ON THE GENERAL PROPERTIES OF MATTER, by Mário Everaldo de Souza, Departamento de Física, Universidade Federal de Sergipe, Campus Universitário, 49000 Aracaju, Sergipe, Brazil, e-mail DFIMES@BRUFSE.BITNET

I. INTRODUCTION

It has been proven beyond any doubt that the universe is expanding \((1, 2, 3, 4)\). Recent data of several investigators show that galaxies form gigantic structures in space. De Lapparent et al. \((5)\) (also, other papers by the same authors) have shown that they form bubbles which contain huge voids of many megaparsecs of diameter. Broadhurst et al. \((6)\) probed deeper regions of the universe with two pencil beams and showed that there are (bubble) walls up to a distance of about 2.5 billion light-years from our galaxy. Even more disturbing is the apparent regularity of the walls with a period of about \(130 h^{-1}\) Mpc. There is also an agglomeration of galaxies forming a thicker wall, called the great wall. It has also been reported \((7, 8, 9)\) (also, other confirming papers) that there is a large-scale coherent flow towards a region named the Great Attractor. All this data show that galaxies form a medium in which we already observe some interactions.

Recent data \((10)\) show, however, that the bubble walls are not so regularly spaced and, therefore, the medium formed by them is rather a liquid (or an amorphous solid) than a crystalline solid. We may call this medium the ‘galactic liquid’.

The facts shown above have also been corroborated by the data of the APM survey \((11)\) which was based on a sample of more than two million galaxies. This survey measured the galaxy correlation function \(w(\theta)\). More evidence towards the same conclusion was provided by the ‘counts in cells’ of the QDOT survey \((12)\) and more recently by the redshift (APM) survey \((13)\) and by the power spectrum inferred from the CfA survey \((14)\) and from that inferred from the Southern Sky Redshift Survey \((15)\). The data from these surveys show that galaxies are not randomly distributed in space on large scales and put a shadow over the cold dark matter model \((16, 17)\). There have been attempts to keep the cold dark matter hypothesis but only at the cost of many \textit{ad hoc} adjustments. There are even proposals of having more than one type of dark matter \((18)\).

Another puzzle of Nature is the existence of strange objects, such as quasars, BL Lacertae and Seyfert galaxies, and the fact of having spiral galaxies with their mystical arms. The evolution of galaxies does not fit either in the general theoretical framework.

At the other end of the distance scale, in the fermi region, it appears now that the quark is not elementary after all. This can be implied just from their number which, now, stands at 18. Particle physics theorists have already begun making models addressing this compositeness \((19)\).

II. GENERAL CLASSIFICATION OF MATTER
Science has utilized specific empirical classifications of matter which have revealed hidden laws and symmetries. Two of the most known classifications are the Periodic Table of the Elements and Gell-Mann’s classification of particles (which paved the way towards the quark model).

Let us go on the footsteps of Mendeleev and let us attempt to achieve a general classification of matter, including all kinds of matter formed along the universal expansion, and by doing so we may find the links between the elementary particles and the large bodies of the universe.

It is well known that the different kinds of matter of nature appeared at different epochs of the universal expansion, and that, they are imprints of the different sizes of the universe along the expansion. Taking a closer look at the different kinds of matter we may classify them as belonging to two different general states. One state is characterized by a single unity with angular momentum, and we may call it, the single state. The angular momentum may either be the intrinsic angular momentum, spin, or the orbital angular momentum. The other state is characterized by some degree of correlation among the interacting particles and may be called the ‘polarized’ state. The angular momentum may (or may not) be present in this state. In the single states we find the fundamental unities of matter that make the polarized states. The different kinds of fundamental matter are the building blocks of everything, stepwise. In what follows we will not talk about the weak force since it does not form any stable matter and is rather related to instability in matter. As discussed in this paper it appears that along the universal expansion nature made different building blocks which filled the space. The weak force did not form any building block and is out of the initial discussion. As is well known this force is special in many other ways. For example, it violates parity in many decays and it has no “effective potential” (or static potential) as the other interactions do. Besides, the weak force is known to be left-handed, that is, particles experience this force only when their spin direction is anti-aligned with their momentum. Right-handed particles appear to experience no weak interaction, although, if they have electric charge, they may still interact electromagnetically. Later on we will include the weak force into the discussion. The single state is made by only one kind of fundamental force. In the polarized state one always finds two types of fundamental forces, i.e., this state is a link between two single states. Due to the interactions among the bodies (belonging to a particular single state) one expects other kinds of forces in the polarized state. In this fashion we can form a chain from the quarks to the galactic superstructures and extrapolate at the two ends towards the constituents of quarks and towards the whole universe.

The kinds of matter belonging to the single states are the nucleons, the atom, the galaxies, etc. The ‘et cetera’ will become clearer later on in this article. In the polarized state one finds the quarks, the nuclei, the gasses, liquids and solids, and the galactic liquid. Let us, for example, examine the
sequence nucleon-nucleus-atom. A nucleon is made out of quarks and held together by means of the strong force. The atom is made out of the nucleus and the electron (we will talk about the electron later), and is held together by means of the electromagnetic force. The nucleus, which is in the middle of the sequence, is held together by the strong force (attraction among nucleons) and by the electromagnetic force (repulsion among protons). In other words, we may say that the nucleus is a compromise between these two forces. Let us, now, turn to the sequence atom-(gas, liquid, solid)-galaxy. The gases, liquids and solids are also formed by two forces, namely, the electromagnetic and the gravitational forces. Because the gravitational force is 1039 weaker than the electromagnetic force, the polarization in gases, liquids and solids is achieved by the sole action of the electromagnetic force because it has two signs. But it is well known that gases, liquids and solids are unstable configurations of matter in the absence of gravity. Therefore, they are formed by the electromagnetic and gravitational forces. The clumping of hydrogen gas at some time in the history of the universe gave origin to galaxies which are the biggest individual clumps of creation. We arrive again at a single fundamental force that holds a galaxy together, which is the gravitational force. There is always the same pattern: one goes from one fundamental force which exists in a single unity (nucleon, atom, galaxy) to two fundamental forces which coexist in a medium. The interactions in the medium form a new unity in which the action of another fundamental force appears. We are not talking any more about the previous unity which exists inside the new unity (such as the nucleons in the nucleus of an atom).

By placing all kinds of matter together in a table in the order of the universal expansion we can construct the two tables below, one for the states and another for the fundamental forces.

In order to make the atom we need the electron besides the nucleus. Therefore, just the clumping of nucleons is not enough in this case. Let us just borrow the electron for now. Therefore, it looks like that the electron belongs to a separate class and is an elementary particle. The above considerations may be summarized by the following: the different kinds of building blocks of the Universe (at different times of the expansion) are intimately related to the idea of filling space. That is, depending on the size of the Universe, it is filled with different unities.

III. THE NUMBER OF FUNDAMENTAL FORCES OF NATURE

In order to keep the same pattern, which should be related to an underlying symmetry, the tables reveal that there should be another force, other than the strong force, holding the quarks together, and that this force alone should hold together the prequarks. Let us name it the superstrong force. Also, for the ‘galactic liquid’, there must be another fundamental force at play. Because it must be much weaker than the gravitational force (otherwise, it would already
have been found on Earth) we expect it to be a very weak force. Let us call it the superweak force.

Summing up all fundamental forces we arrive at six forces for nature: the superstrong, the strong, the electromagnetic, the gravitational, the superweak and the weak forces. We will see later on, at the end of the article, that they are interrelated.

IV. POLARIZATION IN MATTER

The polarized state is made by opposing forces, i.e., they represent a compromise between an attractive force and a repulsive force. Ordinary matter (gasses, liquids and solids) is formed by the polarization of the electromagnetic force. Polarization is also present in nuclear matter which may be described either in terms of the Seyler-Blanchard interaction or according to the Skirme interaction. Both give a type of Van der Waals equation of state\(^{(20,21)}\). In order to keep the same pattern we should expect to have a sort of compromise between the superstrong force and the strong force. This compromise forms the quark. The polarization in this case may be achieved by means of the exchange of a particle, which may be the boson of the superstrong interaction. Actually, it is shown later on that this interaction is mediated by three bosons.

In order to have the ‘galactic liquid’ it is also necessary to have some sort of polarization. This means that we need dipoles and because the gravitational force is always attractive (and thus, can not be the source of such dipoles), the superweak force must be repulsive during the universal expansion. This is consistent with the idea of the expansion itself. That is, the universal expansion must be caused by this repulsive force.

The bodies which form any polarized state exhibit some degree of correlation among them. This degree of correlation is shown by the correlation function which, in turn, is related to the interacting net potential among the particles. The potential has three general features: i) it has a minimum which is related to the mean equilibrium positions of the interacting particles; ii) it tends to zero as the separation among the particles tends to infinity; and iii) it becomes repulsive at close distances. The potential of the ‘galactic liquid’ must also have the same general features. Therefore, it is very important to determine the mean equilibrium position of the galactic superstructures.

As is well known the general motion of the particles of a fluid is quite complex and that is exactly what we are dealing with in the case of the galactic superstructures. It is worth reminding that up to now there is no acceptable theory which describes the liquid state of ordinary matter and there is no general theory which describes nuclear matter either.

V. THE SUPERWEAK FORCE
Let us now try to find a possible mathematical expression for the superweak force. There have been reports of a fifth force inferred from the reanalysis of the Eötvös experiment and from the mine-gravity data\(^\text{22}\). The discrepancies suggest the existence of a composition dependent intermediate-range force.

The potential energy of such hypothetical force is usually represented by a Yukawa potential which, when added to the standard Newtonian potential energy, becomes\(^\text{22}\)

\[
V(r) = -\frac{Gm_1m_2}{r} \left(1 + \alpha \exp \left(-\frac{r}{\lambda}\right)\right),
\]

where \(\alpha\) is the new coupling in units of gravity and \(\lambda\) is its range. The dependence on composition can be made explicit by writing \(\alpha = q_i q_j \zeta\) with

\[
q_i = \cos \theta (N + Z)_i/\mu_i + \sin \theta (N - Z)_i/\mu_i,
\]

where the new effective charge has been written as a linear combination of the baryon number and nuclear isospin per atomic mass unit, and \(\zeta\) is the coupling constant in terms of \(G\).

Until now most experimental results have not confirmed the existence of this force\(^\text{23}\), although they do not rule it out because its coupling constant(s) may be smaller than previously thought. Later on we will propose an estimation of the order of magnitude of the coupling constant of this interaction. Of course, this force may only exist if there is a violation in the weak equivalence principle, which has been proven to hold\(^\text{23}\) to a precision of one part in \(10^{12}\). But it may be violated if the precision goes just one more order of magnitude. There are some experiments that will be carried out within the next few years and that intend to test the equivalence principle to a higher accuracy\(^\text{24}\). They may, then, reveal the existence of the fifth force.

