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FLAT SPACETIME COSMOLOGY: A UNIFIED FRAMEWORK FOR EXTRAGALACTIC REDSHIFTS

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ABSTRACT

It is known that the standard Friedmann cosmology with $k = 0$ can be described equivalently in a conformal frame in which the spacetime is Minkowskian but all particle masses uniformly scale with epoch. In a Machian theory of gravity this spacetime dependence of mass is understood in terms of inertial interactions. This picture is shown to be more versatile than standard cosmology because it allows one to interpret objects of anomalously high redshift to be "young" objects whose particle masses are lagging behind the universal mass function. We discuss here a variety of extragalactic phenomena within the framework of this model and show that these can be understood without recourse to adjustible parameters such as evolution, cosmological constant, etc.

Subject headings: cosmology: theory — galaxies: distances and redshifts

1. INTRODUCTION

The Friedmann solutions of Einstein's field equations provide the conventional framework for understanding the redshifts of extragalactic objects. These solutions use the non-Euclidean Riemannian geometry of the Robertson-Walker metric

$$ds^2 = c^2\,d\tau^2 - S^2(\tau)\left[\frac{dr^2}{1 - kr^2} + r^2(d\theta^2 + \sin^2\theta\,d\phi^2)\right] \quad (1)$$

for describing the cosmological spacetime. Here (r, θ, ϕ) are the comoving coordinates of a typical extragalactic object and t the cosmic time. The hypersurfaces τ = constant are homogeneous and isotropic with constant curvature that is positive ($k = 1$), zero ($k = 0$) or negative ($k = -1$). The redshift of a galaxy is given by

$$1 + z = \frac{S(\tau_0)}{S(\tau_1)}, \quad (2)$$

where τ_1 = epoch when light left the galaxy and τ_0 = epoch when light is recieved by us (as typical observers). The fact that all galaxies (and QSOs) show redshifts that systematically increase with distance means that $S(\tau_0) > S(\tau_1)$ for all $\tau_1 < \tau_0$. That is, $S(\tau)$ is a monotonic increasing function of τ which leads to the usual conclusion that the universe is expanding. The Hubble constant relating redshift to distance is given by

$$H_0 = \frac{\dot{S}}{S}\bigg|_{\tau=\tau_0}. \quad (3)$$

The Einstein field equations determine $S(\tau)$ as a function of τ for different values of k and for the matter treated as dust. These are the well-known Friedmann solutions.

The above paragraph summarizes the simplified conventional picture of modern cosmology. Reality is now being realized to be more complicated. For example, galaxies appear to have large scale streaming motions and random motions within clusters, and hence the constancy of (r, θ, ϕ) for a galaxy is not rigorously correct (Narlikar 1993). Even assuming that these motions add a Doppler component to z, there are problems with understanding the origin of the numerous instances of anomalous redshifts (Arp 1987). Because no understanding is possible within the conventional framework for these latter phenomena, they are often dismissed as unproven or insignificant.

We believe that with the steady accumulation of evidence for anomalous redshifts it is no longer possible to ignore them. It is time to look for a theoretical framework, a framework that accommodates them along with the large body of conventional evidence for cosmological redshifts. Here we attempt such a framework. The following two sections give the broad theoretical outline while § 4 concentrates on observations.

2. THE "VARIABLE MASS HYPOTHESIS"

In 1977 one of us (Narlikar 1977) had proposed a variation of the Hoyle-Narlikar conformal theory of gravity (Hoyle & Narlikar 1966). We shall refer to that paper (Narlikar 1977) as Paper I, and use some of the basic results derived therein. The field equations of the theory are as follows:

$$\tfrac{1}{2}m^2(R_{ik} - \tfrac{1}{2}g_{ik}R) = -3T_{ik} + m(\Box m g_{ik} - m_{;ik}) + 2(m_{,i}m_{,k} - \tfrac{1}{4}m^{,l}m_{,l}g_{ik}), \quad (4)$$

$$\Box m + \tfrac{1}{6}Rm = N. \quad (5)$$

Here m is the universal mass function which, as per equation (5), has sources in the number density N of particles in the universe. All particle masses scale with space and time according to m. The theory is therefore entirely Machian in character and since it allows for spacetime-dependent masses we will refer to it as the variable mass hypothesis (VMH).

