Fifth fundamental force and unification of fundamental forces

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Fifth fundamental force and unification of fundamental forces

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Abstract

There are four known fundamental forces of nature and there is a need to combine them into a unified theory. Progress has been made toward this goal but gravity remains an issue. However, the four forces are body forces that act on points. They together do not make the universe a closed system. Here, I identify a surface force, which acts outward normal to the surface of the universe. Further, using water drop hanging in a vacuum as a model, I provide a formula to find the magnitude of this force. The fifth force is generated by surface tension, a property of dark energy. On the other hand, matter particles interact with each other through cohesive forces and with dark matter through adhesive forces. I give a range of functional forms of all cohesive and adhesive forces and present an equation that unifies all the forces of nature.

Introduction

Currently, there are 12 elementary particles and four fundamental forces of nature[1]. Fundamental forces are gravitational force, electromagnetic force, weak and strong forces. Elementary particles can be grouped into two categories: leptons and quarks[1]. Leptons are not affected by the strong force while quarks reside in the nucleus and experience the strong force[1]. The four forces vary in range and strength and are carried by carrier particles[1]. Starting with Maxwell, the goal has been the unification of these forces[2]. According to gauge field theories, elementary particles represent certain charge operators e.g. mass, electric charge, spin, flavor, color, etc. while forces represent interactions between them[2]. Then, the gauge field theories seek the unification of these charges and forces[2]. Although progress has been made in unifying three forces, unifying gravity with the three remains elusive[3].

Since mass at the surface of the universe is pulled inward by the gravitational field, one can conclude that in absence of an opposite surface force, the surface of the universe will be decelerating (Fig. 1). Since the rest of the universe is expanding at equilibrium, the deceleration of the surface will make the universe an open system. Therefore, I postulate that a fifth fundamental force, acting outward normal to the surface of the universe, exists.

To find the surface force, I consider the universe analogous to a water drop hanging in a vacuum or a medium. An inward normal force acts on the surface of a water drop because of an imbalance between the higher cohesive force between the surface and interior water molecules and the lower adhesive force between surface water molecules and outside medium (or vacuum). This compressive force is balanced by the surface tension of the water drop. The net result of the surface tension is an outward normal force, acting on the surface of the drop, balancing the difference between the cohesive and adhesive forces.

Here, I present a surface tension model of the fifth force. Using water drop as a model, I formulate equations to determine the magnitude of this force. Further, I discuss the implications of this force on our understanding of the universe.

Results

Formulation to determine the fifth fundamental force

One of the cohesive/adhesive forces (Fig. 1) acting on the surface of the universe, F_{cg}, can be given by Newton's law of gravitation as:

$$F_{cg} = -G \, \frac{m_i \, m_e}{r^2} \tag{1}$$

where, m_i is the internal mass and m_e is the mass at the surface of the universe.

Other cohesive and adhesive forces acting on the surface are the electrostatic force, the strong force, and the weak force. Since Newton's second law of motion, which is universally valid, applies to an inertial frame of reference lacking acceleration, the universe can be assumed to be expanding at equilibrium. Thus, the surface of the universe must be moving at equilibrium with no net normal force acting on it. Hence,

$$F = \sum_i F_{ci} + F_s = 0 \tag{2}$$

where, F_{ci} is a cohesive/adhesive force acting on the surface and F_s is the surface tension force that must act outward normal on the surface.

Based on the analogy of the universe with a water drop hanging in a vacuum, the force F_s can be given by the Young-Laplace equation.

$$F_s = \frac{2\gamma}{r} . 4\pi r^2 \tag{3}$$

where, γ is the surface tension of the universe.

Alternatively, the fifth force can be determined by solving the following differential equation. Equation 4 can be used to find F_s both during the freeze-out when the volume of the universe is negative and decreases as well as after the freeze-out when the volume is still negative but increases (see the discussion section).

$$\left(\frac{4\pi}{3V}\right)^{1/3} \frac{dF_s}{dV} - 4\pi \frac{F_s}{S^2} = 8\pi \left(\frac{d\gamma}{dt}\right)\left(\frac{dt}{dV}\right) \tag{4}$$

where, V is the volume and S is the surface area of the universe.