The superweak force proposed in this paper has the same character as the one of the fifth force, but has an infinite range. This means that the mass of the mediating boson is zero. From the above expression for the fifth force potential we may express the potential of the superweak force in terms of the baryon numbers and isospins of two bodies \(i\) and \(j\) as

\[
V(r, N, Z) = (A_B(N + Z)_i(N + Z)_j + A_I(N - Z)_i(N - Z)_j + A_{IB}((N + Z)_i(N - Z)_j + (N + Z)_j(N - Z)_i)) g^2 \frac{\exp \left(-r/\lambda\right)}{r},
\]

where \(A_B\) and \(A_I\) are the force coupling constants of the baryon number and isospin terms, respectively, and \(A_{IB}\) represents the mixed coupling of isospin and baryon number, and \(g\) is the strong force charge. Let us assume that the constants \(A_B, A_I\) and \(A_{IB}\) are positive. Taking into account the homogeneity of the universe we may disregard the distinction between \(i\) and \(j\) and the formula becomes simplified somewhat,

\[
V(r, N, Z) = (A_B(N + Z)^2 + A_I(N - Z)^2 + 2A_{IB}(N + Z)(N - Z)) g^2 \frac{\exp \left(-r/\lambda\right)}{r},
\]
If we assume that we are dealing with a conservative field, the superweak force is given by minus the derivative of the above potential with respect to \( r \), which is a function of time (along the expansion). Let us, at this point, deal with \( r \) only. We will discuss time later on in connection with the expansion rate and the Hubble constant. Let us consider that the baryon number is conserved (and is the same) in the two portions of matter subjected to the potential above, i.e. \( N + Z = B = constant \). Taking this into account the superweak force between the two portions of the universe under consideration becomes

\[
F(r, N(r), B) = -4 \frac{dN(r)}{dr} (A_1(2N(r) - B) + A_{1B}B) g \exp \left( -\frac{r}{\lambda} \right) + \left( \frac{1}{\lambda} + \frac{1}{r} \right) V(r, N(r), B)
\]  

(5)

where \( B \) is the baryon number of any of the two portions. The number of baryons of these two portions has to be extremely large, otherwise we would already have clearly identified this force on Earth.

With the above expression for the superweak force we will be able to explain the expansion of the universe itself and we may be able to show that it may have a cyclic behavior. It also explains the evolution of galaxies and the flat rotational curves of spiral galaxies.

We assume that at \( t = 0 \), in the ‘beginning’ of the universe, \( N \) had a certain value, \( N_0 \) (we will talk about its value later on), which decreased via the weak interaction (free neutron decay) up to a time called \( t_0 \). At this time \( N \) reached its minimum value, being only 13% of all baryons, the remaining 87% being protons. The halt in neutron decay happened due to the formation of atoms because the remaining neutrons were no longer free. These neutrons became bound in the nuclei of helium and deuterium. At some time afterwards galaxies were formed. This paper discusses later on the possibility of having quasars as the precursors of galaxies. Due to gravitational attraction the clumping continued on small scales and stars were formed. From this point on nuclear fusion took place in the core of stars of all galaxies (or quasars) and the number of protons began to decrease slowly. This is explained as follows: As the universe ages the stars become white dwarfs, neutron stars and black holes (not observed yet). During the aging process the core density of a star increases and the high electron Fermi energy drives electron capture onto nuclei and free protons. This last process, called neutronization\(^{(25)}\), happens via the weak interaction. The most significant neutronization reactions are:

- Electron capture by nuclei,

\[
e^- + (Z, A) \xrightarrow{W} \nu_e + (Z - 1, A),
\]

(6)

- Electron capture by free protons,
\begin{equation}
    e^- + p \xrightarrow{W} \nu_e + n,
\end{equation}

where \(W\) means that both reactions proceed via charged currents of the electroweak interaction.

Of course, neutronization takes place in the stars of all galaxies, and thus, the number of neutrons increases relative to the number of protons as the universe ages. For example, a white dwarf in the slow cooling stage (for \(T \leq 10^7\) K) reaches a steady proton to neutron density of about 1/8, and takes about \(10^9\) years to cool off completely, which is a time close to the present age of the universe. By then, most stars have become white dwarfs (or neutron stars and possibly black holes). At a later time, because of the action of the superweak force, during the contraction of the Universe, the galaxies will merge to each other and with further contraction their stars will be disrupted. This will liberate neutrons and protons of stars. The neutrons of white dwarfs and neutron stars will become free and will decay via the weak interaction and the number of protons will increase again (with respect to the number of neutrons). Therefore, we expect to have 
\[
    \eta(r) = \frac{N(r)}{B}
\]
as a function of the separation between the two bodies as shown in Fig.1. The separation when \(\eta\) has a minimum is called \(r_p\) (p for protons); \(r_n\) is the separation when \(\eta\) has a maximum (n for neutrons); when the separation is \(R\) the superweak force is zero. During the contraction there must exist a separation when the contraction stops. This is indicated by \(r_o\). At this separation we will begin to count time. This is all we need to have a cyclic Universe. In this way the superweak force will drive the expansion and contraction of the universe and behaves overall as a spring-like force (see Fig.2).

In Fig.2 \(r_M\) and \(r_m\) are the separations when the force has a maximum and a minimum, respectively. The other points have been defined above. At present the separation \(r\) must be larger than \(r_p\) and smaller than \(R\). According to the Oort limit (26), roughly half of the mass of our galaxy has already been processed by stars that have completed their evolution. This means that there are many neutron stars and white dwarfs which have not yet been detected in our galaxy. Since the same must hold for all galaxies, the ratio of the number of neutrons to the number of protons for the whole universe at the present epoch must be much larger than 13/87. We can find some relations among the coupling constants from the known number of neutrons and protons at some particular times.

In order to have a cyclic Universe the function \(F(r)\) must have two zeros, one corresponding to a stable position and the other one corresponding to an unstable position. Let us analyse the stable position, first. Let us call the time at this point, \(T\) and the respective distance, \(R\). Let us expand the potential around \(t = T(r = R)\) and find the condition for a minimum (in the potential). Up to fourth order in \(r - R\) the potential is given by

\[
    \frac{V(r)}{(B g)^2} = \frac{1}{R} \left( A_B + 2A_{IB}(2\eta_T - 1) + A_I(2\eta_T - 1)^2 \right) + \frac{1}{R} \left( 4a_TA_{IB} 
    + 4a_TA_I(2\eta_T - 1) \right) (r - R) + \frac{1}{R} \left( 4b_TA_{IB} + 4a_T^2A_I + 4b_TA_I(2\eta_T - 1) \right) (r - R)^2
\]
\[
\begin{align*}
&+ \frac{1}{R} \left( 4c_T A_{IB} + 4c_T A_I (2\eta_T - 1) + 8a_T b_T A_I \right) (r - R)^3 \\
&+ \frac{1}{R} \left( 4d_T A_{IB} + 4b_T^2 A_I + 4d_T A_I (2\eta_T - 1) + 8a_T c_T A_I \right) (r - R)^4
\end{align*}
\]

where \( a_T, b_T, c_T \) and \( d_T \) are the first, second, third and fourth derivatives of \( \eta(r) \) with respect to \( r \). The linear term in \( r - R \) should be zero so that we have a minimum at \( r = R \). This leads to the condition

\[
\eta_T = \frac{1}{2} \left( 1 - \frac{A_{IB}}{A_I} \right).
\]

With this condition the potential becomes

\[
\frac{V(r)}{(Bg)^2} = \frac{1}{R} \left\{ (A_B - A_I (2\eta_T - 1)^2) + a_T^2 A_I (r - R)^2 + 8a_T b_T A_I (r - R)^3 + 4A_I (b_T^2 + a_T c_T (r - R)^4) \right\}.
\]

Therefore, taking these conditions into account we obtain a pendulum-like potential (and a restoring force at the bottom of the potential). Making the first term equal to zero (just a reference level) we obtain that \( A_B A_I = A_{IB} \). Therefore, we may write \( V(r) \) as

\[
\frac{V(r)}{(Bg)^2} = 4A_I \frac{(\eta - \eta_T)^2}{r}
\]

where \( \eta_T = \frac{1}{2} (1 - \sqrt{\frac{A_B}{A_I}}) \).

Thus, the expression for the force is given by

\[
\frac{F(r)}{(Bg)^2} = -8A_I \frac{(\eta - \eta_T) \frac{d\eta}{dr}}{r} + 4A_I \frac{(\eta - \eta_T)^2}{r^2}.
\]

We clearly see that \( F = 0 \) when \( \eta = \eta_T (t = T) \). In order to not have three zeros for \( F(r) \)

\[
\frac{d\eta}{dr} \neq \frac{\eta - \eta_T}{2r}.
\]

At \( \eta = \eta_p \), \( F \) is

\[
\frac{F_p}{(Bg)^2} = 4A_I \frac{(\eta_p - \eta_T)^2}{r^2}
\]

which is positive, of course. It is easy to show that the maximum in \( F(r) \) happens at some point before \( r = R \). When \( F(r) \) is maximum \( \frac{dF(r)}{dr} = 0 \). Therefore, we obtain

\[
2(\eta - \eta_T) \frac{d^2\eta}{dr^2} + 2 \left( \frac{d\eta}{dr} \right)^2 - 4 \left( \frac{\eta - \eta_T}{r} \frac{d\eta}{dr} + \frac{(\eta - \eta_T)^2}{r^2} \right) = 0
\]
which may be transformed into

\[ 2(\eta - \eta_T) \frac{d^2\eta}{dr^2} + \left( \frac{d\eta}{dr} \right)^2 + \left( \frac{d\eta}{dr} - 2 \frac{(\eta - \eta_T)}{r} \right)^2 = 0. \]  

(16)

The last two terms are always positive. For \( \eta < \eta_T \frac{d^2\eta}{dr^2} \) has to be positive which means that the maximum happens for \( \eta < \eta_T \). The maximum may happen at \( \eta = \eta_p \) if

\[ \frac{d^2\eta}{dr^2} = \frac{\eta_T - \eta_p}{2r^2}. \]  

(17)

Of course, \( R \) is the largest distance between the two bodies (galaxies, or voids) and the Universe will have its maximum radius for \( \eta = \eta_R \).

VI. THE UNIVERSE OF ANTIPARTICLES

In order to have a contracting Universe the superweak force must become negative. This is possible for times after the point \( r = R \) only if we perform a CP transformation in the relevant variables, \( \vec{r} \) and \( B^2 \eta \). By doing so we obtain a contracting Universe of antiparticles.

Under a CP transformation \( V(r) \) is left unchanged and \( \vec{F}(r) \) goes into \( -\vec{F}(r) \) (because \( \vec{\nabla} \) changes into \( -\vec{\nabla} \)). In the contracting Universe let us name the force \( \vec{F}(r) \). Therefore, \( \vec{F}(r) \) given by

\[ \vec{F}(r) = 4 A f (B g)^2 \left( \frac{2(\eta - \eta_T)}{r} \frac{d\eta}{dr} \frac{(\eta - \eta_T)^2}{r^2} = -F(r) \right) \]  

(18)

where we have used the fact that \( \tilde{\eta} = \tilde{N}/\tilde{B} = N/B = \eta \) in which the bar indicates the antiparticle.

Because of the continuity of \( F(r) \) at \( r = R \) we must have

\[ \frac{d\eta}{dr}_{\eta = \eta_R} = \frac{\eta_R - \eta_T}{2R} = -F(r). \]  

(19)

That is, we obtain \( F(R) = 0 \).

For \( \eta = \eta_n \), \( \vec{F}_{\eta_n} = \vec{F}_n \) is given by

\[ \vec{F}_n = -4 A f (B g)^2 \frac{(\eta_n - \eta_T)^2}{r_n^2} \]  

(20)

which is always negative. From Eqs. 16 and 17 we see that for \( \eta = \eta_n \) the second derivative of \( \eta \) with respect to \( r \) is negative since \( \eta_n > \eta_T \).

For \( \eta = \eta_R \) the velocity, \( v \), must be zero and for later times it must become negative. Let us, now, analyse how the arrow of time is in the contracting
Universe. Under a CP transformation $\vec{v}$ changes sign which is consistent with the fact of having a contraction instead of an expansion. This means that we can not have a T transformation, that is, there is only one arrow for time (otherwise, $\vec{v}$ would not change sign). Or, in other words, time goes from zero (when the expansion begins) to a maximum value $T_U$ (when the contraction ends) and never has a negative rate (i.e., $dt$ is always positive). $T_U$ represents a full cycle of the Universe. Eqs. 6 and 7 are modified by changing particles into antiparticles.

