How Non-Velocity Redshifts in Galaxies Depend on Epoch of Creation

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Non-velocity redshifts of the brightest OB stars in the Magellanic Clouds are correlated with their evolutionary ages. It is shown that these excess redshifts are quantitatively predicted if the stars are made of matter created only $\leq 3 \times 10^6$ yrs. later than the average matter in the Clouds. Intrinsic spectral shifts of galaxies and quasars are produced by relatively small differences in the epochs of their creation, though their average Hertzsprung-Russel diagrams are left essentially unchanged.
The Hubble constant is then quantitatively derived as a predominantly distance-intrinsic redshift effect which is a function of look back time, not as a distance-expansion velocity relation. Present estimates of the age of the oldest stars predict—on the basis of the age-intrinsic redshift law—a Hubble parameter of $H_0 = 45 \pm 7$ kms^{-1} compared to a recently measured value of $H_0 = 52 \pm 2$ kms^{-1} (Sandage and Tamman 1990).

I Introduction

One of the most firmly established but least accepted results in astronomy is that in groups dominated by a larger galaxy, the smaller companion galaxies have systematically higher redshifts. Figure 1 in this paper demonstrates that for the nearest, best known groups, the Local Group and the M81 group, *all* the major companions are redshifted with respect to the central galaxy. A total of 21 out of 21 permits a chance of only one in two million that the result could be accidental. Every test of additional groups at larger distances confirms the excess redshift of companions. (Arp 1983; Arp and Sulentic 1985; Valtonen and Byrd 1986; Arp 1987; Girardi *et al*. 1990).

Since all these companion galaxies have a large component of stars it would seem obligatory to look at those stars in order to see whether there are some kinds which have systematically higher

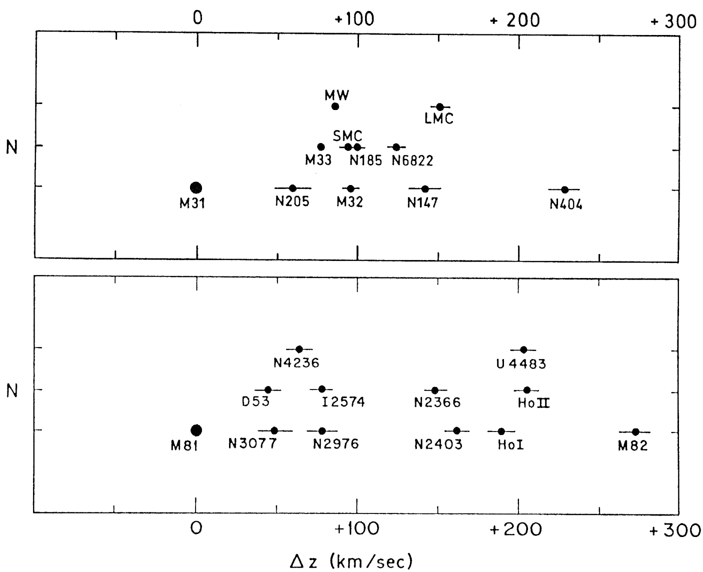

Figure 1 - The redshifts of all major companion galaxies are shown relative to their dominant Sb galaxies. This data is for the two nearest, best known groups of galaxies. (Arp 1986)

redshifts or if the stars are in any way unusual. It has been shown (Arp 1969; 1982) that companion galaxies have relatively younger spectral types than the main galaxy. Recently this result has been confirmed by Girardi *et al*. (1990) who show that excess redshift in companions is correlated with bluer color.

The nearest two external galaxies to us are the Magellanic Clouds. They are companions to our own Milky Way Galaxy (M.W.) which in turn is a companion to M31, the dominant galaxy in our Local Group. The Clouds have positive redshifts with respect to both the M.W. and M31 (Arp 1986) and are characterized by a relatively large population of hot, luminous stars. It should not be surprising, therefore, that the earliest spectral type, most luminous stars in both the Small and Large Magellanic Clouds (SMC and LMC) turn out to have clearly marked, excess redshifts compared to the remaining constituents of the Clouds.

In a preceding paper (Arp 1991; here called Paper I) evidence for systematic redshifts of the OB stars in the clouds is presented and discussed. In the present paper we concentrate on interpreting this result in the context of astronomical and physical theory.

II The Excess Redshift of the OB Stars in the Magellanic Clouds

Paper I shows that in a sample 34 OB stars from both the SMC and LMC, 30 stars have excess redshifts which average ≥ 30 km s^{-1} higher than the mean systemic redshift of the neutral hydrogen (HI) in the Clouds. It was reported that this result was significant at more than a 6σ level. There is another direct and simple way, however, of calculating the significance of these excess OB redshifts. Since the mean, systemic spectral shift for the HI is a well determined:

$$v_{SMC} = 161 \pm 2 \text{ km s}^{-1}$$

$$v_{LMC} = 270 \pm 2 \text{ km s}^{-1}$$

we can say that *regardless of what the rotation or peculiar motions within the clouds may be*, the chance of 30 out of 34 samples in this system showing recessional velocities with respect to HI is:

$$^{30}\mathrm{P}(1/2)_{34} = 2.7 \times 10^{-6}$$

Moreover, in a completely independent sample of O stars in galactic clusters in our own galaxy, Trumpler (1935) found 9 out of 9 to be higher in redshift than their clusters. [$^{9}\mathrm{P}(1/2)_{9} = 2 \times 10^{-3}$]. Separately, the B stars in Orion showed a 10 km s^{-1} recession with respect to their gas (Findlay-Freundlich 1954). Then we must consider the increasing recessional K term as one goes to earlier spectral types in our own galaxy. (Smart and Green 1936; Marmet 1990). Modern measures confirm these discrepancies, and as Paper I shows, an additional ≥ 15 km s^{-1} must now be added to all these values as a stellar wind correction. The final excess redshift for OB stars in our own galaxy becomes $15 < c\Delta z < 37$ km s^{-1}.