The universe contains matter, dark matter, and dark energy. Being a surface force, I hypothesize that F_s is due to dark energy. In analogy with water, the dark energy may be considered as a compressed spring, which may give rise to the surface tension. A part of the dark energy may associate with matter making hybrid particles. This part may be the dark matter. The hybrid particles interact with cohesive and adhesive forces while the interaction between the dark energy components of the hybrid particles may create the surface tension force.

The surface tension and mass of the universe vary with time

Rewriting equation 2 by substituting F_s in terms of the surface tension and considering only the gravitational force:

$$F = -G \frac{m_i \, m_e}{r^2} + 8\pi\gamma r \qquad (5)$$

At t=0, r=0. At t=0, the first term on the right-hand side of equation 5 is infinite while the second term is unknown. Since the universe is expanding at equilibrium, there is no reason to assume that origin was not an equilibrium process. Therefore at t=0, F=0. This is only possible if the right-hand side of equation 5 is indeterminate. Thus, at t=0, m_i=0 and $8\pi\gamma r$=indeterminate. Thus, at t=0, $\gamma \rightarrow \infty$. At t=0, the dark energy may have been at an infinitely compressed state, giving rise to infinite surface tension.

Further, at $t \rightarrow \infty$, $r \rightarrow \infty$. At $t \rightarrow \infty$, the second term on the right-hand side of equation 5 is infinite. Once again, at $t \rightarrow \infty$, F must be zero. Again, the right-hand side of equation 5 must be indeterminate. Thus, at $t \rightarrow \infty$, γ=0, which means that γ varies with time. For m_i two possibilities exist. First, at $t \rightarrow \infty$, $m_i \rightarrow \infty$. In this case, both terms on the right-hand side of equation 5 are indeterminate. Second, at $t \rightarrow \infty$, $m_i = m_{i\infty}$ (finite). In the second case, both terms on the right-hand side of equation 5 are separately zero. Thus with time, while γ decreases, m_i increases. Since mass and surface tension are the only two energy-containing variables of the universe, the surface tension may be converting into mass. The aforementioned analysis is also applicable if a net constant force acts on the surface and the universe expands at a non-equilibrium condition.

The expansion rate of the universe

The theory above also explains the recent observation that the universe is expanding at an ever-increasing rate [4,5], as below:

For illustration, I assume that the observation-making planet (earth), as well as the distant supernova, are located at the surface of the universe (Fig. 2) and the surface is moving radially with a constant velocity v. Then, the Hubble parameter, H is given as:

$$H = \frac{2v\sin(\theta/2)}{d} = \left(\frac{v}{r}\right) \tag{6}$$

$$\frac{dH}{dt} = -\left(\frac{v}{r}\right)^2 \tag{7}$$

While equations (6) and (7) apply to the equilibrium model, equations (8) and (9) are also applicable to the universe expanding with a net normal force acting on the surface.

$$\frac{dH}{dt} = \frac{1}{3}\left[-\frac{1}{V^2}\left(\frac{dV}{dt}\right)^2 + \frac{1}{V}\frac{d^2V}{dt^2}\right] \tag{8}$$

$$\frac{d^2V}{dt^2} = \left(\frac{\partial}{\partial\gamma}\frac{dV}{dt}\right)\frac{d\gamma}{dt} \tag{9}$$

My analysis above predicted that $\frac{d\gamma}{dt}<0$ and from physical understanding of surface tension of any matter, we know that $\left(\frac{\partial}{\partial\gamma}\frac{dV}{dt}\right)<0$. Thus from equation 9, $\frac{d^2V}{dt^2}>0$, explaining the recent finding [4,5] as well as supporting the prediction that $\frac{d\gamma}{dt}<0$. Further, the expansion rate of the universe depends on how the two factors, $\frac{d\gamma}{dt}$ and $\left(\frac{\partial}{\partial\gamma}\frac{dV}{dt}\right)$ vary with time.

