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

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Abstract. It is pointed out that Stephenson (1977) has used incorrect Δz, and has also made an arithmetical error, which invalidate his claims. Tests for randomness of quasar red-shifts clusters, using correct Δz, have been carried out and it is shown that at least for clusters having three red shifts or more, the distribution is highly non-random. The model of the Universe proposed by Stephenson does not in any way explain these red-shift clusters; it merely substitutes one paradox by another.

In a recent paper (Varshni, 1976; hereafter to be referred to as Paper I) the author has presented evidence for 57 coincidences in the apparent red shifts of quasars. Stephenson (1977) has raised the valid question whether *some such* clustering could arise due to random processes. He proposes two tests, both of which are reasonable, to check this point. However, his results and conclusions are erroneous because he has used incorrect Δz in his calculations; and has also made an arithmetical error. We show in this note that, when the correct Δz is used, the essential conclusions of Paper I are substantiated. All the necessary data required for calculations in the present paper are taken from Paper I.

Test 1

We start from the binomial distribution formula

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

In the present context, 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, Δz) and the total number of red shifts is r. Then the number of random coincidences having k or more red shifts (represented here by T_k) is given by

$$T_k = n\left[1-\sum_{j=0}^{k-1} P_j\right]. \tag{2}$$

The first test of Stephenson (1977) compares the calculated values of T_k with the reported ones (Table I of Varshni, 1976). Care must be exercised in the determination of Δz to be used in Equation (2). In Figure 1, we show the case of two red shifts, z_1 and z_2. Let 0.001 be the uncertainty in their values. We distinguish three cases:

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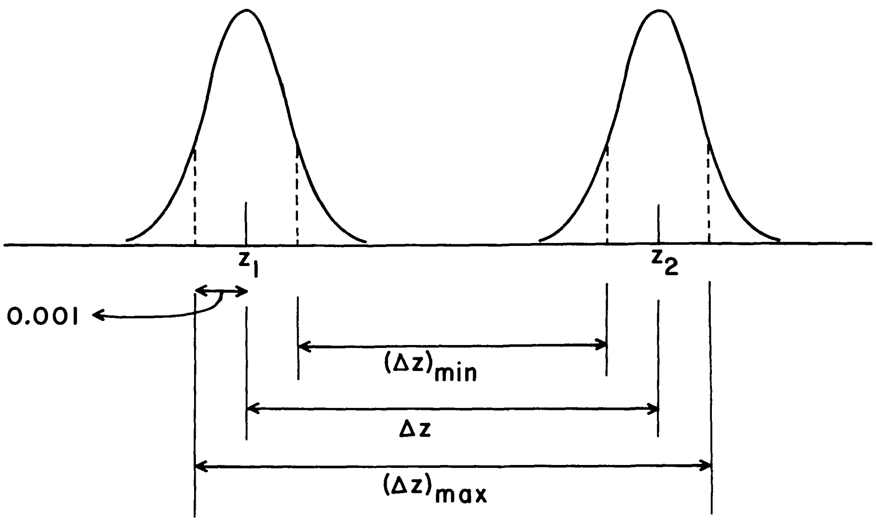

Fig. 1. Determination of the size of box, Δz, when there are two red shifts in a cluster.

(a) $$\Delta z = z_2 - z_1 \tag{3}$$

(b) $$(\Delta z)_{\max} = z_2 - z_1 + 0.002, \tag{4}$$

when the errors are additive.

(c) $$(\Delta z)_{\min} = z_2 - z_1 - 0.002, \tag{5}$$

when the errors are subtractive. $(\Delta z)_{\min} = 0$, if the right-hand side of Equation (5) is negative.

A reference to Figure 1 shows that case (b) is as probable as case (c), and the correct Δz to use in the present situation is that given by case (a). When there are several red shifts, $\Delta z = z$(highest)–z(lowest). Stephenson (1977) has used $(\Delta z)_{\max}$, which invalidates his results. We may also point out that Stephenson is inconsistent in the value of $(\Delta z)_{\max}$ that he uses. For $k \geqslant 3$ he uses the correct value of $(\Delta z)_{\max}$, but for $k \geqslant 2$ he uses a value 0.004, while the correct value is 0.0053.