VII. UNIFICATION OF THE SUPERWEAK FORCE WITH THE STRONG FORCE

Around $t = 0$, that is, for $r \approx r_o (\eta \approx \eta_o)$ the potential is given by

$$V(r) = (Bg)^2 \frac{(\eta_o - \eta_T)^2}{r} \times \frac{B^2 g^2}{r}$$

which is an expression of the strong force potential. Therefore, the strong force and the superweak force are unified at $t = 0$.

VIII. A POTENTIAL FOR THE UNIVERSE

ad infinitum

We represent in Fig.3 the potential of the superweak force according to our calculations and considerations. According to this figure the universe spends most of its time at the bottom of the potential, where it is more stable. This time corresponds to the era of galaxies which are the units that fill the Universe the longest.

The scale is not linear and that is why the curve has a smooth descent and a smooth rise. Actually, the potential is almost a square well because the time $r_p$ is extremely small compared to $R$. Notice that $r$ diminishes after reaching the value $R$.

What is time in such a Universe? Time has a meaning only in each cycle, for if the number of cycles is infinite the Universe is eternal. If we consider that the number of cycles is finite, than we include, in fact, an external agent to the Universe. This is a possibility, but in this case, we would have other Universes.

IX. TIME VARIATION OF THE HUBBLE CONSTANT

Let us now consider the variation of the Hubble constant with time (during the expansion). According to our arguments, it must be decreasing with time since $t = t_p$ (which corresponds to $r = r_p$), and will continue decreasing up to
\[ t = t_n \text{(which corresponds to } r = r_n) \text{. In other words, the expansion must be slowing down at present.} \]

As is well known, it is convenient to represent the universal expansion rate as

\[
\frac{1}{R(t)} \frac{dR(t)}{dt} = f(t) = H(t) \tag{22}
\]

where \( H(t) \) is Hubble’s constant. For an expanding universe \( H(t) \) is positive. The velocity between two bodies (galaxies, for example) separated by a distance \( r(t) \) is given by

\[
v(t) = H(t)r(t). \tag{23}
\]

The relative velocity between any pair of galaxies (or the galactic superstructures) is a rather small velocity. Therefore we may use classical Newtonian mechanics. Having this in mind let us consider that the mass of a body is, to a very good approximation, given by \( m \approx B m_p \), and let us make \( \eta = N/B \). The force between two bodies \((m_1 = m_2, B_1 = B_2 \text{ and } N_1 = N_2)\) will be given by

\[
m_p \frac{d^2r}{dt^2} = -\frac{1}{r} \frac{dL}{dr} + \frac{L}{r^2} \tag{24}
\]

where

\[
L(\eta) = 4A_I(\eta - \eta_T)^2(Bg)^2. \tag{25}
\]

We may make \( r(t) = R(t) r_o \), where \( r_o \) is the initial separation between the two bodies and writing \( r(t) \) in terms of \( R(t) \) and \( H(t) \) one obtains

\[
\dot{H} = -\frac{\dot{L}(\eta)}{m_p r_o^3 H R^3} + \frac{L(\eta)}{m_p r_o^3 R^3} - H^2. \tag{26}
\]

Let us recall that \( \dot{L}(\eta) \) is given by \( \dot{L}(\eta) = 8A_I(Bg)^2 \dot{\eta}(\eta - \eta_T) \). In the range between \( t = t_p \) and \( t = t_T, \dot{\eta} > 0 \) and \( \eta < \eta_T \), and therefore, \( (L) \) is negative. Let us consider \( t \) as being the present epoch of the Universe. If the expansion is slowing down we must have \( \dot{H} < 0, L > 0 \) in this range. Solving the cubic equation in \( \dot{H} \) for \( \dot{H} < 0 \), we obtain

\[
H(t) > \left( \frac{\dot{L}}{2m_p r_o^3 R^3} + \sqrt{-\frac{L^3}{27m_p^3 r_o^9 R^9} + \frac{(\dot{L})^2}{4m_p^2 r_o^6 R^6}} \right)^{1/3}
\]

\[
- \left( \frac{\dot{L}}{2m_p r_o^3 R^3} - \sqrt{-\frac{L^3}{27m_p^3 r_o^9 R^9} + \frac{(\dot{L})^2}{4m_p^2 r_o^6 R^6}} \right)^{1/3} \tag{27}
\]
which means that $H$ is positive.

**X. A NEW POSSIBLE BEGINNING FOR THE UNIVERSE**

We can calculate how $H(t)$ behaves with time around $t = 0$ if we make some assumptions on the relative proportions of neutrons to protons prevailing around $t = 0$. The nuclear reactions which must be considered in determining the proton-neutron ratio are the following:

\[
\begin{align*}
n &\leftrightarrow p + e^- + \bar{\nu}_e, \\
(n + \nu_e) &\leftrightarrow (p + e^-), \\
(n + e^+) &\leftrightarrow (p + \bar{\nu}_e).
\end{align*}
\]

By considering that the temperature is *not* very high so that $m_e c^2 \approx kT$, Alpher et al.\(^{(27)}\) have shown (in another context) that, among the reactions above, free neutron decay is the dominant reaction. If the neutrons are free then $\eta(t) = \eta_0 \exp(-t/\tau)$ and

\[
\frac{d\eta}{dt}igg|_{t=0} = \eta_0. \tag{28}
\]

In order to have a cyclic Universe $v$ must be zero at two different times which are $t = 0$ and $t = t_R$. But, because $\frac{dn}{dt} = \frac{dn}{dx}v$, the neutrons can not be completely free at $t = 0$, i.e., $\frac{dn}{dx}$ cannot be exactly equal to a constant. For times around $t = 0$, $\eta(t)$ must be

\[
\eta(t) = \eta_0 \exp(-g(t)) \tag{29}
\]

such that, for times close to zero, $g(t) \propto t^x$ where $x > 1$. This will assure that $H(t = 0) = 0$. Therefore, there must exist a process that will speed up the decay of neutrons.

The above condition concerning the temperature at $t = 0$ is included in the following considerations about the temperature of the universe at some particular times:

- Each cycle of the universe begins ($t = 0$) with a volume of neutrons, protons and electrons at a temperature of about 1Mev, which is necessary for the primordial formation of the light elements. On this we must reanalyse the papers of Gamow\(^{(28)}\) and of Alpher and Herman\(^{(29)}\) taking into account this new interaction.

- At $t = t_p$ the temperature is about 0.1Mev (necessary because of the deuteron binding energy). Considering free neutron decay this corresponds to $t_p = 25\text{min}$. As we considered above the neutrons must decay at a faster rate and therefore $t_p < 25\text{min}$. 

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The atom is formed when the temperature has dropped to about 1\textit{eV}. This is consistent because for an adiabatic expansion $T \sim l^{-1}$, and since the hydrogen atom is $10^5$ larger than a nucleon, we expect the temperature to be about $0.1 \times 10^{-5} \text{MeV} = 1\text{eV}$.

This possible history of the universe is consistent with the observed quantity of matter with respect to antimatter. What has been observed is that antimatter does not exist by itself and only comes out from nuclear reactions (involving matter) which take place in stars or proto-stars.

This history of the Universe is also consistent with quark confinement. As is well known all high energy experiments have shown that quarks are “mysteriously” confined. If they are permanently confined, then they were never free. That is exactly what this paper assumes, i.e., the paper assumes that neutrons and protons always existed. In this fashion quark confinement is linked to the existence of the superweak force and may be linked to a conservation in the number of nucleons.

In the light of the above considerations we must reinvestigate the origin of the cosmic black body radiation. Because of the recent observations on this radiation\cite{4} we need to reinvestigate its origin anyway. COBE’S data show that the radiation is not absolutely isotropic and exhibits dipole and quadrupole moments. As has been considered by several investigators\cite{30,31,32,33,34,35}, this radiation may have been produced by a generation of “population III” stars which were formed and burned out quickly before galaxy formation.

### XI. QUASARS AS THE PRECURSORS OF GALAXIES

A typical galaxy has $10^{11}$ suns which correspond, roughly, to $10^{68}$ hydrogen atoms. When we consider these atoms close to each other they occupy a volume with a radius of the order of $5 \times 10^{14}$ cm $\approx 0.1$ light day. This figure is a lower bound for the radius of a quasar. We will see below that their radii have to be larger than 10 light years. The radius of the bulge of our galaxy is of the order of $10^4$ light years. Also, the velocity $v$ at the equator of a quasar has to be smaller than the speed of light. Therefore, using angular momentum conservation we obtain that $R_Q > R_B v_B / c$, where $R_Q$ is the radius of the quasar, $R_B$ is the radius of the bulge of our galaxy and $v_B$ is the velocity of a star at the equator of our galaxy’s bulge. One finds that $R_Q > 10$ light years. This is an increase of $10^4$ over the radius previously calculated. The corresponding upper bound for the temperature is $10^{-4}$ eV. The radius of 0.1 light day gives a density of the order of the density of water. The upper bound, 10 light years, provides as a lower bound for the density the figure $10^{-12}$ g/cm$^3$. This means that quasars were formed after the formation of hydrogen atoms. Therefore, they were formed at a temperature between 0.1 mev and 1 eV. At this temperature the kinetic energy of the gas particles at the surface of the gas cloud is larger than the gravitational potential of the gas particles. This is not a problem because each
gas cloud (quasar) will expand anyway due to action of the superweak force. In this picture quasars are formed due to the action of the superweak force. Since this force has an infinite range the repulsion must also exist on larger scales.

We may find that quasars have radii around 10 light years in another way. It is well known that they have an angular diameter of \( \theta = 10^{-3} \) arcsec. The most distant quasars are at distances of the order of \( cT \), where \( T \) is the present age of the Universe. Therefore, their diameters are \( d = cT\theta \approx 10 \) light years. It is known that some quasars vary their brightness from night to night. This flickering may come just from their brighter centers and does not invalidate the above figure of 10 light years. Of course, quasars with lower masses must also have smaller radii.

As is well known we find quasars at redshifts beyond those to which we can see galaxies and there is no quasar at small redshifts. It is shown below how they may have evolved into galaxies. There is also a sharp drop in their numbers at a redshift around \( z = 2.2^{(96)} \). This redshift is just a mark showing when they were formed.

XII. THE EVOLUTION OF GALAXIES

A quasar may become an elliptical galaxy by expanding slowly as a whole. Because of rotation we may have several types of ellipticals according to their oblateness. As is well known ellipticals do not exhibit much rotation (as compared to spiral galaxies). This is explained as follows: As the quasar expands
its angular velocity decreases because of angular momentum conservation. For example, the angular velocity of an EO must be given by (disregarding mass loss)

$$\omega_{EO} = \frac{\omega_Q R_{EO}^2}{R_Q}$$

(31)

where $\omega_Q$ is the angular velocity of the quasar which gave origin to the galaxy; $R_{EO}$ and $R_Q$ are the radii of the elliptical galaxy and the quasar respectively. Because $R_{EO} \gg R_Q$, $\omega_{EO} \ll \omega_Q$. This is consistent with the slow rotation of ellipticals. There is also the following consistency to be considered. Most galaxies in the Universe are ellipticals (about 60%) and as was shown above this means that most quasars expand slowly. Therefore, most quasars must not show rapid variability and must also be radio quite. This is exactly what has been reported (37).

Another evidence to be taken into account is the reported nebulosity around some quasars. Boroson and Person (38) have studied this nebulosity spectroscopically. The emission lines they found are of the same type as the emissions from a plasma.

b) Spiral galaxy.