Freeze-out and dark matter

During the early time, at $t=0^+$, the dark matter and matter may have frozen out due to quantum fluctuation and instability caused by $\gamma\rightarrow\infty$, creating a vacuum. The freeze-out may be responsible for the expansion of the universe. When the universe adds an attractive force during the freeze-out, the entropy, S, $\left(dG = -TdS = -\vec{F}.\overrightarrow{dr} > 0\right)$ of the universe decreases. In contrast, when a repulsive force is added, the entropy increases.

Dark energy may be quantized

Since the surface tension decreases progressively with time, the dark energy may be quantized. Here, I present a model of quantization of dark energy.

We assume that dark energy has '1', '2'…..'N' states while the pure matter has a state '0'. The state '1' is the pure dark energy, which was present at t=0. Its surface tension, γ, is ∞ and mass is 0. States '2', '3',…'N' are hybrid particles, having both the dark energy and the matter components. We assume that, at the time of freeze-out, the states from '2' to 'N' were present and the thermal bath, being at equilibrium, has a uniform distribution of these states. Collisions between the two higher-state particles may generate two particles of lower states. The state '0', characterized by a force of the form $\frac{1}{r^{\infty}}$, does not interact with any other state and is, therefore, excluded from the collisions. The degeneration of hybrid matter may continue till it converts to the pure matter of state '0'. The time evolution of this process can be given by the Boltzmann equation[6].

If there were only two states '2' and '3' of the hybrid particles present initially at the time of freeze-out and they collide to make two particles of state '0' as:

$$'2' + '3' \rightarrow 2\,'0'$$

Then, the Boltzmann equation will give the rate of formation of particles of state '0' as

$$\dot{n}_0 + 3\,H\,n_0 = -\langle\sigma v_{mol}\rangle\left(n_2 n_3 - n_2^{eq} n_3^{eq}\right) \tag{10}$$

where,

$n_2^{eq} = \frac{n_2+n_3}{2}$ and $n_3^{eq} = \frac{n_2+n_3}{2}$ because of the uniform distribution of these states in the thermal bath. H is the Hubble parameter, σ is the annihilation cross-section, v_{mol} is the Moller velocity, n_i denotes the number density of particles in the state 'i' at the time of freeze-out and $\dot{n}_0$ is the rate of change of the number density of particles in the state '0'.

The functional form of the cohesive and adhesive forces

The hybrid matter present at the surface of the universe is the visible form of matter while that present in the interior of the universe may be hard to detect and is, therefore, characterized as dark matter. Since dark matter particles were constrained at r=0, the length scale of particle interaction can be assumed to be the radius of the universe, r, at $t \to 0^+$, just after the freeze-out. A dark matter particle, in the interior of the dark matter, is in equilibrium because of the cohesive and adhesive forces exerted on it in all directions by the neighboring particles. As the universe expands, this equilibrium is temporarily disturbed and the particle accelerates to its new location where it is again in equilibrium. During the motion of an interior dark matter particle from the old to the new location, a net force acts on it. This temporary acceleration, at $t \to 0^+$, just after the freeze out, can be used to determine the functional form, $F_{cohesive\&adhesive} = f(r)$, of the cohesive and adhesive forces. Further, since the surface of the universe is almost a plane and moving at a near-equilibrium condition, the relativistic effect in the r direction is absent.

$$F_{cohesive\&adhesive} = f(r) = m\frac{d^2r}{dt^2} \tag{11}$$

where, m is the mass of the particle and r is the radius of the universe.