In Table I we show, for $k \geqslant 2$, 3 and 4, the observed and calculated values of T_k for the three cases, (a), (b) and (c). A comparison of columns 2 and 4 shows that for $k \geqslant 3$ the clustering is highly non-random.

TABLE I

Observed and calculated values of the number of clusters of red shifts

k	Observed T_k	Δz (average)	Calculated T_k for Δz	$(\Delta z)_{\max}$ (average)	Calculated T_k for $(\Delta z)_{\max}$	$(\Delta z)_{\min}$ (average)	Calculated T_k for $(\Delta z)_{\min}$
$\geqslant 2$	57	0.0033	56.8	0.0053	78.8	0.0016	31.3
$\geqslant 3$	25	0.0046	12.1	0.0066	21.1	0.0026	4.6
$\geqslant 4$	9	0.0051	2.0	0.0071	4.6	0.0032	0.6

Test 2

A comparison of the percentage of quasars which are in clusters with the percentage of the z space that these quasars occupy can be used as some sort of a measure of clustering.

Stephenson (1977) claims that the sum of $(\Delta z)_{max}$ values is 16 % of the whole range of z for the 384 quasars. The number of quasars in Table I of Paper I is 40 % of the total. Actual calculations using the data given in Table I of Paper I give the following results for the three cases enumerated above.

(a) $\Sigma(\Delta z) = 0.188$, i.e., 5.6% of the total z space.
(b) $\Sigma(\Delta z)_{max} = 0.302$, i.e., 9 % of the total z space.
(c) $\Sigma(\Delta z)_{min} = 0.089$, i.e., 2.7 % of the total z space.

It is obvious that Stephenson has made some arithmetical error. The results given above show that 40 % of the quasars occupy 5.6 % of the whole range of z.

Test 3. Chi-square test

It is also of interest to apply the chi-square test to the present problem. In Table II, for an average $\Delta z = 0.0033$, we show the observed and calculated number of clusters for various values of k. We must note here that for $k = 5$ and 6, there is just one cluster for each, and the calculated value in each case is very small; thus it is not very meaningful to include such cases in a χ-square type of test. If we exclude $k = 5$ and 6, we find that $\chi^2 = 90.2$ and the significance level, $\alpha \simeq 10^{-18}$. Clearly, the clustering is highly non-random. (Purely as an academic curiosity we may note here that $\alpha \simeq 10^{-97}$, if $k = 5$ and 6 are included – this is merely to indicate the direction of change in the value of α in the latter case.)

TABLE II

Observed and calculated values of the number of clusters of red shifts for different k

k	Observed number of clusters	Calculated number of clusters
2	32	49.898
3	16	6.303
4	7	0.5955
5	1	0.04489
6	1	0.002813

The foregoing tests clearly show that at least for $k \geqslant 3$ the clustering of quasar red shifts (if there be one!) is highly non-random, thereby fully substantiating the paradox presented in Paper I. It is obvious that for the purpose of the arguments leading to the paradox, the exact number of clusters is not important.

In the last paragraph of his paper, Stephenson (1977) proposes an interesting but contrived model of the Universe to accommodate non-random clustering of quasar red shifts within the framework of the cosmological interpretation. However, this model merely replaces one unaesthetic possibility by another. Instead of having Earth at the center, now we have to assume that the Universe evolved in fits and starts of quasar production. The concept of preferred epochs for quasar production is hardly any more aesthetic than that of a preferred position for the Earth. There is no 'logical simplicity' or 'naturalness' about the proposed suggestion. Merely attributing the non-random clusters to a certain capricious property of the evolution of the Universe at certain arbitrary values of epochs does not explain anything. We are reminded of a well-known quotation due to Newton: 'To tell us that every species of things is endowed with an occult specific quality by which it acts and produces manifest effects, is to tell us nothing.'

References

Stephenson, C. B.: 1977, *Astrophys. Space Sci.* **51**, 117.
Varshni, Y. P.: 1976, *Astrophys. Space Sci.* **43**, 3.