As was discussed by Hoyle & Narlikar (1966), the field equations (4) are conformally invariant and reduce to those of general relativity in the conformal frame m = constant. We shall refer to this frame as the relativistic frame. However, it is not always possible to enforce this frame, especially in a spacetime region where $m = 0$. If we insist on using this frame we

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may have to pay a price in terms of geometrical singularities. It was shown by Kembhavi (1978) that the zero mass hypersurfaces are none other than the spacetime singularities that appear in the general relativistic solutions.

We illustrate this statement with the flat spacetime solution of equations (4) and (5). It can be easily verified that the solution of these equations is given by the Minkowski metric

$$ds^2 = c^2\, dt^2 - dr^2 - r^2(d\theta^2 + \sin^2\, d\phi^2)\,, \tag{6}$$

with the mass function

$$m = at^2\,, \quad a = \text{constant}\;; \tag{7}$$

the number density of particles being constant in the comoving reference frame (r, θ, ϕ).

We have here a flat spacetime cosmology in which light waves travel without spectral shift. How then do we explain redshift? Consider a galaxy G at a given radial coordinate r, the observer being at $r = 0$. A light ray leaving the galaxy at $t_0 - r/c$ reaches the observer at time t_0. Since the masses of all subatomic particles scale as t^2, the emitted wavelengths go as $m^{-1} \propto t^{-2}$. Hence we get the factor

$$1 + z = \frac{t_0^2}{[t_0 - (r/c)]^2} \tag{8}$$

as the ratio of the wavelength *actually emitted* by the galaxy to the wavelength emitted in the laboratory of the observer. As such the observed cosmological redshift is the consequence of the systematic increase in particle masses with the t-epoch.

This solution is observationally *no different* from the Einstein–de Sitter model because we can make a conformal transformation that makes the mass function constant by choosing a conformal function $\propto t^2$. Thus, writing

$$ds_R \propto t^2\, ds \tag{9}$$

the line element in the *relativistic frame* ds_R^2 becomes the familiar Einstein–de Sitter line element if we make the coordinate transformation

$$t \propto \tau^{1/3}\,, \quad t_0 = 3\tau_0\,. \tag{10}$$

It is well-known that all Robertson-Walker cosmological models are conformally flat. Explicit conformal transformations taking the $k = \pm 1$ models to the flat spacetime were given by Infeld & Schild (1945). However, in such cases the conformal function depends both on r and τ. Thus it is possible to obtain flat spacetime solutions of equations (4) and (5), but in these cases the mass function depends on r and t. Such solutions are ruled out in our present cosmology by the requirement that the hypersurfaces t = constant are homogeneous and isotropic.

Nevertheless, such solutions may be of relevance to local regions containing compact massive objects. Indeed, although we have replaced the usual cosmological expansion by an epoch dependent particle mass, local gravitational redshifts will require m depending on space as well as time. Since this paper deals with cosmological effects we will confine our attention to the simple model described by equations (6)–(10).

Notice that in a well behaved conformal transformation the conformal function should not vanish or become infinite. Here we have to pay the price of choosing a conformal function that vanishes at $t = 0$: for in the relativistic frame the $\tau = 0$, $t = 0$ hypersurface has the (big bang) singularity.

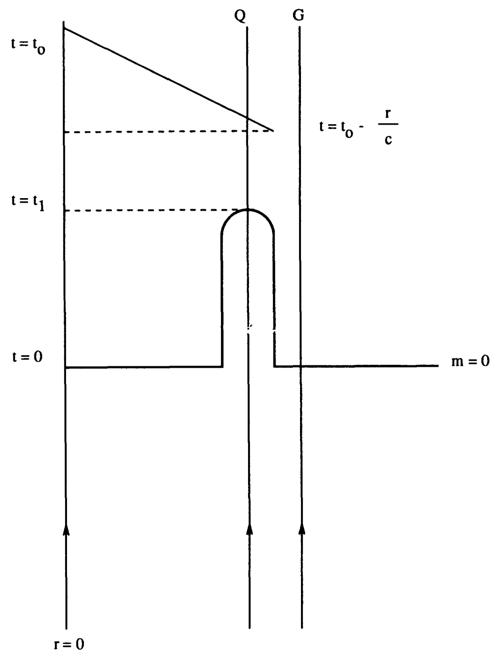

FIG. 1.—Spacetime diagram showing the worldlines of a QSO Q and a galaxy G crossing the zero mass hypersurface. The latter crosses the hypersurface at $t = 0$ while the former crosses it at $t = t_1 > 0$. The hypersurface has a kink which raises it from the generic value $t = 0$ to a local value $t = t_1$.