I assume that at t=0, $\frac{dr}{dt} = v$, which is the velocity of the surface in the equilibrium model. Then, from equations (8) and (11),

$$\frac{dH}{dt} = -\frac{1}{r^2}\left(\int_0^t \frac{f(r)}{m}dt + v\right)^2 + \left(\frac{1}{r}\frac{f(r)}{m}\right) \tag{12}$$

During the time interval after the freeze-out,

$$2v\left|\int_0^t \frac{f(r)}{m}dt\right| \gg \left(\int_0^t \frac{f(r)}{m}dt\right)^2 \tag{13}$$

For the equilibrium model, $\frac{dH}{dt} = -\left(\frac{v}{r}\right)^2$. Thus, from equation 12, the $\frac{f(r)}{m}$ may be zero, which is a trivial case since, in the absence of the cohesive and adhesive forces, the surface tension force will not be present. Thus, in this case, the universe will not have either matter or dark matter, or dark energy after the freeze-out. The trivial case can be proven by the method of mathematical induction using equation 25. Therefore, $\frac{f(r)}{m} \neq 0$, and the velocity of the surface is not constant. Therefore, I postulate that a net constant force acts on the surface and the universe expands at a non-equilibrium condition. However, since Newton's second law of motion is universally valid, I assume that the net constant force acting on the surface and the deviation of $\frac{dH}{dt}$ from $-\left(\frac{v}{r}\right)^2$ is as small as possible while avoiding the trivial case. Thus,

$$\frac{dH}{dt} = -\left(\frac{v}{r}\right)^2 (1+\varepsilon) \tag{14}$$

where, $\varepsilon \rightarrow$as small as possible

Further, $\varepsilon > 0$, since the universe started from $V = 0$, $\varepsilon = 0$, and its volume decreased during the freeze-out i.e. $V < 0$ (see the discussion section) and $\varepsilon > 0$.

From equation 14, we conclude that $\frac{f(r)}{m}$ must include a $\frac{1}{r^{\infty}}$ term but it must also include other terms to avoid the trivial case. If $\frac{f(r)}{m}$ includes a ($\mp \frac{1}{r^n}$, n>1) term, then, the $-\frac{2v}{r^2}\int_0^t \frac{f(r)}{m} dt$ and $\frac{1}{r}\frac{f(r)}{m}$ terms in equation 12 together add a $\pm o\left(\frac{1}{r^{n-1}}\right)$ contribution to ε (since $r = vt$ (see below)). On the other hand, the $-\frac{1}{r^2}\left(\int_0^t \frac{f(r)}{m} dt\right)^2$ term always adds a $+\mathrm{o}\left(\frac{1}{r^{2n-2}}\right)$ and a $-\left(\frac{1}{r_f^{n-1}}\right) o\left(\frac{1}{r^{n-1}}\right)$ contribution to ε regardless of whether an attractive or a repulsive force is added. r_f is the radius of the universe at the time of freeze-out and n>1 so that ε<<1. Since r_f is large, the $-\left(\frac{1}{r_f^{n-1}}\right) o\left(\frac{1}{r^{n-1}}\right)$ contribution to ε, made by the $-\frac{1}{r^2}\left(\int_0^t \frac{f(r)}{m} dt\right)^2$ term, is negligible in comparison to the $\pm o\left(\frac{1}{r^{n-1}}\right)$ contribution, made by the $-\frac{2v}{r^2}\int_0^t \frac{f(r)}{m} dt$ and $\frac{1}{r}\frac{f(r)}{m}$ terms together. Further, since $+\mathrm{o}\left(\frac{1}{r^{n-1}}\right) > +\mathrm{o}\left(\frac{1}{r^{2n-2}}\right)$, the first term in $\frac{f(r)}{m}$, corresponding to n=2, cannot be repulsive, otherwise, $\varepsilon < 0$ due to the $-o\left(\frac{1}{r^{n-1}}\right)$ contribution made by the $-\frac{2v}{r^2}\int_0^t \frac{f(r)}{m} dt$ and $\frac{1}{r}\frac{f(r)}{m}$ terms together. Furthermore, although during the freeze-out the value of ε increased, the addition of multiple states may have kept this increase as small as possible. The number and the form of the terms, included in $\frac{f(r)}{m}$, fixed the value of ε at the end of the freeze-out. The functional form of $\frac{f(r)}{m}$ is derived below although the exact terms can only be found through experiments.

