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Red-Shifts of Quasi-Stellar Objects in the Theory of the Generalised Gravitational Potential

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Abstract

The analysis by Burbidge and co-workers on the proximity of quasi-stellar objects (QSOs) to bright galaxies is considered within the theory of the generalized gravitational potential. It is shown that in this theory the red-shift data are consistent with a connection hypothesis for three of the four QSO-galaxy systems considered in the statistical analysis.

As part of the current discussion on the red-shifts of QSOs, Burbidge *et al.* (1971) have reported the results of a statistical analysis on the proximity of 47 QSOs to bright galaxies. Four of these objects were found to be much closer to bright galaxies than would be expected from a random distribution, and it is therefore presumed that these four QSOs are connected to their respective galaxies. Since the red-shifts of the QSOs are considerably different from the red-shifts of the galaxies with which they are presumed associated, the origin of these differences requires investigation. This problem was previously treated in the context of the general-relativistic scalar field theory in the complex Weyl space (Cherry, 1971a, b, c). In this paper, the generalized gravitational potential inferred from this field theory is applied in greater detail to the red-shift problem implied by the work of Burbidge and co-workers.

If in a given manifold the component g_{00} of the metric tensor differs from a constant there is, according to relativity theory, a shift in the spectrum of an oscillator located alternately at different field points. In Einstein's theory, under the condition of spherical symmetry, the component g_{00} may take the form

$$g_{00} = 1 - \frac{2GM}{c^2 r} \tag{1}$$

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where G is the Newtonian gravitational constant, M the mass of the body, c the speed of light and r the co-ordinate distance of a field point. In the theory of the generalized gravitational potential, with the same symmetry and in the absence of the Newton-Einstein field, g_{00} may take the form

$$g_{00} = 1 - \frac{r_0 A^{1/3}}{r} \tag{2}$$

when oscillators are subject to the field of a stellar body whose density is comparable to that of nuclear matter and where r_0 is the nucleon core radius and A is the stellar mass number (Cherry, 1971c). When the Newton-Einstein field is taken into account, we have

$$g_{00} = 1 - \left(\frac{2GM}{c^2} + r_0 A^{1/3}\right)\frac{1}{r} \tag{3}$$

Equation (3) implies a superposition of these two gravitational fields and thus their independence is assumed, at least on the level of this theory.

When the frequency shifts resulting from the nuclear form equation (2) and the Einstein form equation (1) are compared, we obtain the ratio

$$R \equiv \frac{\Delta\nu_{(2)}}{\Delta\nu_{(1)}} = \frac{r_0 c^2}{2Gm^{1/3}} M^{-2/3} \tag{4}$$

where m is the nucleon mass. For example, with one solar mass and taking $r_0 = 0{\cdot}78\ \mathscr{F}$m, (Cherry, 1971b) we have $R = R_s = 2{\cdot}82$. From equations (3) and (4) we now have for the total gravitational red-shift

$$Z = \left[\frac{2R_0 R}{r_0 \rho^{1/3}(1+R)} - 1\right]^{-1} \tag{5}$$

where $R_0 = 1{\cdot}21\ \mathscr{F}$m. is the nucleon radius and $\rho \equiv D/D_0$ is the ratio of the density D of the QSO to that of the density D_0 of the nucleon. For example, for a solar mass with nuclear density ($\rho = 1$) we have from equation (5) $Z = 0{\cdot}776$, which is sizeably larger than the value obtained from Newton–Einstein gravitation alone. This value of Z is representative of the values for the four QSOs discussed by Burbidge.

TABLE 1. Density ratios and densities of four QSOs

QSO	Z (unidentified)	ρ ($M = 0{\cdot}25\ M_\odot$)	D (g/cm^3) $\times 10^{14}$
3C 232	0·526	0·827	1·85
3C 275·1	0·553	0·909	2·04
3C 309·1	0·900	2·13	4·77
3C 268·4	1·391	4·02	9·01

In Table 1, we list the four QSOs together with the unaccounted for values of Z. The table also includes calculated values of ρ from equation (5), assuming $M = 0{\cdot}25\ M_\odot$, and average QSO densities $D = \rho D_0$, where $D_0 = 2{\cdot}24 \times 10^{14}$ g/cm³.

The value of M was chosen in order to compare the predictions of this theory with neutron star models (Cameron, 1959). For our value of r_0 we obtain a maximum star density of $\sim 6 \times 10^{14}$ g/cm³, which from Cameron's work implies that $M \approx 0{\cdot}25\ M_\odot$ and that $D = 2.80 \times 10^{14}$ g/cm³. A larger choice for M gives a smaller value for D and there is no suggestion that all of these QSOs have identical masses. The comparison of the values of D with the Cameron average density for this choice of mass gives a reasonable correlation except for 3C 268·4. This QSO has a density that is predicted to be greater than the maximum allowable density in this model. It should be noted, however, that the average Cameron density could be arranged if the added gravitational effect postulated here were included in his calculations. Such a modification, however, would still not yield densities greater than the maximum based on the present choice of r_0. We are, therefore, still confronted with the case of 3C 268·4. It is noted, however, from equations (3) and (5) that the 'Schwarzschild' singularity requires that

$$\frac{R_0 R}{r_0 \rho^{1/3}(1+R)} > 1 \tag{6}$$

This condition, in turn, implies that $Z < 1$. From Table 1, we observe that this requirement is met with the exception of 3C 268·4.

It is concluded, therefore, that in the theory of the generalized gravitational potential the connection hypothesis is supported for three of the four systems considered and that in these three cases the red-shift is accounted for by considering a generalized gravitational potential. We note, finally however, that the object 3C 268·4 may also have a large generalized gravitational factor in its red-shift, with the excess due to recession velocity.

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