The flat spacetime cosmology admits anomalous redshifts in a natural way, as was shown in Paper I. Suppose the zero-mass hypersurface has a kink as shown in Figure 1. The world line of a QSO, Q (say) intersects it at an epoch $t_1 > 0$. As shown in Paper I, the particle mass function in Q starts ticking from *this epoch.* Thus at an epoch $t > t_1$ it will be $\propto (t - t_1)^2$. The interpretation of this result is simple; the particle receives all inertial contributions of $1/r$ type from a past light cone extending from t to t_1.

In Figure 1 we see a QSO, Q, and a galaxy, G, both close neighbors but the worldline of Q passes through the kink while that of G does not. For particles in G the mass function is $\propto t^2$ at epoch t. If both Q and G are at a distance r from the observer, formula (8) gives the respective redshifts as

$$1 + z_Q = \frac{t_0^2}{[t_0 - (r/c) - t_1]^2}\,, \quad 1 + z_G = \frac{t_0^2}{[t_0 - (r/c)]^2}\,. \tag{11}$$

So we have $z_Q > z_G$ and an anomalous reshift for the QSO. Narlikar & Das (1980, hereafter Paper II) considered such pairs.

As illustrated in Figure 1, the world lines of Q and G continue on both sides of the zero mass hypersurface. However, the appearance of $m = 0$ corresponds in the relativistic frame to the spacetime singularity, thus giving an incomplete (and erroneous) view of a universe "beginning" at $\tau = 0$. In practice we may interpret Figure 1 as describing a QSO ejected from the neighbor galaxy. Paper II had given a detailed dynamical study of such pairs.

3. SOME IMPLICATIONS OF FLAT SPACETIME COSMOLOGY

We consider in this section a few issues that pertain to the flat spacetime picture given by the VMH.

3.1. *Stability*

How can a static, matter-filled universe remain stable? Would it not collapse as Einstein (and even earlier, Newton) found? The answer is that stability is guaranteed by the mass-dependent terms on the right-hand-side of equation (4). Small perturbations of the flat Minkowski spacetime would lead to small oscillations about the line element (6) rather than to a collapse.

3.2. *Hubble's Constant*

Suppose in equation (8) the galaxy G is nearby. As seen by the observer, it looks younger in age by r/c, compared to the galaxy of the observer. However, this age is measured on the t-scale. If one uses standard atomic/nuclear/particle physics for determining the age of a galaxy one must use the τ-scale. Since $t \propto \tau^{1/3}$, small changes in t and τ near t_0, τ_0 are related by

$$\frac{\Delta t}{t_0} = \frac{1}{3}\frac{\Delta\tau}{\tau_0} . \tag{12}$$

Since $t_0 = 3\tau_0$, we have $\Delta t = \Delta\tau$. Now the first-order Taylor expansion of equation (8) gives for small redshifts

$$z = \frac{2r}{ct_0} , \quad \text{i.e.,} \quad H_0 = \frac{2}{t_0} . \tag{13}$$

Since $r/c = \Delta t = \Delta\tau$, we can express (13) by

$$z = H_0 \Delta\tau = H_0 r/c . \tag{14}$$

Thus the Hubble relation is really an age-redshift effect.

3.3. *The Surface Brightness Test*

It is argued by Sandage & Perelmuter (1990a, b) that the surface brightness of a galaxy (with a "standard candle" and "standard size" assumption built in) varies with redshift as $(1 + z)^{-4}$ in standard cosmology and this fact can be used to distinguish it from other cosmologies where the redshift does not arise from expansion.

In our model the surface brightness can be related to redshift in this way: For galaxies whose world lines cross the zero mass hypersurface at $t = 0$, the luminosity scales as m^2 while surface area scales as m^{-2}. Hence energy flux per unit area per unit time scales as m^4, i.e., as $(1 + z)^{-4}$. Thus the present theory would predict the same relation as standard cosmology. This is not surprising since the present cosmology is a conformal transform of standard cosmology. It would, however be interesting to see how the surface brightness behaves with redshift for the anomalous redshift objects since for them the predicted relation *would be different* and more complicated.