There are two possibilities in this case: normal spiral and barred spiral. This happens when, at some point in its expansion towards becoming a galaxy, a quasar expands rapidly by pouring matter outwards from its center. This pouring will give origin to two jets which will wind up around the central bulge because of rotation and will create the two spiral arms. A possible mechanism is the following: Due to rotation we expect to have some bulging in the spherical shape, and because of angular momentum conservation the outpouring of matter may only happen in a plane perpendicular to the axis of rotation. Because of rotation the core of the quasar becomes also an ellipsoid. This core (which has a higher concentration of baryons) may be broken in two parts, going to a state of lower potential energy (of the superweak interaction). These two parts repel each other and form two centers (lobes) in the equator of the quasar (or young galaxy). These two lobes are seen in many radio galaxies. Because of the outpouring of matter from each center, there must exist all kinds of radiation covering the whole electromagnetic spectrum especially in the form of synchroton radiation caused by collisions among atoms. Because of these collisions we expect to have electrons stripped from hydrogen and helium atoms. These electrons will create the observed synchroton radiation which is associated with jets in very active galaxies. These collisions provide also the enormous energy output observed in quasars.

As the galaxy ages its bulge diminishes and leaves the globular clusters alone without the embedding gas since the gas has either escaped or has been transformed into globular clusters. Also, the activity at the galactic center diminishes
as the age increases due to the increase in the number of neutrons (which decreases the superweak force) because of nuclear fusion and also because of the decrease in material at the nucleus.

The barred spirals are galaxies that have expelled matter more vigorously. That is exactly why their arms are not tightly wound. As the galaxy ages the arms will curl up more and more and the bar will disappear because of the ejection of material outwards. It is worth noting that the more spirals (including barred ones) are wound up, the smaller are their nuclei and, conversely, the larger are their bulges, the less they are wound up. This happens because of the shedding of matter outwards from their nuclei throughout the galaxy’s life due to the action of the superweak force. The bar can be explained in terms of a more vigorous shedding of matter outwards as compared to the shedding that takes place in normal spirals. Therefore, as a spiral evolves its nucleus diminishes and the two arms become more and more tightly wound up. Let us now show why the core preferentially breaks up in two parts. Let us compare the potential energies when the core is broken in two and three parts. For simplification, let us consider that the core is broken in equal parts. In the case of two parts we have

\[ V_2 = \frac{1}{4} \frac{q^2}{d^2} \]  

and in the case of three parts,

\[ V_3 = \frac{1}{3} \frac{q^2}{d^3} \]  

where \( q = (\sqrt{A_B} B + \sqrt{A_I} (N - Z)) g^2 \), in which \( B, N \) and \( Z \) are the numbers of baryons, neutrons and protons of the core before it is broken. Clearly, \( V_2 < V_3 \), and therefore the breaking in two parts is preferred for it corresponds a state of lower energy.

Since a quasar must consist mainly of hydrogen gas, let us disregard the number of neutrons. In this case the potential between the two parts (separated by \( d \)) is given by

\[ V = g^2 \left( \sqrt{A_B} - \sqrt{A_I} \right)^2 \frac{B_1 B_2}{d} \]  

in which \( B_1 \) and \( B_2 \) are the number of baryons in the two parts and \( B_1 + B_2 = B \) (constant). This is consistent with the observation of the two lobes of radio galaxies. For example, a contour map of radio emissions shows that most of the radiation comes from two blobs located on either side of the central galaxy Cygnus A (also called 3C405). When observed in the visible spectrum the central galaxy also shows two blobs. In the framework of gravity it is impossible to explain the situation of this galaxy and its four blobs. They must have been formed due to the action of the superweak force. At some time in the past
there was just a single agglomeration of gas which separated in two main parts leaving a small part in the middle. The radio emission must be caused by the outpouring of matter which takes place in each blob.

c) Seyfert galaxy.

In this case the expansion is more violent. It is well known that these galaxies are powerful sources of infrared radiation. Several Seyfert galaxies are also strong radio emitters, and also, like quasars, they present variability in their energy output. For example, over a period of a few months, the nucleus of the Seyfert galaxy M77 (or NGC1068) switches on and off a power output equivalent to the total luminosity of our galaxy. It is also worth noting that the nuclei of Seyfert galaxies are very bright and have a general starlike appearance.

Researchers have found that Seyfert galaxies exhibit explosive phenomena\(^{(39)}\). For example, M77 and NGC4151 expel huge amounts of gas from their nuclei. The spectra of both galaxies show strong emission lines, just as quasars'.

In summary, the proposed evolution for galaxies including all kinds of galaxies follows the two branches:

\[
\begin{align*}
I) & \text{Quasar(without jets)} \rightarrow (\text{BL Lacertae or radio galaxy}) \rightarrow \begin{cases} \text{Seyfert Galaxies} \\ \text{Elliptical Galaxies} \\ \text{Spiral Galaxies} \end{cases} \\
II) & \text{Quasar(with jets)} \rightarrow \text{radio galaxy} \rightarrow \begin{cases} \text{Seyfert Galaxies} \\ \text{Spiral Galaxies} \end{cases}
\end{align*}
\]

The BL Lacertae objects stage may or may not be present. Radio galaxies represent an intermediate stage. Irregular galaxies have not been included but they only represent 10% of all galaxies and they are not well understood. Besides, it is suspected that many irregulars are the result of collisions among galaxies.

Of course, there must exist evolution in each final branch. As ellipticals age they become more and more oblate as a result of rotation. Spiral galaxies evolve by means of the shedding of matter from their centers towards the disk. Seyfert galaxies may display a complex evolution since not all of them exhibit spiral arms. It is clear that as these galaxies age their nuclei will be less and less bright.

Let us, now, make a general analysis including all kinds of galaxies. Considering the evolution above proposed we do not expect to have very small spiral galaxies because spirals must come from strong expulsion of matter from quasars nuclei, and this must happen only when the number of baryons is sufficiently large. This is the case, indeed, because dwarf galaxies are either irregular or
elliptical galaxies. Ellipticals have masses that range between $10^5$ and $10^{13}$ solar masses while spirals masses are comprised between $10^9$ and $10^{11}$ solar masses. Also, we expect that spirals have faster rotations than ellipticals and, indeed, they do. This is just because the nuclei of spirals are smaller than ellipticals galaxies (for the same mass, of course). Therefore, according to Eq.30 above, spirals should have faster rotational velocities. It is also expected that, since spirals shed gas in their disk throughout their lifetimes, their disks must have young stars. This is an established fact. Our galaxy’s disk, for example, has very hot, young (O-, B-, and A-type) stars, type-I Cepheids, supergiants, open clusters, and interstellar gas and dust. Each of these types represent young stars or the material from which they are formed. Conversely, the globular clusters and the nucleus contain older stars, such as RR Lyrae, type-II Cepheids, and long-period variables. This, of course, is a general characteristic of all spirals. For example, Young O- and B-type stars are the stars which outline the beautiful spiral arms of the Whirlpool galaxy. Because of the lack of gas (i.e., because of the lack of a disk) ellipticals also have primarily very old stars.

It is well known that BL Lacertae objects are powerful sources of radio waves and infrared radiation. They share with quasars the fact of exhibiting a starlike appearance and of showing short-term brightness fluctuations. As some quasars do, they also have a nebulosity around the brighter nucleus. Researchers\(^{(39)}\) have managed to obtain the spectrum of their nebulosity. *The spectrum of the nebulosity is strikingly similar to the spectrum of an elliptical galaxy (M32’s spectrum, in this case).* Because of the short-term variability these objects are very compact objects. In terms of the evolution above described they are simply an evolutionary stage of a quasar towards becoming a normal galaxy.

Radio galaxies share with BL Lacertae object many of the properties of quasars. As Heckman et al.\(^{(40)}\) have shown, in the middle and far infrared (MFIR) quasars are more powerful sources of MFIR radiation than radio galaxies. Also, there have been investigations showing that the emission from the narrow-line region (NLR) in radio-loud quasars is stronger than in radio galaxies of the same radio power\(^{(41,42,43)}\). Goodrich and Cohen\(^{(44)}\) have studied the polarization in the broad-line radio galaxy 3C 109. After the intervening dust is taken into account the absolute V-magnitude of this galaxy becomes $-26.6$ or brighter, which puts it in the quasar luminosity range. The investigators suggest that “many radio galaxies may be quasars with their jets pointed away from our direct line of sight”. It has also been established that radio galaxies are found at intermediate or high redshifts and that they are clearly related to galactic evolution because as the redshift increases cluster galaxies become bluer on average, and contain more young stars in their nuclei. This is also valid for radio galaxies: the higher the redshift, the higher their activity. All these data show that a radio galaxy is just an evolutionary stage of a galaxy towards becoming a normal galaxy, i.e., it is just a stage of the slow transformation by means of an overall expansion of a quasar into a normal galaxy.

In the light of the above considerations the nuclei of old spirals must exhibit
a moderate activity. This is actually the case. The activity must be inversely
proportional to the galaxy’s age, i.e., it must be a function of luminosity. The
bluer they are, the more active their nuclei must be. As discussed above there
must also exist a relation between this activity and the size of the nucleus(as
compared to the disk) in spiral galaxies. Our galaxy has a mild activity at its
center. Most of the activity is concentrated in a region called Sagittarius A,
which includes the galactic center. It emits synchrotron and infrared radiations.
Despite its large energy output Sagittarius A is quite small, being only about
40 light years in diameter. Besides Sagittarius A our galaxy exposes other
evidences showing that in the past it was a much more compact object: 1) Close
to the center, on opposite sides of it, there are two enormous expanding
arms of hydrogen going away from the center at speeds of 53km/s and 153km/s;
b) Even closer to the center there is the ring called Sagittarius B2 which is
expanding at a speed of 110km/s\(^{(45)}\). It is worth noting that the speeds are very
low(as compared to the velocities of relativistic electrons from possible black
holes). This expansion is just a manifestation of the action of the superweak
force. This is not restricted to our galaxy. Recent high-resolution molecular-
line observations of external galaxies have revealed that galactic nuclei are often
associated with similar expanding rings\(^{(46)}\). When the galactic center is seen at
radio wavelengths(3.75cm) it shows a flattened shape along the galactic equator.
This fact also lends support to the above considerations.

The nearby galaxy M31 provides some valuable data towards the evolution-
ary scheme above discussed. The nucleus of this galaxy is a strong emitter of
infrared radiation, even though there is no known star formation in this part of
the galaxy. This radiation may be explained in terms of the expansion of gas
from its center.

A very important result about galaxies is the very tight relationship between
the far-infrared and non-thermal radio emission that extends over nearly three
orders of magnitude\(^{(47)}\). Therefore, these two processes may be tied together.
Our interpretation is that they are caused by the expulsion of matter from
the center. As discussed above this expulsion gives off lots of synchrotron and
infrared radiation.

We may prove or disprove the above evolutionary hypothesis by testing some
of the predictions of the evolution above displayed:

1. The number of spirals must decrease with increasing redshift;
2. The sizes of spirals disks must decrease when we go to higher redshifts;
3. The activity in the nuclei of spirals must be directly connected with the
   sizes of their nuclei. The larger their nuclei are, the higher must be the
   activity in the nuclei(in terms of radio emission and infrared radiation);
4. Small galaxies must hardly exhibit any activity in their nuclei;
A very important support to the above evolution is provided by the number-luminosity relation \(N(> l)\). When expanded in terms of the apparent luminosity, \(l\), the first term (Euclidean term) is given by

\[
N(> l) = \frac{4\pi n(t_0)}{3} \left( \frac{L}{4\pi l} \right)^{1.5}
\]

(35)

where \(n(t_0)\) is the present density of galaxies and \(L\) is the absolute magnitude. The correction term is always negative, so that the number of faint objects \(l\) (small) should always be less than the number that the \(l^{1.5}\) predicts. This conclusion is strongly contradicted by observations on radio sources: many surveys of radio sources agree that there are more faint sources than the \(l^{1.5}\) law predicts. The fitting of the experimental data provides a law of the form

\[
N(> l) \approx \text{constant} \frac{1}{l^{1.8}}
\]

(36)

Since the formula breaks down for small \(l\) (i.e., faint distant sources), we must conclude that in the past radio sources were brighter and/or more numerous than they are today. This, of course, lends support to the above evolutionary scheme.

