J. Astrophys. Astr. (1997) **18**, 435–440

Quasars in Variable Mass Hypothesis

P. K. Das, *Indian Institute of Astrophysics, Koramangala, Bangalore 560 034, India*

Abstract. The variable Mass Hypothesis of conformal gravitation theory of Hoyle-Narlikar is used to develop a model for the anomalous redshift quasar-galaxy associations. It is hypothesised that quasars are born in and ejected from the nuclei of parent galaxies as massless objects and the particle masses in them systematically increase with epoch. The dynamics of such an ejection is discussed and it is shown that the observed features such as redshift bunching and quasar alignments can be understood in this scenario. Further tests of this hypothesis are suggested.

Key words. Hoyle-Narlikar cosmology—anomalous redshift—quasar-galaxy associations.

1. Introduction

A theoretical alternative for noncosmological redshifts is discussed in the framework of Hoyle-Narlikar (HN) theory of gravitation (Hoyle & Narlikar 1974). Observed features of Quasar-Galaxy(Q-G) associations are interpreted in this scenario.

2. The variable mass hypothesis (VMH)

The Machian HN theory admits variable mass solutions with the occurrence of $m = 0$ hypersurfaces (Variable Mass Hypothesis (VMH))

Consider Friedmann E-dS spacetime (r, t)

$$ds^2 = c^2dt^2 - (3H_0t/2)^{4/3}[dr^2 + r^2(d\theta^2 + sin^2\theta d\phi^2)] \tag{1}$$

with a conformal transformation

$$ds^2 \rightarrow d\bar{s}^2 = \Omega^2 ds^2, \quad \Omega(t) = \left(\frac{2}{3H_0t}\right)^{2/3}, \tag{2}$$

we obtain a static, Minkowskian spacetime (r, τ)

$$d\bar{s}^2 = c^2d\tau^2 - [dr^2 + r^2(d\theta^2 + sin^2\theta d\phi^2)], \tag{3}$$

where

$$\tau = \left(\frac{12t}{H_0^2}\right)^{1/3} = (27tt_0^2)^{1/3}, \quad \tau_0 = 3t_0 = \frac{2}{H_0}$$

and

$$\Omega = \left(\frac{t_0}{t}\right)^{2/3} = \frac{\tau_0^2}{\tau^2} = \frac{4}{H_0^2\tau^2}. \tag{4}$$

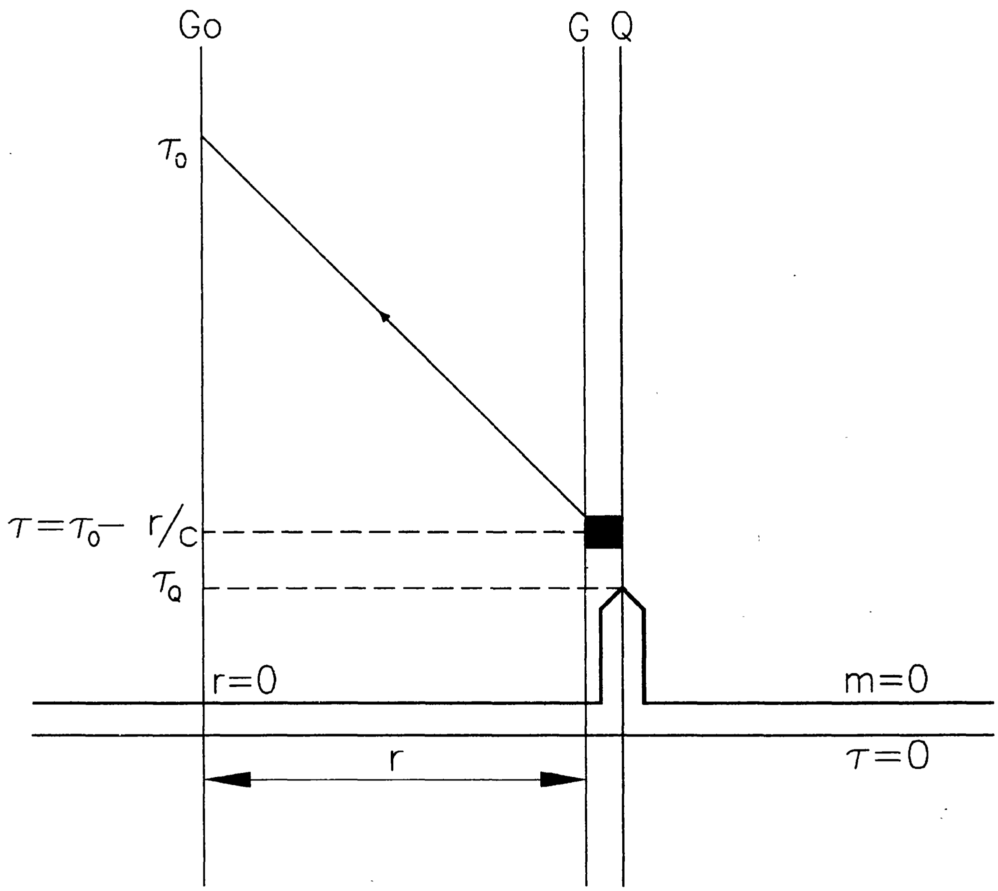

Figure 1. Redshifts in VMH. The worldline of Q crosses the kink in $m = 0$ hypersurface while that of G does not. Q has anomalous redshift.