4. A BETTER FIT TO THE OBSERVATIONS

The primary evidence which needs to be explained by any theory is the observed redshift-distance relation for normal galaxies. In the early seventies Fred Hoyle (1972) showed that the Hubble law could be produced in one mathematical step from an equation equivalent to (11). This is because the look-back time to a distant galaxy shows it an earlier era when its particle masses are smaller and its redshift therefore higher.

From (13) the Hubble constant is simply determined by the age of the galaxies which comprise the relation. If we take the age of the galaxies to be equal to the age of the oldest stars they contain, then for galaxies like our own (cf. Sandage & Cacciari 1990):

$$17 > \tau_0 > 13 \times 10^9 \text{ yr} . \quad \text{given age ,}$$

yielding:

$$39 < H_0 < 51 \text{ km s}^{-1} \text{ Mpc}^{-1} \quad \text{predicted by equation (13) ,}$$

compared to:

$$42 < H_0 < 56 \text{ km s}^{-1} \text{ Mpc}^{-1} \quad \text{observed .}$$

The observed values of the Hubble constant are by Allan Sandage (1988a, b, 1991) and are estimated to give $H_0 = 50 \pm 10$.

The importance of this result is that our formula predicts the observed value of the Hubble constant and that it does so without any possibility of adjusting the prediction by changing the geometry or introducing cosmological constants. Only one datum is introduced—the measured age of the oldest stars—and that uniquely determines the value of the Hubble constant which must be observed.

4.1. *Observed Hubble Constants Greater than $H_0 = 50$*

What about the higher values of $H_0 = 80$–100 km s^{-1} Mpc^{-1} reported by many investigators? First, those investigators agree that H_0 is near 50 in our neighborhood. They report, however, that it increases to about 90 at about twice the distance to the Virgo Cluster. Adherents of 50 for the global value of H_0 claim that this is due to luminosity-biased selection effects. But others argue that this is not a bias but a real effect (Tully 1988; Arp 1990a; Giraud 1988, pp. 327–331). Can both the $H_0 = 50$ and $H_0 = 80$ to 100 measurements be right?

In fact evidence has been presented to show that as one goes to higher redshift samples one perforce encounters galaxies younger than the norm (Arp 1991a, b). By our equation (11) they will have larger intrinsic redshifts. Figure 2 shows how

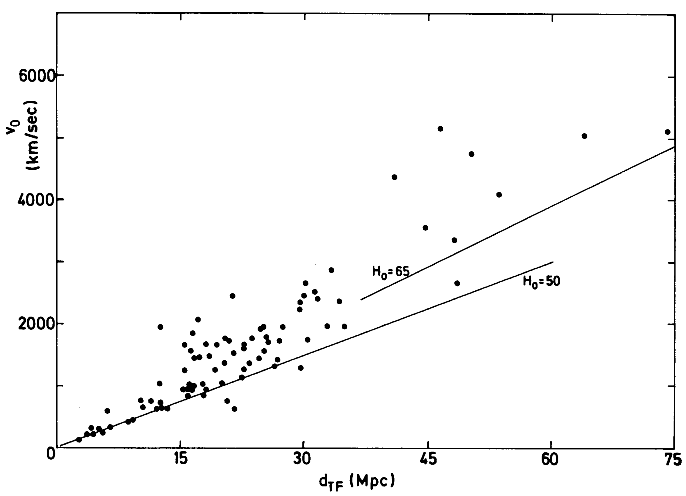

FIG. 2.—Hubble diagram from rotational Tully-Fisher distances (d_{TF}) plotted against redshifts (v_0) for a sample of Sc spiral galaxies. These distances are not derived from the systemic redshifts of the galaxies but through their inferred rotational masses. For low-redshift galaxies a very accurate fit to $H_0 = 50$ km s^{-1} Mpc^{-1} is evident. From Arp (1988).

such galaxies would raise the Hubble constant above the local value of 50. (Remember that any young, higher redshift galaxies would be automatically considered out of our local region). Our suggestion is that both sets of observations are valid and that H_0 only *appears* to increase from the correct value of $H_0 = 50$ due to the inclusion of an increasing number of younger galaxies at higher redshift.