Because the supersensitive force goes with the square of the number of baryons we expect that quasars with small masses (i.e., small number of baryons) must evolve less rapidly and more quietly. Also, small ellipticals must be very quiet galaxies. This is a well known fact.

At this point it is worth mentioning that there is a very important drawback against the traditional view of explaining the formation of arms in spirals by the bulging effect of rotation. If this were the case we would find a higher proportion of pulsars off the galactic equator of our galaxy. But the real distribution reveals that these sources are mostly concentrated in the galactic equator. The traditional view does not explain either why all spirals have large amounts of gas in their disks. Besides, within the traditional framework quasars are just exotic objects. Evolution is clearly out of question without a repulsive force.

XIII. THE ARMS OF SPIRAL GALAXIES

The rotational curve of spiral galaxies is one of the biggest puzzles of nature. It is possible to give a reasonable explanation for this puzzle in terms of the action of the supersensitive force. In the process we will also explain the formation of the spiral structure of the arms.

First, let us consider the central nucleus (or bulge). The bulge was formed by means of an overall repulsion mainly among all hydrogen atoms. This repulsion took place a long time ago as the globular clusters show us. For simplification let us consider a uniform density for the bulge. Because mass varies as \(r^3\) and the gravitational force varies as \(r^{-2}\) we expect the tangential velocity to be proportional to \(r\). This provides a cancellation of the gravitational force with
the centrifugal force. The superweak force just contributed to the small radial velocities at the time of formation of the bulge.

Now, let us consider the tangential velocities of stars in the disk. As was shown above the disk was formed by the shedding of matter from the center of the galaxy where a denser core existed. Let us consider that the bulge has a radius \( R_B \). Let us consider that, because of the action of the superweak force, a certain mass of gas \( m \) is expelled from the center. While the mass is inside the bulge its tangential velocity will increase with \( r \) and, therefore, will reach its maximum value, \( v_B \), at \( R_B \). Because of its radial velocity, the mass \( m \) will continue to distance itself from the bulge. But its tangential velocity is kept fixed because of the action of repulsion and because of the transfer of angular momentum from the bulge to the mass. This may be shown in the following way: As the mass goes away from the center it increases its angular momentum. At a distance \( r \) the angular momentum is given by

\[
L = mrv_t
\]

(37)

where \( v_t \) is the tangential velocity. Because \( L \) (of the mass \( m \)) increases with time (and with \( r \)) we have

\[
\frac{d v_t}{v_t} > \frac{d r}{r} .
\]

(38)

Integrating, we obtain

\[
ln \frac{v_t}{v_{to}} > ln \frac{r_o}{r} ;
\]

(39)

where \( r_o \) is the position of the mass at a time \( t_o \) and \( r \) is its position at a later time. Both positions are measured from the center. Because the logarithm is an increasing function of the argument, we must have

\[
\frac{v_t}{v_{to}} > \frac{r_o}{r} .
\]

(40)

We clearly see that \( v_t = v_{to} \) is a solution of the above inequality because \( r \) is always larger than \( r_o \).

Now, let us examine what happens to the mass in terms of energy. At a position \( r \) from the center of the galaxy its energy is given by

\[
E = \frac{L^2}{2mr^2} + \frac{1}{2} mv_r^2 - \frac{GMm}{r} + U(r)
\]

(41)

where \( L \) is the star’s angular momentum, \( v_r \) is the radial velocity of the mass \( m \), \( M \) is the mass of the galaxy, \( G \) is the gravitational constant and \( U(r) \) is the repulsive potential of the superweak force. The first time derivative of the energy (of the mass \( m \)) is

\[
\frac{dE}{dt} = m v_t \frac{dv_t}{dt} + m v_r \frac{dv_r}{dt} + \frac{GMm}{r^2} \frac{dr}{dt} + \frac{dU}{dt} .
\]

(42)
Assuming a conservative field and disregarding the action of any other forces on the mass $m$, we must have $\frac{dE}{dt} = 0$. Because the superweak force is a radial force, $\frac{dv}{dt}$ must be zero. Therefore, $v_r$ is a constant and is, therefore, independent of the distance to the center of the galaxy. The superweak potential $U(r)$ is given by

$$U(r) = \frac{\left(\sqrt{A_B} + \sqrt{A_I}(2\eta - 1)\right)^2 Bb g^2}{r}$$

(43)

where we have considered that the bulge and the mass $m$ have the same proportion of neutrons to baryons, $\eta$. Let us call $Q = \left(\sqrt{A_B} + \sqrt{A_I}(2\eta - 1)\right)$ to make the calculation simpler. Taking this into account we have

$$\frac{dU}{dt} = 2BbQ \frac{dQ}{dt} - \frac{BbQ^2}{r^2} \frac{dr}{dt}. \quad (44)$$

Substituting this expression into Eq.(57), we obtain that

$$v_r = \frac{\frac{2BbQ}{r} \frac{dQ}{dt}}{\frac{Bbc g^2}{r^2} + \frac{GMm}{r^2} - m \frac{dm}{dt}}. \quad (45)$$

Let us analyse in detail the above expression for $v_r$. As the mass $m$ goes further from the center the superweak force diminishes. Therefore, $\frac{dv}{dt}$ must be negative. But, since the middle term of the denominator is dominant (because the superweak force is weaker than the gravitational force), the denominator is always negative. The numerator is given by

$$\frac{2BbQ}{r} \frac{dQ}{dt} = 2Bb \left(\sqrt{A_B} + \sqrt{A_I}(2\eta - 1)\right) \frac{2}{\frac{dt}{dt}} \sqrt{A_I} \quad (46)$$

which, with the use of Eq.(13), may be transformed into

$$\frac{2BbQ}{r} \frac{dQ}{dt} = 8BbA_1 g^2 (\eta - \eta_T) \frac{d\eta}{dt}. \quad (47)$$

As we saw before, for $T_t > t > t_p$, $\eta < \eta_T$ and $\frac{d\eta}{dt} > 0$. Therefore, $v_r$ is always positive, i.e., the mass $m$ moves outward and, as time goes by, it gets further from the center. In this way the mass $m$ gains angular momentum. Because of conservation of angular momentum the galactic nucleus must decrease its angular momentum by the same amount. If we consider that the angular velocity of the nucleus does not diminish (which is more plausible than otherwise), then its mass must diminish, i.e., the nucleus sheds more matter outwards. Since $v_t$ remains the same the angular velocity must decrease as the mass goes away from the center. This generates the differential rotation observed in all spiral galaxies. The formation of the spiral structure is, therefore, directly connected with the evolution of the galaxy. Fig.6 illustrates the formation of the differential rotation.
We may easily show that the beautiful spiral arms are described by a logarithmic spiral (in an inertial frame). For this let us consider Fig. 7. In this figure the mass \( m \) has moved away from the bulge following the curve \( C \). The point \( P \) in the bulge where the mass \( m \) passed has moved to the position \( Q \). Also, we have seen that the tangential velocity of the mass \( m \) is a constant. Therefore,

\[
 r \omega = r \frac{d\theta}{dt} = R \frac{d\phi}{dt} = v_t = \text{constant}
\]

where \( R \) is the radius of the galactic bulge and \( v_t \) is the tangential velocity of the mass \( m \). We have that

\[
d\theta = \omega dt = \frac{R \Omega}{r} dt = \frac{R \Omega}{rv_r} dr
\]

where we have used the fact that \( v_r = \frac{dr}{dt} \). Considering that \( v_r \) varies slowly with \( r \) (or \( t \)) we may integrate \( d\theta \) and obtain

\[
r \approx Re^{\frac{v_r}{v_t} \theta}
\]

*This is the equation of the logarithmic spiral.* We immediately obtain that

\[
\omega \approx \Omega e^{-\frac{v_r}{v_t} \theta}.
\]

We may also calculate \( \phi \). It is given by

\[
\phi \approx k \left( e^\frac{\theta}{k} - 1 \right)
\]

where \( k \) is given by \( v_t/v_r \).

The ratio \( k = v_t/v_r \) distinguishes between the two types of spiral galaxies. If \( k \ll 1 \), then \( \omega \) diminishes rapidly with \( \theta \). This corresponds to spirals with bars. Conversely, if \( k \gg 1 \), then \( \omega \) diminishes slowly and only reaches a very low value for large \( \theta \). This is consistent with the experimental data on spiral galaxies. The middle ground \( k \approx 1 \) must correspond to intermediate cases.

From the point of view of a frame fixed in the galactic bulge and rotating with it the mass \( m \) describes an arch according to Fig. 8. The angle \( \psi \) is related to \( \theta \) and \( \phi \) by \( \psi = \phi - \theta \). Therefore, \( \psi \) is given by

\[
\psi = k \left( e^\frac{\theta}{k} - 1 \right) - \theta.
\]

For small \( \theta \) one has \( \psi \approx \theta^2/2k \) and

\[
r \approx Re^{\psi^5}
\]

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and for large $\theta$ we have $\psi \approx k e^{\theta}$ and

$$r \approx R \frac{\psi}{k} \tag{55}$$

Therefore, in this rotating frame the mass $m$ also describes a spiral curve as it moves away from the center.

Let us now estimate the order of magnitude of the radial velocity of gas (and stars) in the galactic disk. The radius of our galaxy is 50000 light years and the age of our galaxy is of the order of magnitude of the age of the Universe, $10^{17}$s. The gas which is at the edge of the disk must have moved from the center with an average velocity of 5km/s. This is just a rough estimation. It is very important to obtain the mean radial velocities of the spiral arms of the Milky Way to compare with the above figure.

XIV. THE MAGNITUDE OF THE SUPERWEAK FORCE

We may estimate the strength of the superweak force in the following way: A star (or the material that formed it) near the edge of our galaxy’s disk has traveled 50,000 light years in about $10^{17}$s. Therefore, the order of magnitude of its acceleration is about $a = 10^{-13}$ms$^{-2}$. This figure is the upper limit of the accuracy of the experiments which have been performed so far on the fifth force$^{(23)}$. Let us, now, have an estimation on the values of $(A_B)^{1/2}g$ and $(A_I)^{1/2}g$. As has been previously discussed, the above star (or the material that formed it) has left the center of our galaxy about 10 billion years ago. The superweak force which acted upon the star when it left the center was of the order of

$$\frac{(\sqrt{A_B} - \sqrt{A_I})^2 g^2 B b}{r^2} = b m_p a \tag{56}$$

where $B$ and $b$ are the number of baryons of the galaxy and of the star, respectively; $m_p$ is the proton’s mass; and $r$ is the distance between the star and the center of the galaxy. This distance was very small, probably a few light years. Let us take for $r$ the size of the center of our galaxy, about 40 light years$^{(39)}$. Therefore, the order of magnitude of $\sqrt{A_B}g$ and $\sqrt{A_I}g$ is $10^{-37}$ (in MKSC units). We, clearly, see that the coupling constant of the superweak interaction is extremely small. The superweak force between two 1kg masses separated by 1m is only $10^{-20}$ Newton, which is $10^{10}$ times smaller than the gravitational force between the two masses.