In (r, τ) frame the particle masses are variable.

$$m \to \bar{m} \propto \Omega^{-1} = \mu\tau^2, \quad \mu = \text{constant}. \tag{5}$$

Redshifts

In Fig. 1 if observer galaxy G_0 at $r = 0$, $\tau = \tau_0$ views observed galaxy G at $r > 0$, $\tau = (\tau_0 - r/c)$ the particle masses in G_0 and G are

$$\bar{m}_{G_0} = \mu\tau_0^2,$$
$$\bar{m}_G = \mu\tau^2 = \mu(\tau_0 - r/c)^2.$$

Since length scales inversely as mass the lower particle masses in G give rise to redshift when observed from G_0

$$(1 + z_G) = \frac{\bar{\lambda}_G}{\bar{\lambda}_{G_0}} = \frac{\bar{m}_{G_0}}{\bar{m}_G} = \frac{\tau_0^2}{(\tau_0 - r/c)^2}, \tag{6}$$

this is the usual cosmological redshift expressed in a different form.

Anomalous redshifts

To incorporate anomalous redshifts we introduce kinks (local inhomogeneities) in the zero mass hypersurface (Narlikar 1977) Consider a quasar Q in the neighbourhood of G (same r) but located in a kink. Zero mass of Q occurs at a later epoch $\tau_Q > 0$. Particle mass in Q is

$$\bar{m}_Q = \mu(\tau - \tau_Q)^2$$

and

$$(1 + z_Q) = \frac{\bar{m}_{G_0}}{\bar{m}_Q} = \frac{\tau_0^2}{[\tau_0 - r/c - \tau_Q]^2}. \qquad (7)$$

Thus $z_Q > z_G$ i.e. Q has an anomalous redshift. We may look upon $\bar{m} = 0$ as the 'creation epoch' and consider Q being 'born' in and ejected from the nucleus of G in a mini explosion at $\tau_Q > 0$.

We assume that the bulk of the matter is 'normal'($\bar{m} = 0$ at $\tau = 0$) and the kinks are few and far between. So the cosmological solution is unaltered.

3. The dynamics of quasar-galaxy pair

In E-dS (r, t) frame the masses of 'normal' matter become constant but the masses in quasars remain variable

$$m(t) = m_0\left[1 - \left(\frac{t_Q}{t}\right)^{1/3}\right]^2, \quad m_0 = \text{constant}. \qquad (8)$$

We assume that the mass of Galaxy G is mostly concentrated in a spherically symmetric nuclear region and analyze the radial motion of the variable mass quasar Q in the external Schwarzschild field of G. (Narlikar & Das 1980) The radial motion can be considered as an approximation to motion in a highly eccentric orbit (Fig. 2).

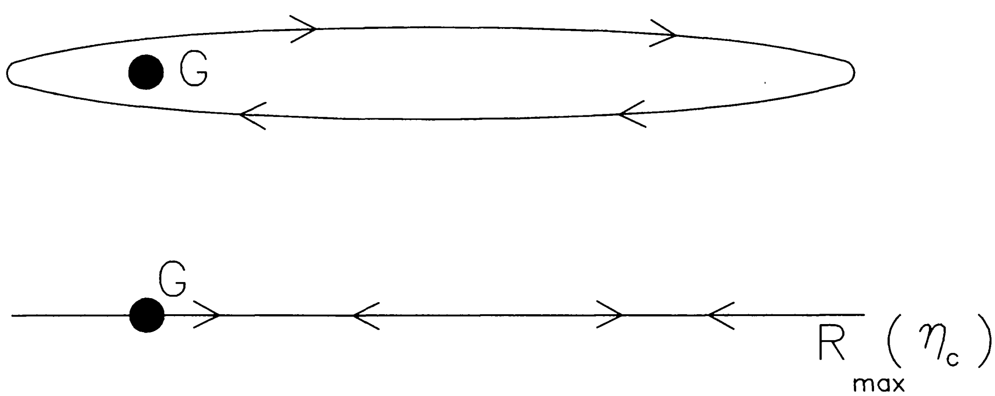

Figure 2. Linear motion as an approximation to motion in a highly eccentric orbit. $R_{\max}(\eta_C)$ is the maximum separation between G and Q for bound quasars.