Since all these investigations are independent, the probability of the OB stars just accidentally appearing to have excess redshift is a *multipicative* combination of all these terribly small probabilities. It appears from the evidence gathered for over 50 years that the chance of this result not being true is astonishingly, negligibly small. But in any case we know that the early type companion galaxies, of which OB stars are a conspicuous component, have systematically positive redshifts relative to their local, dynamical standard of rest. Therefore we already independently know that OB stars can have excess redshifts.

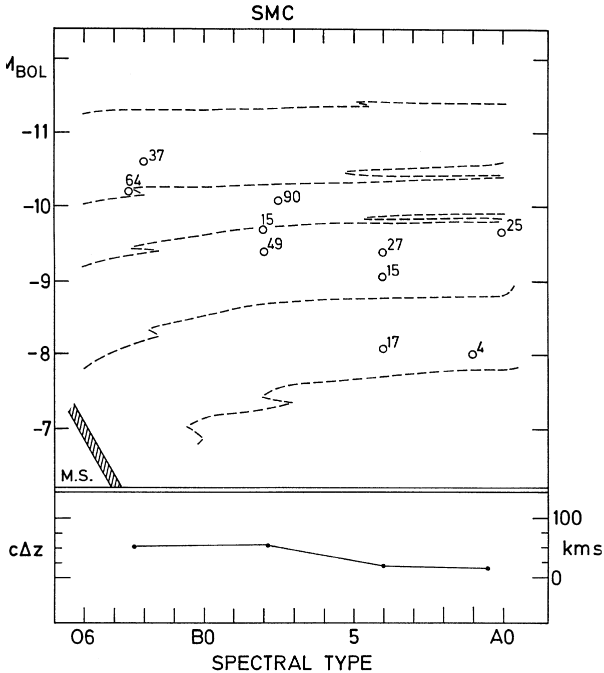

Figure 2 - The Hertzsprung-Russel diagram for 24 OB stars in the LMC. (Magnitudes and spectral types from Hutchings 1980). Redshifts of each OB star relative to the systemic velocity of the LMC is written to the upper right of each star (From Arp paper I). Bottom graph shows that mean excess redshift for these OB stars is not a function of temperature.

III What Property of the OB Stars is Responsible for the Excess Redshift?

The fundamental properties of stars are exhibited by the classic Hertzsprung Russell diagram which plots spectral type (temperature) versus absolute magnitude (luminosity). These quantities are available from the measurements made with modern equipment on the 34 OB stars in the SMC and LMC (Hutchings 1980) which were analyzed in Paper I. The H-R diagram for the LMC is shown here in Figure 2.

A. The LMC

The first correlation we test is whether the excess redshift (written next to the position of each star in the H-R diagram) is a function of temperature. Spectral class is an accurate indicator of temperature, and extends here from O stars (~ 35,000° K) to AO stars (~ 10,000° K). The graphical insert on the bottom of Figure 2 shows there is no apparent correlation of temperature with excess redshift. Some theories of inelastic collisions of photons with intervening matter ("tired light theories") require the redshifting to be proportional to the temperature of the emitting source (Marmet 1990). Clearly this is not true in the LMC stars. In any case such an effect would be generally ruled out because many star clusters have been studied where less luminous stars range from late K (~ 3,000° K) to early O (~ 40,000° K). No conspicuous redshift anomalies are evident.

There appears to be some correlation of excess redshift with luminosity in Figure 2, but the LMC is not the best galaxy in which to study such an effect. This is because there is some dust present in the LMC, particularly associated with young stars, and therefore the unobscured absolute magnitudes of these OB stars may be somewhat uncertain. Moreover, since the mass density concentrations in the LMC are greater than in the SMC there may be more peculiar velocities associated with the OB stars in the LMC than those in the SMC.

B. The SMC

Figure 3, which shows the H-R diagram for the SMC, should give much more trustworthy results for the luminosity of the OB stars because the reddening and absorption is generally much less than in the LMC. Moreover, the stellar density is less in the SMC and should

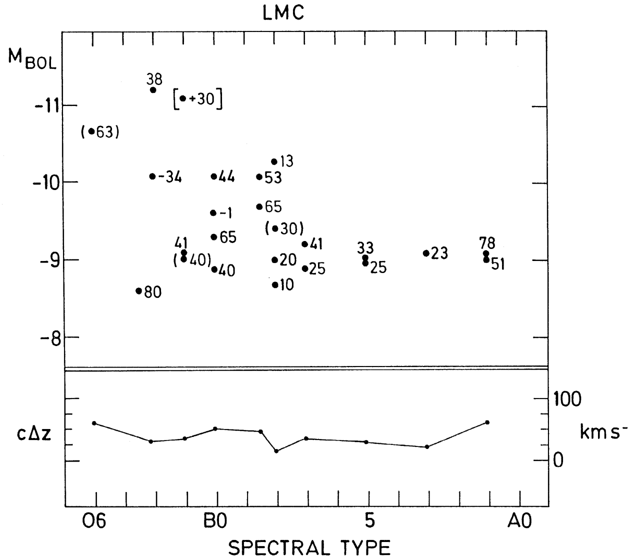

Figure 3 - The Hertzsprung-Russel diagram for 10 OB stars in the SMC (Data as in Figure 2). Mean temperature dependences of excess redshifts shown at bottom.

therefore produce smaller peculiar velocities via gravitational perturbation.

