θ, and ϕ are co-moving coordinates.

Consider the universe at a particular time t_0. Then we have $dt=0$, and the line element for three-dimensional space at the time t_0 becomes

$$ds^2 = -\frac{R^2(t_0)}{(1 + \frac{1}{4}kr^2)^2}\{dr^2 + r^2(d\theta^2 + \sin^2\theta\,d\phi^2)\}. \tag{3}$$

At a later time t_1 we would have exactly the same line element, except that every interval ds would be multiplied by the factor $R(t_1)/R(t_0)$. Thus the Robertson-Walker line element implies that the distance between two co-moving observers can be written as

$$D(t) = D_0 R(t), \tag{4}$$

where D_0 is a constant. It is also clear that although the distance between observers changes as a function of world time, the relative distance does not change.

Also, it is known that the red shift z is connected with $R(t)$ by the relationship

$$\frac{\lambda}{\lambda_0} = 1 + z = \frac{R(t)}{R(t_0)}, \tag{5}$$

where λ_0 and λ are the wavelengths of the emitted and received light signals, respectively. From this discussion it is obvious that if two or more quasars have the same value of z, they are at the same distance (though in different directions) from the

Earth. In other words, assuming the cosmological red-shift hypothesis, the quasars in the 57 groups in Table I are arranged on 57 spherical shells with Earth as the center. This is certainly an extraordinary result. Some of the possibilities that we shall consider to accommodate this result may be disturbing, but we must consider these possibilities dispassionately.

(1) Coincidence in distances could be possible if there were clustering. However, an examination of the coordinates of the various members of individual groups shows that in most cases there is no such correlation. Hence, this explanation has to be ruled out.

(2) Quasars may be arranged like atoms in a crystal lattice, with the Earth being either at an empty lattice site or at a suitable interstitial site. Should that be the case, one would expect some pattern or regularity in the directions of quasars belonging to a certain group. No such evidence is found and this possibility must also be abandoned.

(3) The Earth is indeed the center of the Universe. The arrangement of quasars on certain spherical shells is only with respect to the Earth. These shells would disappear if viewed from another galaxy or a quasar. This means that the cosmological principle will have to go. Also, it implies that a coordinate system fixed to the Earth will be a preferred frame of reference in the Universe. Consequently, both the Special and the General Theory of Relativity must be abandoned for cosmological purposes.

We must also consider the two other possibilities which have been discussed in the literature to explain the apparent red shifts of quasars. The difficulties in assuming that the red shifts are gravitational are well known and we need not repeat them here; in addition there is no reason why there should be coincidences in the M/r values (z is essentially a function of M/r for the gravitational red shift). The local-Doppler interpretation of red shifts also has serious difficulties; in addition it will have to explain why the quasars were ejected in shells.

We are essentially left with only one possibility – No. 3 in the cosmological red-shift interpretation. However, before we accept such an unaesthetic possibility, we must raise the question: Are the 'red shifts' real? We wish to point out that we have proposed an alternative explanation of the spectra of quasars (Varshni, 1973, 1974, 1975; Menzel, 1970; Varshni and Lam, 1974) which is based on sound physical principles, does not require any red shifts, and has no basic difficulty.

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