In Schwarzschild time coordinate T of G the epochs of observation and the 'birth' of Q are given by

$$T_G \approx \frac{2}{3H_0}(1+z_G)^{-3/2}, \tag{9}$$

$$T_Q \approx \frac{2}{3H_0}[(1+z_G)^{-1/2} - (1+z_Q)^{-1/2}]^3, \tag{10}$$

and the mass of Q grows as

$$M_Q = M_0\left[1 - \left(\frac{T_Q}{T}\right)^{1/3}\right]^2$$

$$= \frac{(1+z_G)}{(1+z_Q)}M_0 \quad \text{at} \quad T = T_G, \quad M_0 = \text{constant}. \tag{11}$$

Results of numerical solutions of the equations of motion:

(1) Q, though fired with speed of light, quickly slows down as its mass grows as per eqn (11),

(2) motion of Q is characterized by a parameter η which determines the time span of relativistic motion. For a given mass M of G there exists a critical η_c such that For $\eta < \eta_c Q$ forms a bound system with G, undergoing damped oscillations of decreasing periods.
For $\eta > \eta_c Q$ escapes the gravitational influence of G.
Thus η_c is analogous to 'escape speed'.

We hypothesise that all quasars are born in galactic explosions. Those with $\eta < \eta_c$ are seen as anomalous companions of galaxies whereas those with $\eta > \eta_c$ are seen as field quasars.

(3) The maximum separation $R_{max}(\eta_c)$ between Q and G (for bound quasars) depends upon z_G, z_Q and M.
(a) $R_{\max}$ decreases very slowly with z_G and z_Q.
(b) $R_{\max} \propto M^{1/3}$.

4. Observational support

The model is fairly successful in explaining observed features of typical Q-G associations.

(1) Angular separation (θ_{QG}) – galaxy redshift (z_G) correlation:-

The near constancy of $R_{\max}$ with z_G implies a constant physical separation between Q and G. This shows up as the well known $\theta_{QG} \propto 1/z_G$ dependance in the $\log \theta_{QG}$– $\log z_G$ plots.

(2) Alignments and redshift bunchings:

Multiple quasar creation in a single explosion will result in many quasars of (nearly) equal redshift around a galaxy and the conservation of momentum will

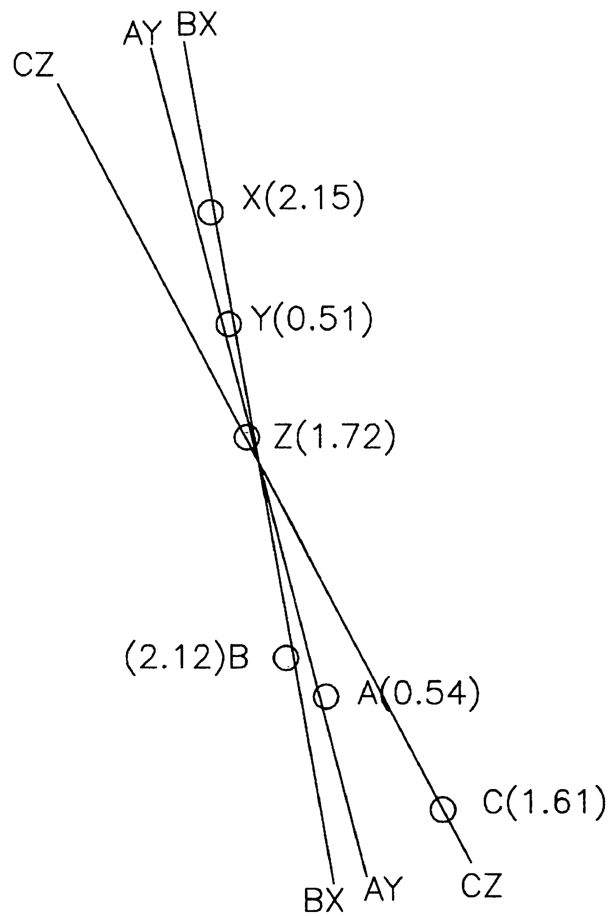

Figure 3. The Arp–Hazard triplets. Quasars A, B, C and X, Y, Z are roughly collinear. The lines AY, BX and CZ pass close to one another near Z.

give rise to alignments of quasars. Similarly multiple ejections at different epochs will result in quasars with redshifts bunched around values corresponding to these epochs.

We illustrate this with the example of Arp-Hazard triplets (Fig. 3) (Arp & Hazard 1980).

Here we have 3 quasars A, B, C ($z_A = 0.54$, $z_B = 2.12$, $z_C = 1.61$) in a straight line with another triplet X, Y, Z with similar redshifts close by ($z_Y = 0.51$, $z_X = 2.15$, $z_Z = 1.72$). In the present scenario we try to locate the seat of explosion by joining the pairs with similar redshifts. The lines AY, BX and CZ pass close to each other near Z. Could this be the location of the parent galaxy?

5. Further tests for VMH

(1) Evidence for smaller particle masses in higher redshift quasars could come from the enhanced synchrotron luminosity from less massive electrons.
(2) The redshift dependance of the age of quasars (higher redshift implies younger quasar) can be used in any age estimation criterion for quasars.

References

Arp, H., Hazard, C. 1980, *Astrophys. J.*, **240**, 726.
Hoyle, F., Narlikar, J. V. 1974, *Action at a Distance in Physics and Cosmology* (San Francisco: Freeman).
Narlikar, J. V. 1977, *Ann. Phys.*, **107**, 325.
Narlikar, J. V., Das, P. K. 1980, *Astrophys. J.*, **240**, 401.