4.2. *Evolution Away from the Hubble Relation at High z*

Spinrad & Djorgovski (1987) report measures of radio galaxies which deviate from the Hubble relation by 5–6 mags at $z \approx 1.5$. This is conventionally attributed to evolution but it requires these galaxies to be 100–240 times brighter in the past than at present. Naturally this requires "star bursts" of unprecedented scale and would make it necessary to observed hydrogen dominated precursor galaxies which have not been seen.

If, however, these active galaxies and the material in them have been created more recently we would expect by our precepts to have them deviate to higher redshift from the Hubble line. In this respect the radio galaxies would have a deviation due to intrinsic redshift intermediate between quasars and normal galaxies. This would agree with their generally intermediate physical properties.

More normal *E* galaxies, however, can be measured out to redshifts $z \approx 1$. For observations in the infrared where young stars hardly affect the magnitude we see deviations of about 2 mag brightward from an unevolved Hubble line of $q_0 = 0$. It is interesting to note that our predicted value of H_0 pertains only locally, for $z \to 0$. If we differentiate equation (8) we obtain:

$$\frac{c\,d(1+z)}{dr} = H = \frac{2}{t_0}(1+z)^{3/2} . \qquad (15)$$

Therefore for $z = 1$ we predict $H = 2.8H_0$. If this were interpreted as a deviation from the Hubble relation in an expanding universe it would require a normal galaxy to be 2.3 mag more luminious in the past. But, in fact, as we see in both the Bruzal (1983) and Grasdalen (1980) analyses this is just about the 2 mag deviation from the Hubble line which is observed in normal *E* galaxies. The point is that the additional epicycle of systematic evolution which is needed in the big bang theory to reconcile theory with observations is not needed in the flat spacetime cosmology discussed here.

4.3. *The Dispersion in the Hubble Relation for Cluster Galaxies*

It is often claimed that the Hubble relation for clusters of galaxies is so tight that it precludes any other explanation than an expanding universe. We agree that it has small dispersion, too small in fact for the kind of universe we are supposed to live in. Measures of peculiar velocities of clusters are reported as 0 to 1000 km s^{-1} (Mould 1988) $\gtrsim \pm 1500$ km s^{-1} (Rubin 1988) and $\sqrt{2}\,\sigma = 2000$ km s^{-1} (Bahcall 1988). As Figure 3 shows this kind of dispersion in velocity should blow up the lower $\frac{1}{3}$ of the clusters Hubble diagram. Can the classic Hubble diagram for clusters be correct in view of these large, supposed peculiar motions in the universe?

The answer is yes if the redshifts are not due to velocity. If Sandage has measured only very similar clusters which have galaxies of very nearly the same age then he would get very little dispersion from the exact Hubble relation required by the flat universe solution of equation (8). The investigators who measured clusters of increasingly different characteristics would get higher dispersion in redshifts but these would not represent velocity peculiarities.

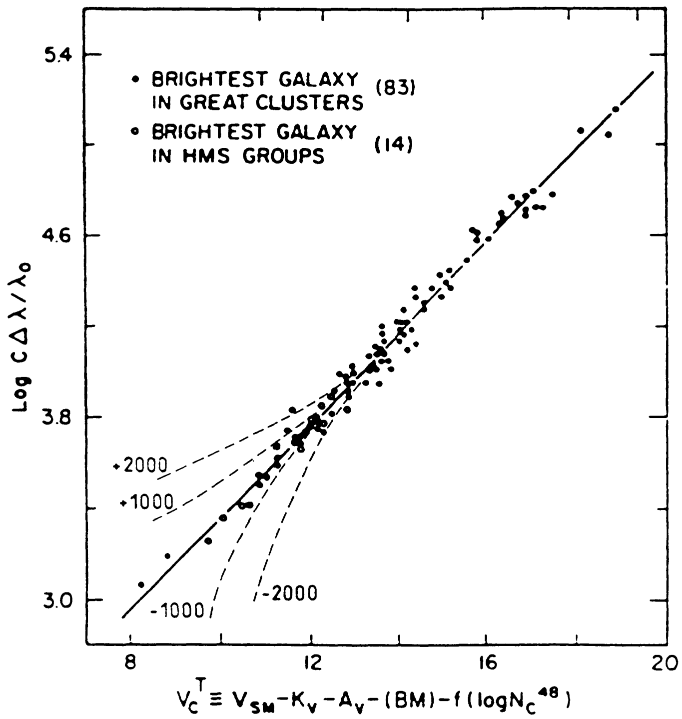

FIG. 3.—Hubble diagram for clusters of galaxies from Sandage (1975). The dispersions which clusters with peculiar velocities of ±2000 and ±1000 km s^{-1} should show are indicated by the added dashed lines.