I assume that the approximate equilibrium condition extends till the end of the freeze-out. Then,

$$r = vt \tag{15}$$

Next, we consider a case in which $\frac{f(r)}{m}$ includes a constant term.

$$\frac{f(r)}{m} = k_0'' = \text{constant} \tag{16}$$

Then, from equations (12), (15), and (16),

$$\frac{dH}{dt} = -\left(\frac{v}{r}\right)^2 \left[1 + \left(\frac{k_0'' \, r}{v^2}\right)^2 + \frac{k_0'' \, r}{v^2}\right] \tag{17}$$

Since $\varepsilon \ll 1$, ε must not contain the positive powers of r. Therefore, $\frac{f(r)}{m}$ may not include a constant term.

Next, we consider another case in which $\frac{f(r)}{m}$ includes a term $\frac{1}{r^x}$, where x is a positive real number other than 1,

$$\frac{f(r)}{m} = \frac{k_x''}{r^x} \tag{18}$$

Then,

$$\frac{dH}{dt} = -\frac{\left(v - \frac{k_x'' \, r_f^{1-x}}{v\,(1-x)}\right)^2}{r^2} - \left(\frac{k_x''}{v\,(1-x)\,r^x}\right)^2 - \left(\frac{2}{1-x} - \frac{2k_x'' \, r_f^{1-x}}{v^2\,(1-x)^2} - 1\right)\frac{k_x''}{r^{1+x}} \tag{19}$$

or

$$\frac{dH}{dt} =$$

$$-\left(\frac{v-\frac{k''_x \; r_f^{1-x}}{v\;(1-x)}}{r}\right)^2 \left[1+\left\{\left(\frac{k''_x}{v\;(1-x)}\right)\Big/\left(v-\frac{k''_x \; r_f^{1-x}}{v\;(1-x)}\right)\right\}^2\left(\frac{1}{r^{2x-2}}\right)+\right.$$

$$\left.\left\{\left(\frac{2}{1-x}-\frac{2k''_x \; r_f^{1-x}}{v^2\;(1-x)^2}-1\right)k''_x\Big/\left(v-\frac{k''_x \; r_f^{1-x}}{v\;(1-x)}\right)^2\right\}\left(\frac{1}{r^{x-1}}\right)\right] \qquad (20)$$

where, r_f is the radius of the universe at $t \rightarrow 0^{+},$ the start of the freeze-out.

In equation 20, for $\varepsilon \ll 1$, x must be greater than 1. Further, in equation 20, the sign of the $\left\{\left(\frac{2}{1-x}-\frac{2k''_x \; r_f^{1-x}}{v^2\;(1-x)^2}-1\right)k''_x\Big/\left(v-\frac{k''_x \; r_f^{1-x}}{v\;(1-x)}\right)^2\right\}\left(\frac{1}{r^{x-1}}\right)$ term may change depending on the sign of k''_x (see equations 28 and 29). Thus, the two terms, $\left\{\left(\frac{k''_x}{v\;(1-x)}\right)\Big/\left(v-\frac{k''_x \; r_f^{1-x}}{v\;(1-x)}\right)\right\}^2\left(\frac{1}{r^{2x-2}}\right)$ and $\left\{\left(\frac{2}{1-x}-\frac{2k''_x \; r_f^{1-x}}{v^2\;(1-x)^2}-1\right)k''_x\Big/\left(v-\frac{k''_x \; r_f^{1-x}}{v\;(1-x)}\right)^2\right\}\left(\frac{1}{r^{x-1}}\right)$ may neutralize and minimize the value of ε as multiple terms, with different values of x, are included in $\frac{f(r)}{m}$. Further, since

V<0, x can be either natural numbers greater than 1 or x=3/2, 5/2, 7/2, … . If x=3/2, 5/2, 7/2,…., the forces must be attractive-repulsive perfect conjugate pair for each x so that $\left(\frac{1}{r^{x-1}}\right)$ terms in ε cancel.