Figure 3 now shows clearly that the more luminous OB stars have the higher excess redshifts. There is some correlation with temperature also, but that is because the less luminous supergiants here happen to have the later spectral type. The H-R diagram for the OB stars in the SMC is so well defined that we are able to sketch in evolutionary tracks. The tracks are from Maeder (1990) for a metal content of $Z = .0002$. (Of the chemical compositions calculated, this is closest to that of the SMC, although this factor makes no essential difference to the ages we will interpolate.)

The SMC supergiant OB stars clearly reside along evolutionary tracks which range from over 60 to almost 15 solar masses. The ages,

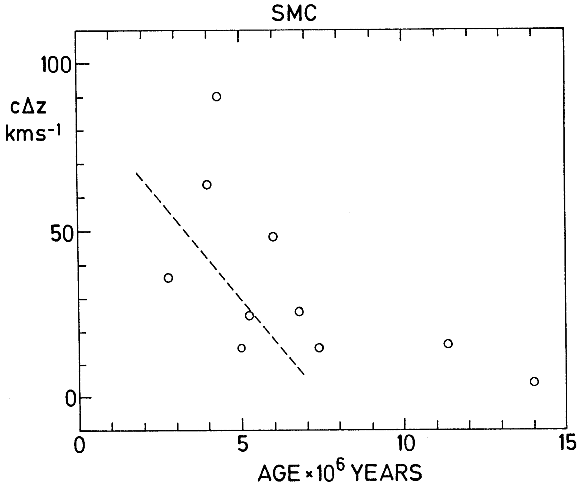

Figure 4 - The ages of the 10 SMC stars have been read from the evolutionary tracks in Figure 3 and are plotted here against their excess redshift. If the age of the evolutionarily youngest possible first generation stars in the SMC is $\sim 7 \times 10^6$ yrs., then only stars younger than this (comprising more recently created material) would be seen, and they would extend to the left as far as the dashed line. Some stars from more recent material would have older evolutionary ages and spread to the right of the dashed line, but would soon be overwhelmed in number by stars of the first generation material.

at spectral class B1, are 3×10^6, 4×10^6, 5×10^6, 8×10^6 and 13×10^6 yrs for the five pictured evolutionary tracks. It is a simple matter to interpolate along tracks and between tracks to get ages for the 10 supergiants. These ages are plotted against the excess redshift for each of the OB stars in Figure 4. Clearly there is a correlation in the sense that the younger stars have the higher excess redshifts.

IV Quantitative Prediction of Excess Redshift with Age

There is a necessary relationship between the redshift of matter and how much time has elapsed since it was created. This relation, which will be discussed in a later section is:

$$\frac{1+z_1}{1+z_0} = \frac{t_0^2}{t_1^2} \tag{1}$$

where z_0 is the redshift of matter created t_0 years ago and z_1 the redshift of matter created t_1 years ago. We take t_0 to be the age of the oldest created matter considered and, for reference, its redshift to be $z_0 \equiv 0$. Then we ask how much later stellar matter would have to be created in order for that star to have an intrinsic, relative redshift of z_1. If the age of the oldest matter in its own reference frame is, for example, $\tau_0 = 17 \times 10^9$ yrs, then in our t reference frame its age will be $3 \times \tau_0 = t_0 = 51 \times 10^9$ yrs. (See Section XI for derivation of relation between τ time and t time.) The following Table 1 gives sample values:

Table 1

Intrinsic redshift—age calculations from (1)

cz_1	$t_0 - t_1$
106 km s^{-1}	9×10^6 yrs
71	6×10^6
35	3×10^6
12	1×10^6

Figure 4 shows that if the youngest stars formed from first generation matter in the SMC are about $7–8 \times 10^6$ yrs evolutionary age, then all the stars of younger evolutionary age must come from matter created more recently. These later generation stars must have an intrinsic redshift-creation age envelope limit as shown by the dashed line in Figure 4.

That the observed SMC brightest supergiants actually follow roughly the line is impressive from two standpoints:

1) We know the age of the oldest stars in galaxies like the SMC is $13–17 \times 10^9$ yrs. (Sandage and Cacciari 1990). Formula (1) then gives very closely the observed relative ages of the excess redshift OB stars. The actual age of the SMC itself could be less than 17×10^9 yrs. but since the age difference of the (younger) excess redshift OB stars is only a small percentage of this total age, it would still be very close to the $\sim 3 \times 10^6$ yrs. observed.

2) We cannot be sure what the evolutionary age of the youngest first generation stars in the SMC is, but it must be somewhere near $7–8 \times 10^6$ yrs. Accordingly as the stars are younger or older, the slanted line shifts somewhat to the left or right. But the younger generation stars that are young in evolutionary terms must emerge on this side of the diagram with roughly this slope.