We shall see in the following section that in any case the existence of such velocities may very well be ruled out by the observational evidence on quantization of galaxy redshifts and the failure to observe dark matter.

4.4. *Quantization of Redshifts and Missing Mass*

Quantization has now been observed from the highest to the lowest extragalactic redshifts. For quasars (Arp et al. 1990a) $\Delta \ln(1 + z) = 0.205$, while Duari et al. (1992) find periodicity of $\Delta cz \approx 0.0565$ for over 2000 quasars with a confidence level exceeding 90%. For medium redshift galaxies $\Delta cz \approx 0.06$ from $z = 0.06$ to 0.24 (Burbidge & Hewitt 1990). Broadhurst et al. (1990) have also reported a lattice-like structure on the scale of $\Delta cz \approx 0.044$ in a pencil beam survey of galaxies. For low-redshift galaxies the case for quantization of $c\Delta z = 72$ km s^{-1} by Tifft & Cocke (1984) and $c\Delta z \sim 37$ km s^{-1} by Guthrie & Napier (1991) has been very persuasive, the latter to a confidence level of 0.99999.

On the large scale the universe could not be expanding in shells because the likelihood of our being at the exact center of all these shells is vanishingly small. On the small scale any large number of peculiar velocities appreciably larger than ± 37 km s^{-1} would effectively wash out that observed quantization. Therefore the existence of large-scale systematic as well as large and small random velocities are observationally excluded.

The "missing mass" problem which arises from the inferred peculiar velocities and velocity dispersions of galaxies, however, gives us the same answer. Since strenuous observational and laboratory searches have not detected the theoreticians' menu of exotic dark matter we are pushed toward the conclusion that, with the exception of flat rotation curves in spiral galaxies, the galaxy redshifts need not translate into true velocities.

Redshifts which arise from a difference in age, however, could solve the quantization problem in a natural way. Creation processes which produce galaxies at different times must originate at a zero mass surface. Close to the zero mass surface the classical action is very small and hence physics is dictated by quantum considerations. Thus one could argue that the material that emerges from the zero mass, quantum mechanical realm may do so in discrete bursts spaced at discrete intervals. This could lead to a quantized distribution of redshift intervals. Although this is at the moment only a crude suggestion, the alternative of trying to explain the observed quantization in a velocity-only universe seems quite daunting.

4.5. *Excess Redshifts of Quasars and Active Galaxies*

For more than 25 years evidence has been building up that quasars of generally large redshifts are associated with larger, much lower redshift galaxies (Arp 1990a, b). Recent analyses of all known quasars reinforce this conclusion very strongly (Burbidge et al. 1990). This result is, of course, inexplicable on the conventional interpretation. There is a natural explanation, however, if the quasars represent newly created material ejected from a nearby galaxy (Narlikar & Das 1980). There is considerable evidence for such ejection (Arp 1987). The attractive feature of explaining the quasar redshifts by young matter is that the quasars appear young—i.e. with unsustainable energy densities and compact morphologies and in some cases with evidence for young stars. Active galaxies which also show excess redshifts but lesser in amount, would represent a later development stage as this intrinsic redshift decays with age.

4.6. *Excess Redshifts of Companion Galaxies and Stars*

Galaxies characteristically group together in space usually around a large, dominant galaxy. The rather normal looking companion galaxies have redshifts systematically larger by the order of 100 km s^{-1} (also quantized). In just the two nearest groups, the Local Group and M81 Group, this excess is found to be statistically significant at the 1–5 $\times 10^{-7}$ level (Arp 1987, 1991a, b).

The only apparent difference between these companions and the dominant galaxy is that the former appear to be slightly younger. By our equation (8), however, they would only need to be 8×10^6 yr younger to give this observed excess redshift. But this age difference corresponds to a fraction of only $\sim 5 \times 10^{-4}$ of the presumed age of the present galaxy. Such small age differences would not be readily detectable in a composite Hertzsprung-Russell diagram. As a consequence intrinsic, excess redshifts in a number of galaxies of different morphology and activity could be easily explained by our model even though the stellar composition of these galaxies looked quite normal (Arp 1991a).