XV. VARIATION OF THE GRAVITATIONAL CONSTANT

In the light of the present theory we can discuss Dirac’s Large Number
Hypothesis. Dirac considered the ratio of the electrostatic force to the gravitational force between the electron and the proton in the hydrogen atom, which is given by

$$\frac{e^2}{Gm_em_p} \approx 2 \times 10^{39}$$

(57)

where $e$ is the charge of the electron (and proton), $G$ is the gravitational constant, and $m_e, m_p$ are the masses of the electron and proton respectively. How can we understand the meaning of this large number? Taking a look at Tables 1 and 2 we can understand the reason of this number. Galaxies were formed out of hydrogen atoms (mainly), i.e., the gravitational force was only able to form something stable by means of the build up of atoms (electromagnetic force). Therefore, this number just represents a relation between these two bound states of matter. Of course, we have other numbers relating the other bound states (of the universe), i.e., relating any two fundamental forces.

Dirac also expressed the age of the Universe in terms of the time that light takes to traverse a classical electron. Taking this time as a basic unit the present age of the Universe (18 billion years) may be expressed as

$$t \approx 7 \times 10^{39} \frac{e^2}{m_ec^3}.$$  

(58)

He concluded, that, since the age of the universe is increasing with time, $G$ must vary inversely proportionally to time. This could be true only if the gravitational force were the ultimate force for the universe. Since this is not the case, $G$ may not vary with time. As was shown above the age of the universe depends (mainly) on the strength of the superweak force.

XV. PRELIMINARY IDEAS ON PREQUARKS

The classification of matter achieved in the beginning of the paper implied that quarks are formed of prequarks. Let us develop some preliminary ideas which may help us towards the understanding of the superstrong interaction. This interaction may manifest itself as corrections to the interaction among quarks. Presumably, just as quarks do, prequarks are supposed to be permanently confined inside baryons.

Actually, the composition of quarks is an old idea, although it has been proposed on different grounds (49). A major distinction is that in this paper leptons are elementary particles. This is actually consistent with the smallness of the electron mass which is already too small for a particle with a very small radius (50).

In order to distinguish the model proposed in this paper from several other models of the literature we will name these prequarks with a different name.
We may call them primons, a word derived from the Latin word *primus* which means first.

From the above considerations quarks are composed of primons. Also, we saw above that there must be a sort of polarization in the formation of a quark. The best candidate is the exchange of a particle which may be the carrier of the superstrong force. Since a baryon is composed of three quarks, it is reasonable to consider that a quark is composed of two primons which are polarized by the exchange of some kind of charge which is carried on by the corresponding boson. Let us name the exchanged particle the mixon (this choice will become clearer below).

In order to reproduce the spectrum of 18 quarks (6 quarks in 3 color states) we need 12 primons (4 primons in 3 supercolor states). Therefore, we have 4 triplets. As to the charge, one triplet has charge $(5/6)e$ and any other triplet has charge $(-1/6)e$.

Let us assume that the exchanged particle is a boson. Since quarks have spin $1/2$, the spin of each pronom has to be equal to $1/4$. In this case the boson has spin zero. At this stage we may introduce a postulate concerning the unit of quantization. As is well known the unit of quantization is $\hbar$. This unit of measure is arbitrary and was taken as such in order to have an agreement between experimental data and theory at the level of atomic physics. Later on this unit of measure was applied to elementary particles and up to the level of quarks it still holds. However, at the level of the quarks constituents it may not hold anymore. We may postulate that at the level of primons the unit of measure is $\hat{\hbar} = \hbar/2$. In this way primons are also fermions with a spin given by

$$s = \left( \frac{1}{2} \right) \hat{\hbar}. \quad (59)$$

As we will see below, this is consistent with the required properties which are needed for forming quarks with primons.

Let us try to arrive at a possible equation for free primons beginning with Dirac’s equation,

$$\left( i\hbar \alpha_{\mu} \frac{\partial}{\partial x_{\mu}} - \beta mc \right) \Psi = 0 \quad (60)$$

where $\mu = 0, 1, 2, 3$. If, now, we divide this equation by 2, and make the substitutions $\hbar/2 = \hat{\hbar}$ and $\beta/2 = \beta$, we obtain of course another Dirac equation. By imposing that each component $\Psi_{\sigma}$ of $\Psi$ must satisfy Klein-Gordon equation we obtain the following algebra, which is slightly different from Dirac’s,

$$\begin{align*}
\alpha_i \alpha_k + \alpha_k \alpha_i &= 2 \delta_{ik} \\
\alpha_i \beta + \beta \alpha_i &= 0 \\
\alpha_i^2 &= 1
\end{align*}$$

26
\[ \bar{\beta}^2 = \frac{1}{4} \]

Of course, \( \alpha_i \) are the same as in Dirac’s equation, but now \( \bar{\beta} = \beta/2 \).
The new Dirac equation becomes
\[
\left( i\bar{H}_\alpha \frac{\partial}{\partial x^\mu} - \bar{\beta}mc \right) \Psi = 0 \quad (61)
\]
where \( \bar{H} \) is a new unit of quantization and \( \bar{\beta} \) is Dirac’s \( \beta/2 \). Of course, this equation is also Lorentz covariant.

Since quarks have spin equal to 1/2, only primons with parallel(or antiparallel) spins form bound states(quarks). This means that the spin wave function of a bound state(quark) is symmetric and, because the total wave function is antisymmetric, the rest of the wave function(which includes the superflavor, supercolor and spatial parts) has to be antisymmetric.

The superstrong interaction is such that only primons with different quantum numbers form bound states, that is, quarks. Taking into account the above considerations on spin and charge, we have the following table for primons(Table III). With this table we are able to form all quarks as is shown in Table IV. The colors are formed from the supercolors as shown in Table V.

Therefore, we assume that a prequark transforms \( p_{ij} \), with

- superflavor index: \( i = 1, 2, 3, 4 \)
- supercolor index: \( j = \alpha, \beta, \gamma \).

These indices must transform respectively under \( SU(4)|_{\text{superflavor}} \) and \( SU(3)|_{\text{supercolor}} \). Because of the selection rules the group \( SU(3)|_{\text{supercolor}} \) is reduced to the subgroup \( SU(2)| \), and therefore the number of bosons must be 3.

As was said at the beginning of this section the ideas on prequarks are very preliminary and a deeper understanding of the superstrong interaction, as proposed in this paper, is under consideration. This understanding must begin defining the internal quantum numbers for the interaction, i.e., substitutes for hypercharge, isospin, and so on.

XVI. THE FUNDAMENTAL INTERACTIONS OF MATTER

\textit{A maximis ad minima}

It is well known that the electromagnetic interaction is mediated by a massless boson, the photon. The weak interaction is mediated by the three heavy vector bosons, \( W^+, W^- \) and \( Z^0 \). It was shown by Weinberg, Salam and Glashow that the weak and electromagnetic interactions are unified at short distances.
In the domain of the atomic nucleus the strong interaction is mediated by the three pions, $\pi^+, \pi^-$ and $\pi^0$. It has been shown in this paper that the strong and superweak interactions are unified at $t = 0$. This means that total unification may not be possible and that the fundamental interactions are unified in pairs.

In this paper it was assumed that the range of the superweak interaction is infinite. This means that its mediator is a massless boson which, of course, must be linked to baryon number conservation and isospin. Let us name this boson as the symmetron.

We have two interactions left, the superstrong and the gravitational interactions. We may suppose that they are also unified at $t = 0$. As was shown in the previous section that there must exist 3 bosons mediating the superstrong interaction. The gravitational interaction is presumably mediated by the graviton, which is a massless boson of spin 2. The data for all interactions of nature are shown in Table VI.

As is proposed in this paper the forces of nature are unified in pairs. It is interesting to notice that we have the table below:

UNIFICATION OF THE FORCES OF NATURE

| Weak (3 bosons) | Electromagnetic (1 boson) |
|----------------|----------------------------|
| Strong (3 bosons) | Superweak (1 boson) |
| Superstrong (3 bosons) | Gravity (1 boson) |

XVII. QUARK CONFINEMENT

Present experiments show that quarks are permanently confined inside hadrons, at least, within the energies allowed by the present generation of particle accelerators.

Quark confinement can be explained as the result of the superstrong interaction. Because the quark belongs to a polarized state it is formed by the action of the superstrong and strong forces. That is, we expect that there must exist an effective attractive potential as we have in the other kinds of polarized states. Therefore, we expect to have a sort of Lennard-Jones effective potential in the interaction among quarks. Expanding a Lennard-Jones potential around the minimum we obtain a harmonic oscillator potential. Thus, if we consider that in their lowest state of energy quarks are separated by a distance $r_q$, then for small departures from equilibrium the potential must be of the form

$$V(r) = V_o + K(r - r_q)^2$$

(62)

where $K$ is a constant and $V_o$ is a negative constant representing the deepness of the potential well. As $r$ increases the restoring force among quarks also increases. Because of it quarks may be permanently confined.
Quark confinement is in agreement with other considerations and results of this article, for as was shown above the superweak force must exist at \( t = 0 \) in order to make the expansion begin. *This may only happen if neutrons and protons are present at \( t = 0 \).* This, in turn, means that quarks are not free at \( t = 0 \). That is, it means that they are confined inside the nucleons. We will see more on quark confinement below, when we will find out the behavior of the quark wavefunction with the separation \( r \) between two quarks.

XVIII. THE ENERGIES OF BARYON STATES(INCLUDING RESONANCES)

We have deduced above that there must exist a sort of Lennard-Jones potential in the interaction among quarks. Around its minimum we may approximate this potential by the potential of a harmonic oscillator and include the anharmonicity as a perturbation. By doing so we may be able to calculate the energies of almost all baryon states.

Let us consider a system composed of three quarks which interact in pairs by means of a harmonic potential. Let us disregard the electromagnetic interaction which must be considered as a perturbation. Also, let us disregard any rotational contribution which must enter as perturbation too. This is reasonable because the strong and superweak interactions must be much larger than the “centrifugal” potential. If we disregard the spin interaction among quarks, we may just use Schrödinger equation in terms of normal coordinates:\(^51\)

\[
\sum_{i=1}^{6} \frac{\partial^2 \psi}{\partial \xi_i^2} + \frac{2\hbar^2}{\omega_i} \left( E - \frac{1}{2} \sum_{i=1}^{6} \omega_i \xi_i^2 \right) \psi = 0 \tag{63}
\]

where we have used the fact that the three quarks are always in a plane. The above equation may be resolved into a sum of 6 equations

\[
\frac{\partial^2 \psi_i}{\partial \xi_i^2} + \frac{2\hbar^2}{\omega_i} \left( E_i - \frac{1}{2} \omega_i \xi_i^2 \right) = 0, \tag{64}
\]

which is the equation of a single harmonic oscillator of potential energy \( \frac{1}{2} \omega_i \xi_i^2 \) and unitary mass with

\[
E = \sum_{i=1}^{6} E_i. \tag{65}
\]

The general solution is a superposition of 6 harmonic motions in the 6 normal coordinates.

The eigenfunctions \( \psi_i(\xi) \) are the ordinary harmonic oscillator eigenfunctions

\[
\psi_i(\xi_i) = N_i e^{\left(\alpha_i/2\right)\xi_i^2} H_{\nu_i}(\sqrt{\alpha_i} \xi_i), \tag{66}
\]
where $N_v$ is a normalization constant, $\alpha_i = \nu_i/\hbar$ and $H_v(\sqrt{\alpha_i} \xi_i)$ is a Hermite polynomial of the $v_i$th degree. For large $\xi_i$, the eigenfunctions are governed by the exponential functions which make the eigenfunctions go to zero very fast. Of course, this is valid for any energy and must be the reason behind quark confinement. We will come back yet to this point after calculating the possible energy levels of the baryons.