Therefore the zero point and slope of this line in Figure 4 is calculated within fairly close constraints and it furnishes a fairly good fit to the observed points. It is therefore an unexpected success of the theory as expressed in equation (1) to give quantitatively correct values for the size of the observed excess redshift and its dependence on age. Of course as we go to lower luminosity stars in the SMC we should encounter some later generation stars with excess, non velocity redshifts. But they would soon be overwhelmed by the much greater

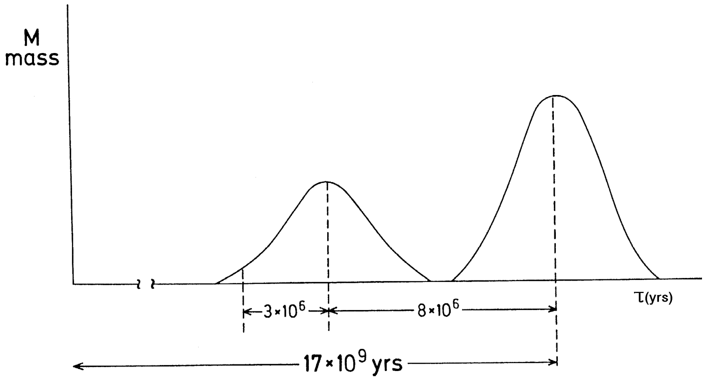

Figure 5 - Schematic representation of massive galaxy created at an epoch 17×10^9 yrs. in the past. The smaller companion galaxy is created 3×10^6 yrs. later. The rightest OB stars in the companion are created 8×10^6 yrs. after epoch of creation of companion.

number of original generation stars. Spectra integrated over the SMC would show only slight, if any, broadening of lines to the red.

V The Effect of Later Generation Stars on the Composite H-R Diagram

We are now able to account semi-quantitatively for the entire range of non-velocity redshift phenomena in galaxies. Figure 5 schematically shows the creation of a large mass galaxy at epoch $t_0 = 17 \times 10^9$ yrs. Let us call this galaxy the giant *Sb*, M31. At a time 8×10^6yrs. later a smaller companion galaxy is created from newer matter. Let us call this the dwarf irregular, SMC. Formula (1) tells us that the SMC would have ~ 94 km s^{-1} non-velocity, excess redshift. It is observed to have 94 km s^{-1} (Arp 1986). Stars within the SMC which were in turn created from matter about 3×10^6 yrs younger than the mean matter

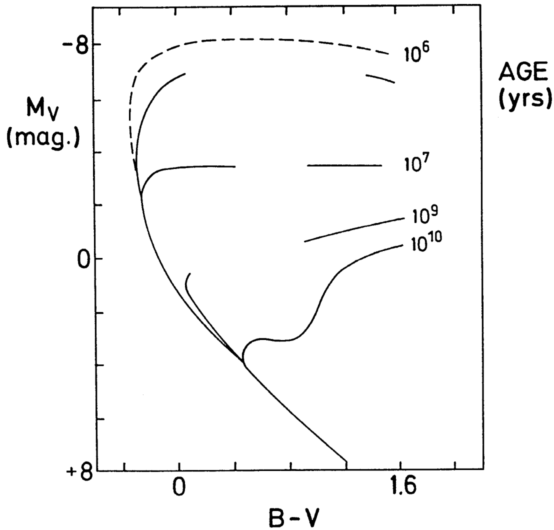

Figure 6 - A schematic Hertzsprung-Russel diagram of a galaxy. Stars created $\sim 3 \times 10^6$ yrs more recently than the mean age of the galaxy would only deviate from its brightest, youngest evolutionary tracks, as shown by the dashed line.

in the SMC, would in turn have non velocity, excess redshifts of ~ 35 km s^{-1}, as we have observed in the SMC.

In fact, since all of the companion galaxies shown here in Figure 1 are of the order of 100 km s^{-1} systematically redshifted, they would be all about this order of magnitude more recently created than their parent *Sb*'s. Figure 6 shows that mixing stars of $3\text{-}8 \times 10^6$ yrs. later generation into a galaxy does not affect the composite H-R diagram for the vast majority of stars. Old clusters of evolutionary age $\sim 10^{10}$ yrs. are not affected at all by an admixture of stars $\sim 3\text{-}8 \times 10^6$ years younger. Likewise stellar evolutionary tracks of 10^9 and 10^8 yrs remain essentially unchanged. Only when stars of evolutionary age $\sim 7\text{-}8 \times 10^6$ yrs are reached does a younger generation of supergiant stars stand away from the first generation stars. Then all of those highest luminosity stars have the higher redshift.

Companion galaxies of higher intrinsic redshift would have to be of more recent creation, though still not a large percentage of the age of the oldest galaxies. Table 2 below shows the relative epochs of creation for two (out of many examples) of long puzzling, interacting companions with large discordant redshifts:

Table 2

Intrinsic redshift—age calculation from (1)

Object	$cz_1 = c\Delta z$	$t_0 - t_1 = \Delta t$	
NGC 7603 companion	8,000 km s^{-1}	6.7×10^8 yrs.	(Arp 1971)
NGC 1232 blue companion	28,000	2.2×10^9	(Arp 1982)

The NGC 7603 companion would only have to have been created $\Delta\tau \sim 7 \times 10^8$ yrs. later than the main galaxy from which it is emerging. That would have very little effect on its composite color-magnitude diagram. But it would supply a natural answer to a heretofore bothersome question: "Why does the NGC 7603 companion have a relatively old appearing spectrum?" The answer—it could have stopped forming stars say $\Delta\tau \sim 10^8$ yrs. ago but the material out of which its stars were formed is still only about 10^9 yrs. younger than the main galaxy.