If galaxies can have intrinsic redshifts because they were created relatively more recently, then we should test whether individual stars within galaxies can have different intrinsic redshifts if they consist of material created at slightly different times. A population of stars made of material which is 3×10^6 yr younger will stand out in luminosity above a population of stars of the same evolutionary age made of older material. The younger material stars should have an excess redshift of 35 km s^{-1}. Now observationally if we look at the most luminous stars in our galaxy we encounter an apparent expansion away from the sun of the earliest stars. This so called *K* effect has been known since 1911 and there is still no satisfactory explanation for it. The systematic excess redshift of O stars in galactic clusters is the same effect and was established by Robert Trumpler in 1955 at a signficance level of 10 σ! This excess redshift of the youngest, most luminous stars is confirmed at the 35 km s^{-1} level independently in both Magellanic Clouds and the nearby galaxies NGC 1569, NGC 2777, and NGC 4399 (Arp 1992).

Assuming from the above that the brightest *stars* in a number of galaxies show excess, nonvelocity redshifts; the fact that our static model predicts the values of these intrinsic redshifts *quantitatively* as a function of age would seem to be a strong point in its favor.

5. THE COSMIC MICROWAVE BACKGROUND

Although the topic of microwave background will be discussed by us in greater detail in a subsequent paper, we make a few remarks of a qualitative nature here in anticipation of the inevitable question: "How do you explain the origin of the microwave background in a static universe?"

In the mid-seventies Fred Hoyle (1975) had discussed the nature of cosmic microwave background in the Hoyle-Narlikar cosmology as described in our flat spacetime solution of equations (6) and (7). The fact that the zero mass surface $t = 0$ enables the photons to be very effectively scattered by particles like electrons helps in the thermalization of the radiation created "on the other side" of the zero mass surface, i.e., at $t < 0$.

Our present picture is a modification of the homogeneous and isotropic model discussed by Hoyle, in that we have kinks in the $m = 0$ surface which allow for delayed mini-bangs. We have considered the ejections of quasars from galactic nuclei as examples of such mini-bangs. It is possible to envisage such mini-bangs of larger dimensions eventually giving rise to masses of cluster and supercluster size. F. Hoyle (1992, private communication) has, for example, shown that the mini-bang of mass $\sim 5 \times 10^{15}$ $M_\odot$ simulates the primordial big-bang nucleosynthesis exactly.

The radiation from such events would naturally remain. Indeed, if it is argued that all helium found in the universe is made in such mini-bang nucleosynthesis in relatively recent epochs, then the resulting radiation can, in terms of energy density, entirely account for the observed microwave background. The problem is how to thermalize the radiation.

Thermalization with the help of graphite or carbon whiskers condensed from the metallic vapors ejected by supernovae is a possible mechanism as discussed by Arp et al. (1990b). The important point to note is that out to redshift of $z \sim 4$, the needles would generate an optical depth of $\tau \sim 7$ which can lead to smoothening the microwave background to fluctuations in temperatures $\Delta T/T$ of the order of a few times 10^{-6}. Thus the apparent patchiness of sources in the form of mini-bangs is not inconsistent with the observed level of structures in the microwave background (Smoot et al. 1992).

6. SUMMARY

In our model the universe is not expanding, and the redshift arises from the age-redshift effect. A dispersionless redshift-distance relation results for galaxies which are all of the same age. Currently observed deviations from the Hubble relation are accounted for without the customary introduction of added assumptions. Most importantly the static universe with creation at different epochs explains a number of observations which cannot be accounted for by the big bang theory: for example, association of high-redshift quasars and galaxies with low redshift galaxies, apparent large extragalactic peculiar velocities, quantization of redshifts and small but well determined excess redshifts of companion galaxies and stars.

The VHM automatically satisfies the surface brightness test for galaxies which has been put forward as a test for expansion. The static universe solution is stable against collapse, the point which originally caused Einstein to seek a cosmological constant term. Finally, the Euclidean, flat spacetime becomes a natural, primary reference frame in which cosmological processes are most simply described.

In this paper we have confined our attention to the redshift effect which is commonly interpreted as the result of expansion of the universe. How does our alternative of a static universe explain the cosmic microwave background and the abundances of light nuclei? We will discuss this important question in a subsequent paper.

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