The energy of each harmonic oscillator is

$$E_i = h \nu_i (v_i + \frac{1}{2}),$$

(67)

where $\nu_i = 0, 1, 2, 3, ...$ and $v_i$ is the classical oscillation frequency of the normal vibration $i$, and $v_i$ is the vibrational quantum number. The total vibrational energy of the system can assume only the values

$$E(v_1, v_2, v_3, ... v_6) = h \nu_1 (v_1 + \frac{1}{2}) + h \nu_2 (v_2 + \frac{1}{2}) + ... h \nu_6 (v_6 + \frac{1}{2}).$$

(68)

The three quarks in a baryon must always be in a plane. Therefore, each quark is composed of two oscillators and so we may rearrange the energy expression as

$$E(n, m, k) = h \nu_1 (n + 1) + h \nu_2 (m + 1) + h \nu_3 (k + 1),$$

(69)

where $n = v_1 + v_2$, $m = v_3 + v_4$, $k = v_5 + v_6$. Of course, $n, m, k$ can assume the values, 0,1,2,3,... We may find the constants $h \nu$ from the ground states of some baryons. They are the known quark masses taken as $m_u = m_d = .31$Gev, $m_s = .5$Gev, $m_c = 1.5$Gev and $m_b = 5$Gev. The mass of the top quark has not been determined, but as we will show the present theory may help in the search for its mass.

Let us start the calculation with the states $\text{ddu}(\text{neutron})$, $\text{uud}(\text{proton})$ and $\text{ddd}(\Delta^-$), $\text{uuu}(\Delta^{++})$ and their resonances. Because $m_u = m_d$, we have that their energies must be given by(in Gev)

$$E_{n,m,k} = .31(n + m + k + 3).$$

(70)

The calculated values are displayed in Table 7. The agreement between the calculated values and the experimental data is quite good except for a very small number of states. We will discuss this later on.

The energies of the particles $\Sigma$ and $\Lambda$ and their resonances are given by(in Gev)

$$E_{n,m,k} = .31(n + m + 2) + .5(k + 1).$$

(71)

Again the agreement with the experimental data is very good except for a few states(Table 8).
For the $\Xi$ particle the energies are expressed by (in Gev)

$$E_{n,m,k} = .31(n + 1) + .5(m + k + 2).$$

(72)

See Table 9 to check the agreement with the experimental data.

In the same way for the particles $\Omega$ and $\Delta_+^c$ we have the following formulas, respectively:

$$E_{n,m,k} = .5(n + m + k + 3),$$

(73)

and

$$E_{n,m,k} = .31(n + m + 2) + 1.5(k + 1).$$

(74)

In the same fashion we list below the formulas for calculating the energies of many other states:

- ucc, $E_{n,m,k} = .31(n + 1) + 1.5(m + k + 2)$;
- ssc, $E_{n,m,k} = .5(n + m + 2) + 1.5(k + 1)$;
- scc, $E_{n,m,k} = .5(n + 1) + 1.5(m + k + 2)$;
- ccc, $E_{n,m,k} = 1.5(n + m + k + 3)$;
- ccb, $E_{n,m,k} = 1.5(n + m + 2) + 5(k + 1)$;
- cbb, $E_{n,m,k} = 1.5(n + 1) + 5(m + k + 2)$;
- ubb and ddb, $E_{n,m,k} = .31(n + 1) + 5(m + k + 2)$
- ubb and ddb, $E_{n,m,k} = .31(n + m + 2) + 5(k + 1)$
- bbb, $E_{n,m,k} = 5(n + m + k + 3)$.

We clearly see from Tables 7, 8 and 9 that there are discrepancies in some states between the calculated energy and the experimental data. This is expected because of the assumptions that we made. An improved model must include the electromagnetic interaction and the effect of rotation (spin). Both will split the levels. Also, we must include the anharmonicity of the potential. The present treatment assumed that the oscillators are independent. But, this may not be the case and there must exist coupling between them. We clearly see that the overtones coincide with the main levels.

The states $\Lambda(1.520)$, $N(1.670, 1.688, 1.700, 1.780)$, $\Delta(1.650, 1.670)$ were not reproduced but they can be built up with transitions from other states. The decay of $\Lambda(1.520)$ shows that it may be constructed from the $\Sigma(1.385) + \pi$, that is, $1.520 \sim 1.385 + .140$. This is not just a pure summation of two numbers. It represents the transition from the level $\Sigma(1.385)$ plus the energy of the boson, in the same manner as we have with electronic transitions in an atom. In the same
fashion $N(1.670)$, $N(1.688)$ and $N(1.700)$ are combinations of $N(1.535) + \pi$, and $N(1.780)$ may be formed from $N(1.535)$ by means of a two pion transition. The states $\Delta(1.650, 1.670)$ may be formed from the state $N(1.535)$ plus a pion transition.

From the above discussion we see clearly that it is meaningless to try to make quarks free by using more energetic collisions between two baryons because we will just get more excited states. That is, we will obtain more and more resonances. This is so because, as as shown above, as the separation between two quarks increases the wavefunction vanishes very fast regardless of the state of energy.

The parity of the spatial part of the wavefunction is given by $(-1)^{m+n+k}$. The multiplicity of each level must be given by $2I + 1$, where $I$ is the isospin.

XIX. CONCLUSION

The present theory rules out any role of the exotic dark matters which have been proposed in the literature as serving as the missing mass necessary for closing the universe. It is shown a way of having a closed universe by means of another force which brings the universe back to its ‘beginning’ even having $\Omega < 1$.

It is shown that the universal expansion must be slowing down at the present epoch and that the expansion is not so fast around $t = 0$. It is just an expansion rather than an explosion.

A possible galactic evolution which is consistent with the observational data has been presented. It is given a reasonable explanation for the flat rotational curve ($v \times r$) of spiral galaxies. It is shown that the flat rotational curve of spirals is directly connected with the spiral structure itself and with the evolution of such galaxies.

It is proposed that nature has six fundamental forces which are unified in pairs and, therefore, reduced to three at $t = 0$. Some general ideas concerning the characteristics of the superstrong interaction have been presented.

A reasonable physical explanation has been provided for quark confinement. The energies of most baryon states are calculated in a simple manner.

It is shown that it is consistent to have a contracting Universe of antimatter.

It is expected that the ‘galactic liquid’ (with its superstructures) is quite complex just as all normal liquids are. It has to be described by the superweak and gravitational forces. We intend to further the studies in this direction towards understanding its formation and structure.

Taking into account the existence of this new interaction we must investigate the formation of the light elements and rethink concepts such as the entropy of the universe and its apparent order.

It is hoped that in the near future experimenters will find evidence of the superweak force.
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References

1. A. A. Penzias and R. W. Wilson, *Astrophys. J.* **142**, 419 (1965).

2. J. C. Mather, Cheng, E. S., Eplee, R. E., Isaacman, R. B., Meyer, S. S., Shafer, R. A., Weiss, R., Wright, E. L., Bennet, C. L., Boggess, N. W., Dwek, E., Gulkis, S., Hauser, M. G., Janssen, M., Kelsall, T., Lubin, P. M., Moseley, Jr., S. H., Murdock, T. L., Siverberger, R. F., Smoot, G. F., and Wilkinson, D. T., *Astrophys. J. (Letters)* **354**, L37 (1990).

3. E. Hubble, in *Proceedings of the National Academy of Science*, **15**, 168-173 (1929).

4. J. C. Mather, talk at the XIII Interantional Conference on General Relativity and Gravitation, Huerta Grande, Argentina, 1992.

5. V. de Lapparent, M. J. Geller, and J. P. Huchra, *Astrophys. J. (Letters)* **302**, L1 (1986).

6. T. J. Broadhurst, R. S. Ellis, D. C. Koo, and A. S. Szalay, *Nature* **343**, 726 (1990).

7. A. Dressler and S. M. Faber, *Astrophys. J.* **354**, 13 (1990).

8. A. Dressler, S. M. Faber, D. Burnstein, R. L. Davies, D. Lynden-Bell, R. J. Terlevich, and G. Wegner, *Astrophys. J. (Letters)* **313**, L37 (1989).

9. D. Lynden-Bell, S. M. Faber, D. Burnstein, R. L. Davies, A. Dressler, R. J. Terlevich, and G. Wegner, *Astrophys. J.* **326**, 19 (1988).

10. H. Kurki-Suonio, G. J. Mathews, and G. M. Fuller, *Astrophys. J. (Letters)* **356**, L5 (1990).

11. S. J. Maddox, G. Efstathiou, W. J. Sutherland and J. Loveday, *Mon. Not. Astr. Soc.* **242**, 43p (1990).

12. W. Saunders, M. Rowan-Robinson, and A. Lawrence, “The Spatial Correlation Function of IRAS Galaxies on Small and Intermediate Scales”, 1992, QMW preprint.

13. G. B. Dalton, G. Efstathiou, S. J. Maddox, and W. J. Sutherland, *Astrophys. J. Lett.* **390**, L1, 1992.

14. M. S. Vogeley, C. Park, M. J. Geller, and J. P. Huchra, *Astrophys. J. Lett.* **391**, L5, 1992.

15. C. Park, J. R. Gott, and L. N. da Costa, *Astrophys. J. Lett.* **392**, L51, 1992.

16. M. Rowan-Robinson, *New Scientist* **1759**, 30 (1991).

17. W. Saunders, C. Frenk, M. Rowan-Robinson, G. Efstathiou, A. Lawrence, N. Kaiser, R. Ellis, J. Crawford, X.-Yang Xia and I. Parry, *Nature* **349**, 32 (1991).

18. S. White, talk at the XIII International Conference on General Relativity and Gravitation, Huerta Grande, Argentina, 1992.

19. H. Fritzsch, in *Proceedings of the twenty-second Course of the International School of Subnuclear Physics*, 1984, ed. by A. Zichichi (Plenum Press, New York, 1988).