Even in NGC 1232 blue companion the required creation epoch of the companion is only about $\Delta\tau = 2.1 \times 10^9$ yrs, or 12% later than the epoch of creation of the main galaxy. In NGC 1232 blue companion, however, the spectrum is abnormally, peculiarly blue. Certain old star indicators like Na I absorption and MgI absorption are missing—perhaps indicating that the era of the oldest star formation has been pushed to noticeably more recent times than in normal galaxies.

VI The Necessity of Matter Creation at Different Epochs.

Observational evidence against the Big Bang has been mounting. Excessive age of the oldest stars for most values of the Hubble constant, smoothness of the microwave background and failure to detect the missing mass required for most inflationary models have all led an increasing number of cosmologists to question the validity of the model which has been conventionally used for 60 years. (van den Bergh 1990; Arp, Burbidge, Hoyle, Narlikar, Wickramasinghe 1990) Additionally it has been argued that the obvious existence of young galaxies is a direct disproof of the essential Big Bang requirement that all galaxies are born at the same time in the distant past. (Arp 1990b).

What is the alternative to the Big Bang? Only continuous creation. From detailed observations of young galaxies it has been argued that the material which forms new galaxies emerges from the nuclei of active galaxies. This material must of necessity be in a compact, low mass state (Arp 1987). The conditions of emergence as well as the conditions of creation require matter to start from a state of zero mass. The conditions of creation must be that the mass cannot be transported but must materialize from a potential or state diffused throughout the universe. Therefore it is a general, logical argument that newly created matter must start from a zero mass/energy state.

VII The Necessity of Non-Velocity Redshifts for More Recently Created Matter

The basic reasoning with respect to the magnitude of mass of an elementary particle is that it must depend on the amount of material with which it can exchange gravitons. That in turn depends on the volume of the universe it sees, i.e. its light signal speed multiplied by the time during which it has been in existence. It would seem absurd to consider an electron to have a terrestrial value for its mass just after it had appeared in a previously empty vacuum. Its mass would dominate the whole universe which it saw.

The above reasoning is my interpretation of the theory of conformal gravity as developed by Fred Hoyle and Jayant Narlikar (1974). Formula (1) of the present paper is explicitly developed by Narlikar and Das (1980) from calculations on the relative masses particles feel from the ratio of material within their light signal spheres. The energy of the photon an atom emits or absorbs (and hence inversely its redshift) is then proportional to the mass of the electron making the orbital transition.

The theory leads to the conclusion that elementary particles have masses which are a function of position and time, $m = m\ (x, t)$. It is important to stress that in the case where m = constant, the theory reduces to the special case described by the accepted general realtivistic formulation. The more general case where $m = m\ (t)$ is, however, required by the failure of the Big Bang theory and the arguments advanced for the continuous creation of galaxies. In the case of $m = m\ (t)$ the preceding paragraphs argue that redshift, z, must then also be a function $z = z\ (t)$ of the epoch of creation of the matter.

In Section XI following we discuss the necessity of making calculations in a Euclidean space/time and what this requires as a model for the universe.

VIII Quantization of Redshifts

The schematic representation of the creation of matter in galaxies in Figure 5 suggests an obvious way in which the 72 km s^{-1} periodicity observed in galaxy redshifts could arise. (Tifft 1976; Arp and Sulentic

1985; Arp 1987). The mechanism is simply that matter would tend to be created in bursts at periodic time intervals of 6×10^6 yrs.*

For periodicities in the highest redshifts observed, those of the quasars, the redshift intervals are not linear. They are observed to vary as $(1+z_{i+1})/(1+z_i)= 1.228$ (Karlsson 1977; Arp, Bi, Chu and Zhu 1989). In order to produce this periodicity the epoch of the more recently formed quasar relative to the older quasar is $t_{i+1} = .9024\, t_i$. The required epoch of formation to give each of the quasar redshift peaks is calculated below:

The recently discovered periodicity in galaxy redshifts (Broadhurst *et al.* 1990) includes the first two quasar redshift peaks and intermediate peaks as well. The intermediate galaxy redshift peaks

zero epoch	**Peaks**								
$z_i = 0.00$	0.06	0.30	0.60	0.96	1.41	1.96	2.64	3.47	4.49
$\tau_i = 17 \times 10^9$ yrs.	16.5	14.9	13.4	12.1	11.0	9.9	8.9	8.0	7.3
$t_i = 51 \times 10^9$ yrs.	49.5	44.7	40.3	36.4	32.9	29.6	26.7	24.1	21.8

would have to represent submultiples in times of creation. But in a sense the 72 km s^{-1} periodicity also represents a submultiple. As emphasized in Arp (1990b) the entire known range of extragalactic redshifts is observed to be quantized. It would seem to be very

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* It should be noted that orbital or peculiar velocities of order 72 km s^{-1} or more would rapidly render a pattern of intrinsic redshifts of this order undiscoverable. Therefore we must conclude real velocity components in many circumstances are considerably less than presently assumed. If redshifts contain a large component of intrinsic shift, however, the masses generally ascribed to groups and clusters of galaxies is less (the question of missing mass may well disappear altogether) and there is less need for gravitationally generated, true velocities.

difficult to explain such quantization if the major component of redshift were velocity.

