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Quasar Red Shifts

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Abstract

The results of techniques developed in earlier papers are used in a discussion of the quasar red shifts. An expression with the form of a kinetic energy arises in relation to the probability distribution of red shifts. Agreement with the Hoyle & Burbridge (1966) red shift data at the time of writing is statistically significant, the correlation coefficient being 0·82.

It was shown (Yates, 1968) that singular transformations may arise in physical formalisms which require the negation concept. In this note, it is shown how the above-mentioned methods can in principle lead to results which agree with astronomical observations hitherto without proven physical explanation.

Analogously with the result obtained for the quantum mechanical problem, one obtains equations of the following type

$$\begin{bmatrix} \mathbf{r}_1(t) \\ \mathbf{r}_2(t) \end{bmatrix} = \begin{bmatrix} 0 & G_1(t,0) \\ 0 & G_2(t,0) \end{bmatrix} \begin{bmatrix} \mathbf{r}_1(0) \\ \mathbf{r}_2(0) \end{bmatrix} \tag{1}$$

Details of the derivation of (1) are not given in this brief note, since the formalism used is complicated, follows the same lines as the earlier work, and is therefore at this time only of additional interest insofar as it gives correct predictions. For a single particle $\mathbf{r}_2(t)$ represents the position coordinates at time t. $\mathbf{r}_1(t)$ also represents particle coordinates in three dimensions, which are called A-space here for convenience

$$\mathbf{r}_1(t) = \begin{bmatrix} x_1(t) \\ y_1(t) \\ z_1(t) \end{bmatrix} \qquad \mathbf{r}_2(t) = \begin{bmatrix} x_2(t) \\ y_2(t) \\ z_2(t) \end{bmatrix} \tag{2}$$

The metric is defined by (3)

$$ds^2 = dx_1{}^2 + dx_2{}^2 + dy_1{}^2 + dy_2{}^2 + dz_1{}^2 + dz_2{}^2 - c^2\,dt^2 \tag{3}$$

General relativistic considerations are not dealt with. Other particles present in the system are assumed not to exert forces on the typical particle considered above. In this sense the model is simplified.

Since particle accelerator experiments suggest that the special theory of relativity may be adequate even at velocities approaching c for small particles near a large mass, it is reasonable to suppose at least temporarily that particles which are close to heavy particles have similar velocities $\dot{x}_1$, $\dot{y}_1$, $\dot{z}_1$ in A-space.

The red shift of a body emitting radiation and moving directly away from the observer at a relative velocity v_2 is given by

$$z = \sqrt{\left(\frac{c - v_2}{c + v_2}\right)} - 1 \tag{4}$$

in the special theory of relativity. Using the present method, remembering that ordinary 3-space distances are given in terms of (x_2, y_2, z_2) only, the expression becomes

$$z = \frac{1}{\sqrt{[1 - (v_1{}^2/c^2)]}} + \sqrt{\left(\frac{c - v_2}{c + v_2}\right)} - 1 \tag{5}$$

This is because any velocity v_1 in A-space is at right-angles to the coordinate axes in ordinary space, so the additional correction term gives a transverse correction to the calculated red shift.

Now, if one has a set of N particles, each obeying equations like (1), the probability $P(v_1)$ of finding a particle with velocity v_1 in A-space is given by

$$P(v_1) = M \exp\left(-T(v_1)/\bar{T}\right) \tag{6}$$

$$T(v_1) = m_{01}\, c^2 \left\{\frac{1}{\sqrt{[1 - (v_1{}^2/c^2)] - 1}}\right\} \tag{7}$$

M is a normalising constant, $T(v_1)$ is the A-space external energy of the particle and $\bar{T}$ has the dimensions of an energy term. The equations of constraint are as follows:

$$\sum_s a_s = N \tag{8}$$

$$\sum_s \delta a_s = 0 \tag{9}$$

$$\sum_s a_s T(v_{1s}) = U \tag{10}$$

$$\sum_s T(v_{1s})\, \delta a_s = 0 \tag{11}$$

a_s is the number of particles in one notional cell c_s of the A-velocity diagram, all cells being small and of equal volume. U is the total A-space external energy. v_{1s} is a velocity in cell c_s. The summation is carried out over all cells. Nothing has been said about the possibility of A-space universe expansion and similar factors since nothing is known about them. For this and related reasons, other appropriate though more complicated theories such as those involving the Ornstein-Uhlenbeck statistics were not explored since these would in general have required a more specific physical model and more astronomical data for comparison.

M_{01} is the A-mass of the particle. If this is assumed to be the same as the special relativistic proper mass M_0 then if the rather small relative number of objects exhibiting anomalous red shifts is not increased by orders of magnitude because of subsequent observations, the immediate physical explanation for the anomalous shifts could be that quasars have a rather lower proper mass (thus a higher probability of having a high relative velocity in A-space) than other very distant large objects.

The stationary observer (relative to whom velocities are measured) is assumed to be situated on a massy object. One assigns N as the number of observable quasars, and uses an average mass m'_{01} for all quasars since the quasar masses are unknown. This does not necessarily entail the observations of the previous paragraph.

If m_v is the virtual magnitude of an observed source, then the distance of source from observer in ordinary space can be calculated in the customary way (Bondi, 1961) and the probability of finding a source at this distance in a homogeneous universe is roughly proportional to $10^{+0.4m_v}$. Let $P_0(z)$ be the observed probability distribution of red shifts. Then the probability corrected for this distance effect is given by

$$P_{\text{corr}}(z) \propto P_0(z) \times 10^{-0.4m_v(z)} \tag{12}$$

The integrated probability distribution for $z > 0.2$ is given, by

$$I_{\text{corr}}(z) = N \int_{0.2}^{z} P_0(z) \times \exp\left[-0.4m_v(z)\right] dz \tag{13}$$

N is a constant. From the first moment of the distribution obtained using the experimental results of Hoyle & Burbridge (1966) and equations (5), (6) and (7), one can estimate a theoretical distribution for convenience normalised to unity between $z = 0.2$ and $z = 2.2$

$$P_{\text{theory}}(z) = 0.686 \exp(-0.273z) \tag{14}$$

This assumes, reasonably, that $v_1 \gg v_2$.

The integrated form of (14),

$$I_{\text{theory}}(z) = 0.251\,\{0.947 - \exp(-0.273z)\} \tag{15}$$

correlates well with $I_{\text{corr}}(z)$ calculated by numerical integration from the Hoyle and Burbridge results. The t-test typically gives $t \doteqdot 3.8$ for nine equally spaced values of z between $z = 0{\cdot}2$ and $z = 2{\cdot}2$. This is highly significant statistically and looks fine on a graph, but of course t does depend on the range of z values considered.

There could be other reasons why a good correlation holds; for instance it may well be explicable by a version of Macrae's (1968) model.

However, if the technique still gives plausible results for subsequent astronomical observations it provides experimental confirmation for the ideas presented briefly in earlier papers (Yates, 1968).

[*Note added in proof:* Later measurements (Burbridge, E. R. and Burbridge, E. M. (1968). *Nature*, **222**, 735), suggest that there are very few red shifts larger than $z = 2{\cdot}5$. The present model has sufficient flexibility to allow new results of this kind to be used to refine it.]

References

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