20. W. Küpper, G. Wegmann, and E. R. Hilf, *Ann. Phys.* **88**, 454.

21. D. Bandyopadhyay, J. N. De, S. K. Samaddar, and D. Sperber, *Phys. Lett. B* **218**, 391.
22. E. Fischbach, in Proceedings of the NATO Advanced Study Institute on Gravitational Measurements, Fundamental Metrology and Constants, 1987, ed. by V. de Sabbata and V. N. Melnikov (D. Reidel Publishing Company, Dordrecht, Holland, 1988).
23. E. G. Adelberger, B. R. Heckel, C. W. Stubbs and W. F. Rogers, Annu. Rev. Nucl. Part. Sci. 41, 269(1991).
24. C. M. Will, talk at the XIII International Conference on General Relativity and Gravitation, Huerta Grande, Argentina, 1992.
25. S. L. Shapiro and S. A. Teukolsky, Black Holes, White Dwarfs and Neutron Stars (Wiley, New York, 1983).
26. J. H. Oort, itBull. Astron. Inst. Neth. 15, 45(1960).
27. R. A. Alpher, J.W.Follin,Jr., and R.C.Herman, Phys.Rev. 92,1347(1953).
28. G. Gamow, Phys. Rev. 70, 572(1946).
29. R. A. Alpher and R.C.Herman, Rens. Modern Phys. 22, 153(1950).
30. M. Rees, Phys. Rev. Lett. 28,1669(1972).
31. D. Layzer and R. M. Hively, Astrophys. J. 179,361(1973).
32. M. Rees, Nature 275, 35(1978).
33. B. J. Carr, Mon. Not. R. Astr. Soc. 181, 293(1977).
34. B. J. Carr, Mon. Not. R. Astr. Soc. 195, 669(1981).
35. B. J. Carr, J. R. Bond and W. D. Arnett, Astrophys. J. 277, 445(1984).
36. M. V. Berry, in Principles of Cosmology and Gravitation (Adam Hilger, Bristol, 1991).
37. K. L. Visnovsky, C. D. Impey, C. B. Foltz, P. C. Hewett, R. J. Weymann and S. L. Morris, Astrophys. J. 391, 560(1992).
38. T. A. Boroson and S. E. Persson, Astrophys. J. 293, 120(1985).
39. W. J. Kaufmann,III, in Galaxies and Quasars (W.H.Freeman and Company, San Francisco, 1979).
40. T. M. Heckman, K. C. Chambers and M. Postman, Astrophys. J., 391, 39(1992).
41. S. Baum and T. M. Heckman, Astrophys. J 336, 702(1989).
42. N. Jackson and I. Browne, Nature, 343, 43(1990).
43. A. Lawrence, Mon. Not. R. Astr. Soc., 1992, in press.
44. R. W. Goodrich and M. H. Cohen, Astrophys. J. 391, 623(1992).
45. Y. Sofue, Astro. Lett. Comm. 28, 1(1990).
46. N. Nakai, M. Hayashi, T. Handa, Y. Sofue, T. Hasegawa and M. Sasaki, Pub. Astr. Soc. Japan39, 685(1987).
47. C. A. Beichman, Astro. Lett. Comm. 27, 67(1988).
48. P. A. M. Dirac, in Directions in Physics (Wiley, New York, 1978).
49. K. Huang, in Quarks, Leptons and Gauge Fields (World Scientific, Singapore, 1982).
50. G. ’tHooft, in Recent Developments in Gauge Theories, eds. G. ’tHooft et al.(Plenum Press, New York, 1980).
51. L. Pauling and E. B. Wilson Jr., Introduction to Quantum Mechanics (McGraw-Hill, New York, 1935).
52. L. Ryder, *Elementary Particles and Symmetries* (Gordon Breach Science Publishers, New York, 1975).
ATTENTION! ATTENTION!

Table 6 has been separated into two tables. You will have to join them.
Table 1. The two general states which make everything in the Universe, stepwise. The table is arranged in such a way as to show the links between the polarized states and the single states.

|       | quark   | nucleon |
|-------|---------|---------|
| nucleon | nucleus | atom    |
| atom   | gas     | galaxy  |
|        | liquid  |         |
|        | solid   |         |
| galaxy | galactic liquid | ? |

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|            |            | strong force |
|------------|------------|--------------|
| strong force | strong force | electromagnetic force |
| electromagnetic force | electromagnetic force | gravitational force |
| gravitational force | gravitational force | ? |

Table 2. Three of the fundamental forces of nature. Each force appears three times and is linked to another force by means of a polarized state. Compare with Table I.
| superflavor | charge | spin |
|-------------|--------|------|
| $p_1$       | $\frac{5}{6}$ | $\frac{1}{2}$ |
| $p_2$       | $-\frac{1}{6}$ | $\frac{1}{2}$ |
| $p_3$       | $-\frac{1}{6}$ | $\frac{1}{2}$ |
| $p_4$       | $-\frac{1}{6}$ | $\frac{1}{2}$ |

Table 3. Table of charges and spins of primons.
Table 4. Table of composition of quark flavors.

|     | $p_1$ | $p_2$ | $p_3$ | $p_4$ |
|-----|-------|-------|-------|-------|
| $p_1$ | u     | s     | t     |
| $p_2$ | u     | d     | c     |
| $p_3$ | s     | d     | b     |
| $p_4$ | t     | c     | b     |
|   | α   | β   | γ   |
|---|-----|-----|-----|
| α | blue | green |
| β | blue | red  |
| γ | green | red  |

Table 5. Table of the generation of colors out of the supercolors.
| Interaction | Superstrong | Strong | Electromagnetic | Gravity | Superweak |
|------------|-------------|--------|-----------------|---------|-----------|
| Static     | \( \frac{q_1 q_2 e^{-\mu r}}{\mu c} 10^{-13} \) | \( \frac{q_1 q_2 e^{-\mu r}}{4\pi \epsilon} 10^{-13} \) | \( \frac{q_1 q_2 e^{-\mu r}}{4\pi \epsilon} 10^{-13} \) | - \( \frac{m_1 m_2 e^{-\mu r}}{\mu c} \) | \( \frac{Q_1 Q_2 e^{-\mu r}}{\mu c} \) |
| Coupling   | ?           | \( \frac{g^2}{4\pi \hbar c} \approx 10 \) | \( \frac{e^2}{4\pi \hbar c} = \frac{1}{137.036} \) | \( \frac{m_e^2 c}{\hbar c} = 5.76 \times 10^{-36} \) | \( m_p = \) proton mass |
| Bosons     | 3 mixons    | \( \pi^+, \pi^-, \pi^0 \) | photon | graviton | symmetron |

Table IV. The Six Interactions of Nature
### Table IV. The Six Interactions of Nature

| Superweak | Weak |
|-----------|------|
| $\frac{Q_1 Q_2 e^{-\mu r}}{\mu = \infty}$ | none |
| $A_B, A_I \approx 10^{-67}$ | $\Lambda m_p^2 = 1.01 \times 10^{-5}$ |
| symmetron | $W^+, W^-, Z^0$ |
| \(n, m, k\) | \(E_C(\text{Gev})\) | \(E_M(\text{Gev})\) | Error\% | Isospin | Parity |
|---|---|---|---|---|---|
| 0,0,0 | 0.93 | 0.938(\(N\)) | 0.96 | 1/2 | even |
| \(m + n + k = 1\) | 1.24 | 1.24(\(\Delta\)) | 0 | \(3/2\) | odd |
| \(m + n + k = 2\) | 1.55 | 1.47(\(N\)) | 5.2 | 1/2 | even |
| \(m + n + k = 2\) | 1.55 | 1.52(\(N\)) | 1.9 | 1/2 | even |
| \(m + n + k = 2\) | 1.55 | 1.535(\(N\)) | 1.0 | 1/2 | even |
| \(m + n + k = 3\) | 1.86 | 1.86(\(N\)) | 0 | 1/2 | odd |
| \(m + n + k = 3\) | 1.86 | 1.89(\(\Delta\)) | 1.6 | 3/2 | odd |
| \(m + n + k = 3\) | 1.86 | 1.91(\(\Delta\)) | 2.7 | 3/2 | odd |
| \(m + n + k = 3\) | 1.86 | 1.95(\(\Delta\)) | 4.8 | 3/2 | odd |
| \(m + n + k = 4\) | 2.17 | 2.19(\(N\)) | 0.9 | 1/2 | even |
| \(m + n + k = 4\) | 2.17 | 2.22(\(N\)) | 2.3 | 1/2 | even |
| \(m + n + k = 5\) | 2.48 | 2.42(\(\Delta\)) | 2.4 | 3/2 | odd |
| \(m + n + k = 6\) | 2.79 | 2.65(\(N\)) | 5.0 | 1/2 | even |
| \(m + n + k = 6\) | 2.79 | 2.85(\(\Delta\)) | 2.2 | 3/2 | even |
| \(m + n + k = 7\) | 3.10 | 3.03(\(N\)) | 2.3 | 1/2 | odd |
| \(m + n + k = 7\) | 3.10 | 3.23(\(\Delta\)) | 4.2 | 3/2 | odd |

Table 7. Baryon states \(N\) and \(\Delta\). The energies \(E_C\) were calculated according to the formula \(E_{n,m,k} = 0.31(n + m + k + 3)\). \(E_M\) is the measured energy. A few states were not reproduced with this simple treatment. The error means the absolute value of
\((E_C - E_M)/E_C\).
| State\((m, n, k)\) | \(E_C\) (Gev) | \(E_M\) (Gev) | Error\% | Isospin | Parity |
|-------------------|----------------|----------------|----------|---------|--------|
| 0,0,0             | 1.12           | 1.1156(Λ)      | 0.4      | 0       | even   |
| 0,0,0             | 1.12           | 1.1894(Σ)      | 6.2      | 1       | even   |
| 0,0,0             | 1.12           | 1.1925(Σ)      | 6.5      | 1       | even   |
| 0,0,0             | 1.12           | 1.1973(Σ)      | 6.9      | 1       | even   |
| \(m + n = 1\), \(k=0\) | 1.43           | 1.385(Σ)       | 3.2      | 1       | odd    |
| \(m + n = 1\), \(k=0\) | 1.43           | 1.405(Λ)       | 1.7      | 0       | odd    |
| 0,0,1             | 1.62           | 1.67(Σ)        | 3.1      | 1       | odd    |
| 0,0,1             | 1.62           | 1.67(Λ)        | 3.1      | 0       | odd    |
| \(m + n = 2\), \(k=0\) | 1.74           | 1.69(Λ)        | 2.9      | 0       | even   |
| \(m + n = 2\), \(k=0\) | 1.74           | 1.75(Σ)        | 0.6      | 1       | even   |
| \(m + n = 2\), \(k=0\) | 1.74           | 1.765(Σ)       | 1.4      | 1       | even   |
| \(m + n = 1\), \(k=1\) | 1.93           | 1.915(Σ)       | 0.8      | 1       | even   |
| \(m + n = 1\), \(k=1\) | 1.93           | 1.94(Σ)        | 0.5      | 1       | even   |
| \(m + n = 3\), \(k=0\) | 2.05           | 2.03(Σ)        | 1.0      | 1       | odd    |
| 0,0,2             | 2.12           | 2.1(Λ)         | 0.9      | 0       | even   |
| \(m + n = 2\), \(k=1\) | 2.24           | 2.25(Σ)        | 0.5      | 1       | odd    |
| \(m + n = 4\), \(k=0\) | 2.36           | 2.35(Λ)        | 0.4      | 0       | even   |
| \(m + n = 1\), \(k=2\) | 2.43           | 2.455(Λ)       | 1.0      | 0       | odd    |
| 0,0,3             | 2.62           | 2.585(Λ)       | 1.3      | 0       | odd    |
| 0,0,3             | 2.62           | 2.62(Σ)        | 0        | 1       | odd    |

Table 8. Baryon states Σ and Λ. The energies \(E_C\) were calculated according to the formula 
\[
E_{n,m,k} = 0.31(n + m + 2) + 0.5(k + 1).
\]

\(E_M\) is the measured energy. A few states were not reproduced by this simple treatment. The error means the absolute value of \((E_C - E_M)/E_C\).
| State($m, n, k$) | $E_C$(Gev) | $E_M$(Gev) | Error(%) | Isospin | Parity |
|-----------------|------------|------------|----------|---------|--------|
| 0,0,0           | 1.31       | 1.315      | 0.4      | 1/2     | even   |
| 0,0,0           | 1.31       | 1.321      | 0.8      | 1/2     | even   |
|                 |            |            |          |         |        |
| 1,0,0           | 1.62       | 1.53       | 5.6      | 1/2     | odd    |
|                 |            |            |          |         |        |
| $n = 0, m + k = 1$ | 1.81       | 1.82       | 0.6      | 1/2     | odd    |
|                 |            |            |          |         |        |
| 2,0,0           | 1.93       | 1.94       | 0.5      | 1/2     | even   |
|                 |            |            |          |         |        |
| ...             | ...        | ...        | ...      | ...     | ...    |

Table 9. Baryon states $\Xi$. The energies $E_C$ were calculated according to the formula $E_{n,m,k} = 0.3(n + 1) + 0.5(m + k + 2)$. $E_M$ is the measured energy. The error is the absolute value of $(E_M - E_C)/E_C$. 

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