IX Negative Spectral Shifts and the Epoch of Local Creation

We have noted that oldest generation, lowest intrinsic redshift galaxies appear to be the giant *Sb*'s at the centers of groups of galaxies like the M81 and Local Group. (Figure 1 here and also Arp 1990a, c). The question arises whether there are any observed candidates which could be galaxies created even earlier. If so they would be characterized by negative, intrinsic spectral shifts. There is only one group of candidates—and they are outstanding because they all clustered in the direction of the Virgo Cluster of galaxies.

Of the negative spectral shifts on the sky outside the Local Group, there are only 7 candidates, and all are concentrated toward the center of the Virgo Cluster. Thus there can be hardly any doubt they are members. Out of these 7, however, a total of 5 are morphological class *Sb* or *Sab*. Even more striking is the fact that though they are very few, the only certain, true *Sb*'s in the Virgo Cluster have negative redshifts (Arp 1988, Table 1). These are not *velocity* spectral shifts for the obvious reason that one particular morphological type should not show a preferential motion within a cluster. But in addition, it is just this morphological class, *Sb*, which has demonstrated itself to be the lowest intrinsic redshift, earliest generation galaxy in the best known, nearby groups of galaxies.

The average of the 4 largest negative values of redshift in the Virgo cluster is $cz = -284$ km s^{-1} (Arp 1988 Table 4). From formula (1) of Section IV of the present paper we can compute that this would represent galaxies made from material that was created 24×10^6 yrs. earlier than the material, in say M31, if we take the age of that nearest

Sb to be $t_0 = 51 \times 10^9$ yrs. But if we adopt a distance to the Virgo Cluster of $d = 21.9$ Mpc, (Sandage and Tamman 1990) the look back time is 71×10^6 yrs. Therefore the epoch of creation of these Virgo *Sb*'s is 95×10^6 yrs greater than the epoch of creation of our Local Group (M31). But that is only 0.6% earlier than the age of our Local material. Therefore we are led to a picture where all the earliest matter in the Local Supercluster (taking the Virgo Cluster as the rough center of the Local Supercluster) was created at nearly the same time but that in outlying regions near our own galaxy the earliest material emerged slightly later.

Surprisingly we have arrived at a picture very much like the Big Bang where all matter originated about $\tau_0 = 17 \times 10^9$ years ago. The only difference is—and this is a crucial difference—that matter and galaxies and quasars have continued to be created, at least to some extent, after that initial burst of creation.

X Is the Hubble constant an Indicator of Expansion Velocity?

The discerning reader (but not the author) could have noted back in Table 1 that a difference of about 3×10^6 yrs. in epoch of creation would lead to an intrinsic, relative redshift of ~ 35 km s^{-1}—but that since 3.26×10^6 light years = 1 Mpc, that the look back time to any galaxy would therefore require:

$$c\,\Delta z_i \approx 38 \text{ km s}^{-1} \text{ Mpc}^{-1}$$

where z_i is the intrinsic redshift of the material caused by the fact at the greater distance the material was younger when the light left it. This value is very close to one of the two claimed values of the Hubble constant, $H \sim 50$ and $H \sim 100$ km s^{-1} Mpc^{-1}.

The galaxies which we are referencing $z_o \equiv 0$ for intrinsic redshift, however, have epochs of formation $13 < \tau_0 < 17 \times 10^9$ yrs. If we now take the lower limit for ages of the oldest stars as $t_0 = 3\ \tau_0 = 39 \times 10^9$ yrs, we then compute!

$$c\,\Delta z_i = 51 \text{ km s}^{-1} \text{ Mpc}^{-1} \tag{2}$$

which is almost exactly the value of the Hubble constant of 52±2 km s^{-1} Mpc^{-1} measured by Sandage and Tamman (1990).

The upshot of the matter is that equation (1) predicts a Hubble constant of $38 < H < 51$ km s^{-1} Mpc^{-1} depending on whether the age of the oldest stars in the galaxies measured lies between $17 > \tau_0 > 13 \times 10^9$ yrs. In other words a value of 44.5±6.5 is predicted for the intrinsic redshift-distance relation compared to the most recent measured Hubble constant of 52±2 km s^{-1} Mpc^{-1}. The astonishing result is that the application of equation (1), required for galaxies whose particle masses are proportional to the mass of the universe they see, leads to a Hubble constant which is, within the observational uncertainties, numerically equal to that observed. In the universe then, for matter created at the same cosmological epochs *there is a strict distance-redshift relation required but very little distance-expansion velocity permitted by the current measures*.

This whole situation was anticipated in detail by Fred Hoyle in 1972 when he produced the Hubble law in one mathematical step from an equation equivalent to (1). The only further step we have taken here is to assign a conventional age for the oldest galaxies which then yields a quantitatively correct Hubble constant.

How would this interpretation work quantitatively for the Virgo cluster, which represents the classical group of calibration galaxies for the Hubble constant? If, following Sandage and Tamman (1990), we take the distance to Virgo = 21.9 Mpc., then using a predicted redshift-distance relation from (1) with $\tau_0 = 15 \times 10^9$ yrs., yields a redshift of Virgo of 975 km s^{-1}. This corresponds almost exactly to the adopted redshift of the 6° core of Virgo of 976±45 km s^{-1}. Sandage and Tamman correct this by an infall velocity of 168 km s^{-1} to obtain the cosmic Virgo velocity. We could not deny the possibility of such an infall velocity but would only point out that older generation galaxies toward the core of the cluster could simulate infall to an undetermined extent.

Of course the mean redshift of the Virgo Cluster depends on what types of galaxies one chooses to average. In order to obtain the most appropriate value of redshift for the distance of the Virgo Cluster, one should identify and select those galaxies whose τ_0 is most representative of the galaxies which are used to define the Hubble relation. In Arp (1988) it was shown that the mean mass of the galaxy material in the Virgo Cluster (luminosity weighted) had $\bar{v}_0^L = 863$ km s^{-1}. Using this value instead of Sandage and Tamman's $v = 976$ km s^{-1}, and adding 168 km s^{-1} infall, produces a Hubble constant from the Virgo Cluster of $H = 47$ km s^{-1} Mpc^{-1}. This calculation of the observed value of H is closer to the 45 km s^{-1} Mpc^{-1} predicted from equation (1) with a middle of the range estimate of $\tau_0 = 15 \times 10^9$ yrs. I feel this is illustrative of the remaining uncertainties.

Finally, we should comment that the values of H near 100 km s^{-1} Mpc^{-1} which many observers have reported are generally derived from higher redshift (presumed more distant) galaxies. There is an apparent gradient from $H = 50$ to $H = 100$ km s^{-1} Mpc^{-1} as one considers higher redshift galaxies (Giraud 1988; Tully 1988, Arp 1990a). This could be explained naturally in the context of the present paper as due to the inclusion of galaxies younger than the standard τ_0 which then contribute higher intrinsic redshifts.

Of course, there is also the possibility that there is some component of expansion to the universe or the local supercluster of galaxies. Since the intrinsic redshift-distance relation accounts for ~ 45 km s^{-1} Mpc^{-1} of the observed Hubble relation, however, any expansion component, if present, is restricted to considerably smaller velocities than previously believed.

XI. The Physical Relation Between *t* time and τ Time and the Model Universe Implied

If we could watch the history of a nearby galaxy run backward in time, we should see that the masses of its constituent particles diminish as it approached its origin. Now the rate at which atomic time runs (R) is dependent on the mass of its particles (m). Since m was smaller in the past in this galaxy, time ran slower. The amount of our time (t) elapsed in an interval of the galaxy's time (τ) is:

$$\frac{dt}{dt} = R(t) \propto m \propto t^2 \tag{3}$$

Then integrating the time difference backward to the origin:

$$t = -\int_t^0 \frac{t^2}{t_0^2}\mathrm{d}t = \frac{t^3}{3t_0^2} \tag{4}$$

At the origin, $t = t_0$ and $\tau = \tau_0$, giving:

$$\tau_0 = t_0/3\ . \tag{5}$$

This is the relation used in Section IV and thereafter. It simply means that viewed from our own reference frame, time in an early galaxy ran more slowly.

Differentiating equation (1) with respect to $\Delta t = t_0 — t_1$ we obtain:

$$\frac{\mathrm{d}z}{\mathrm{d}(\Delta t)} = \frac{2}{t_0}(1+z)^{3/2} \tag{6}$$

In terms of the conventional expanding universe, Δt = look back time to a galaxy at its inferred redshift distance and, for small z, $cz = v$. Therefore (6) becomes:

$$\frac{\mathrm{d}cz}{\mathrm{d}\left(\mathrm{c}\Delta t\right)} \approx \frac{\mathrm{d}v}{\mathrm{d}r} = \frac{2}{t_0}\left(1+z\right)^{3/2} \tag{7}$$

$$H = 2/t_0 \text{ at } z = 0 \tag{8}$$

which is exactly what was found in Section X for the Hubble relation predicted by equation (1) for small z.

It should be noted that for large z the apparent expansion velocity in (7) is not constant but grows as $(1+z)^{3/2}$. This would mean, in a static universe where the redshifts were a function of look back time, that the apparent Hubble constant would grow larger with z. For $z = 1.5$, for example $\mathrm{d}z/\mathrm{d}\Delta t = 3.95\ H_0$. If this were interpreted as a deviation from the Hubble relation in an expanding universe, it would require the galaxy to be 3 *mag*. more luminous in the past. These are just the order of deviations observed, but which are conventionally attributed to the systematic brightening of galaxies as we go back in time. (Spinrad and Djorgovski 1987).

It is astonishing to note that the relations we have developed through elementary derivations from the principle that $m(t) \propto t^2$ are exactly the same as those which come from a formal solution of the Einstein general relativistic equations for geometry and mass/energy:

$$R_{mn} - \frac{1}{2} g_{mn} R = -8GT_{mn} \tag{9}$$

The most commonly used solutions of these equations are the Friedmann models. Following Narlikar (1977) these solutions can be transformed to flat space by making the coordinate transformation

$$t = \frac{H^2}{12} t^3 \tag{10}$$

(we have reversed the t, τ symbols used by Narlikar), then at $\tau_0 = t_0/3$

$$t_0 = 2H^{-1} \text{ and } t = \frac{2}{3} H^{-1} \tag{11}$$

These are the same as our derived relations (4), (5) and (8). We conclude therefore that we are using formally valid solutions of the basic general relativistic equations. We are simply giving the quantities different interpretations, namely, m (const) $\rightarrow m(t)$ and $z(r) \rightarrow z(t)$.

XII The Model of the Universe Required by *m* = *m* (*t*) Near the Horizon

The observations we have discussed appear to require that at distances near the horizon, $r \approx ct_0$ (where t_0 is the age of the oldest galaxies), that the volumes grow as a Euclidean function of $r = ct$. Otherwise the masses would not grow as t^2 and the increase of redshift as a function of look back time would not be required to be 45 km s^{-1} Mpc^{-1}.

Is there a reasonable model of the universe which satisfies the general relativistic equations (9) and also the observed local parameters of the universe but still gives simple, Euclidean geometry at the largest scale?

If we assume the mass/energy density for most of the universe is very low, then $T_{mn} \approx 0$ in equation (9), and we have a simple, approximately zero curvature geometry. In the region of the Local Supercluster, mass/energy densities could be as normally measured but a region of radius ≈ 100 Mpc would only represent $(.326/45)^3 = 4 \times 10^{-7}$ of the visible universe. It was perhaps unwise in the past to extrapolate conditions near our locally observed galaxies out to such enormously greater distances in the universe.

Moreover, since large redshifts in many cases can now mean younger, smaller objects at much closer distances, the conventional view of large numbers of massive galaxies far beyond our Local Supercluster may have to change to one where much emptier space is characteristic of larger volumes in the universe. If there are other dense islands or creation centers like our own elsewhere in this low density space I know of no good candidates at this time.

I note that this model should describe a non-homogeneous universe which can be solved in the Einstein Equations of general relativity. The conventional assumptions which lead to "Great Walls" and "Great Attractors", on the other hand, represent inhomogeneities on such a large scale that (3) cannot be solved and cosmology cannot even be discussed.

XIII Comparison of what is Logically Expected to what is Observed

This paper started from the observation that intrinsic redshifts of stars varied with their ages. This led to a test of the general physical law that the constitutent masses comprising matter depend on their age since creation. With this law, the observed stellar redshifts and ages predict a Hubble parameter numerically very close to what is observed for the general universe that we can measure. In fact with more and better corrected OB star redshifts, an accurate value for H_0 could be obtained directly. But, of course, the predictions of the intrinsic redshift-age law can be tested by many other objects, for example companion galaxies and young galaxies with discordant redshifts and quasars. So far these other objects appear to give further confirmation that the variable mass law is a better representation of the major part of their redshifts than an expanding universe.

In general, we remark that the key aspect of inertial mass is that it must be a result of the interaction with other particles in the universe. The alternative leads to the inability to operationally define inertial mass. If this is so, then the creation of particles at different times requires their masses to be different because they see different sized universes.

Even in the Big Bang if mass/energy were ever to be "created" in the sense of going from a non local state to local materialization, it is extremely unlikely, even in a relatively limited region of space, to be created all at exactly the same instant. For reasons discussed in Section VI, however, the conventional Big Bang is today counterindicated by the evidence. The only alternative is creation of matter in the universe over a finite time span. But unlike the special case of the steady state theory of Bondi and Gold (1948) and Hoyle (1948), the general case of continuous creation could come in bursts of varying duration and spacing. The creation of matter at different times, however, must then produce bodies with different particle masses and therefore with different intrinsic redshifts.

Consequently, we should observe increasing non velocity redshifts for objects at light travel distances of greater than a few $\times 10^6$ yrs together with a Hubble type, distance-redshift relation beyond our nearest galaxy neighbors. Since many of the Local Super Cluster galaxies appear to be about the same epoch of creation, a local burst of galaxy formation appears to have taken place. This is a picture close to the creation of galaxies in a conventional Big Bang. But with the redshift-distance relation not caused by velocity, there are no longer contradictions like the age of the oldest stars being older than the expansion age of the universe. In fact the age of this epoch of major creation in this necessarily Machian universe then gives directly the observed numerical value of the Hubble constant. No other value of the Hubble constant could be observed.

The major observational difference from the Big Bang is that the continuous creation scenario leads us to expect extragalactic objects of more recent creation, which would appear systematically redshifted with respect to other objects at the same distance. There is a huge body of evidence showing such cases now. Objects with excess redshifts range from quasars, compact active galaxies, young spectral type companions, spirals containing high proportions of youngs stars to, finally now, hot young OB stars in young spectral type companions, such as the SMC and LMC. One incontrovertible example is the complete census of major companions in the nearest galaxy groups as shown in Figure 1. It is required at a decisive confidence level that most of their relative redshifts be non-velocity. Finally we observe the oldest, large central objects like the S_b galaxy M31 to have a slightly negative redshift (–86 km s^{-1}) which cannot be velocity without violating the dynamics of our Local Group. (Arp 1986). We also observe *Sb* galaxies in the Virgo cluster to have negative redshifts. Quantization of redshifts observed throughout the redshift domain, moreover, could be accounted for in periodic bursts of matter creation. On the other hand, with redshifts interpreted as velocities or having large components of velocity, it would be difficult to explain their quantization.

The final summary of this situation must be that only continuous creation of matter is logically expected and observationally permitted. Inertial mass scaling of particles as a function of their epoch of creation , $m = m(t)$, is the more general case of general relativistic equations which are accepted to be fundamental to physics. Therefore non-velocity redshifts as a function of the epoch of creation of the object is not “new physics”—it is just correct physics and it is required to account for the observations.

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