Next, we consider another case in which $\frac{f(r)}{m}$ includes a $\left(\frac{1}{r}\right)$ term,

$$\frac{f(r)}{m} = \frac{k_1''}{r} \tag{21}$$

Then,

$$\frac{dH}{dt} = -\left(\frac{v}{r}\right)^2 \left[1 + \left(\frac{k_1'' \ln\frac{r}{v}}{v^2}\right)^2 - 2\left(\frac{k_1''}{v^2}\right)^2 \left(\ln\frac{r_f}{v}\right) \ln\frac{r}{v} + 2\frac{k_1''}{v^2}\ln\frac{r}{v} - \frac{k_1''}{v^2} + \left(\frac{k_1'' \ln\frac{r_f}{v}}{v^2}\right)^2 - 2\frac{k_1''}{v^2}\ln\frac{r_f}{v}\right]$$

(22)

Since in equation 22, ε contains the logarithmic term in r, ε will diverge. Therefore, $\frac{f(r)}{m}$ may not include a $\left(\frac{1}{r}\right)$ term. For a similar reason, $\frac{f(r)}{m}$ may also not include terms with positive powers of r. Therefore,

$$\frac{f(r)}{m} = \frac{k''_x}{r^x} + \cdots \pm \frac{k''_{x-1/2}}{r^{(x-1/2)}} \dots \dots \dots + \frac{k''_\infty}{r^\infty} \tag{23}$$

where, x is a natural number greater than 1, $k''_x \ldots k''_{x-1/2} \ldots k''_\infty$ are real number constants and m is the mass of the particle experiencing the cohesive and adhesive forces.

Thus, from equation 23, the cohesive and adhesive forces between two dark matter particles of mass m_1 and m_2 can be given as:

$$f(r) = m_1 m_2 \left(\frac{k'_x}{r^x} + \cdots \pm \frac{k'_{x-1/2}}{r^{(x-1/2)}} \dots \dots \dots + \frac{k'_\infty}{r^\infty}\right); \text{ where, x is a natural number>1} \tag{24}$$

Equation 24 also includes the gravitational force.

Rewriting equation 2,

$$m_i m_e \left(\frac{k'_2}{r^2} + \frac{k'_3}{r^3} + \frac{k'_4}{r^4} \dots \dots \pm \frac{k'_{x-1/2}}{r^{(x-1/2)}} \dots \dots + \frac{k'_\infty}{r^\infty}\right) + 8\pi\gamma r = k_0 \tag{25}$$

where, k_0 is the net force acting on the surface. Further, k_0 is a constant, otherwise, the net force acting on the surface would diverge for $0 \leq t < \infty$.

Equation 25 unifies all the forces acting on the surface and can be considered as the unified theory of the universe.

Further, from the front term, $\left(\frac{v - \frac{k_x'' \; r_f^{1-x}}{v\;(1-x)}}{r}\right)^2$, in equation 20, the change in the velocity of the surface, Δv, after the addition of each state during the freeze-out is

$$\Delta v = -\frac{k_x'' \; r_f^{1-x}}{v\;(1-x)} \tag{26}$$

where, r_f is the radius and v is the velocity of the surface at the start of the addition of the state.

Since x>1, the velocity increases if a repulsive state is added and decreases if an attractive state is added. Further, when a state with a large value of x is added, the change in the velocity is small. Furthermore, if a pair of attractive-repulsive perfect conjugate corresponding to x=3/2 or 5/2 or 7/2….is added, the velocity does not change.

From equations 14 and 20,

$$\epsilon = \left\{ \left(\frac{k_x''}{v\;(1-x)}\right) \Bigg/ \left(v - \frac{k_x'' \; r_f^{1-x}}{v\;(1-x)}\right) \right\}^2 \left(\frac{1}{r^{2x-2}}\right) +$$

$$\left\{ \left(\frac{2}{1-x} - \frac{2k_x'' \; r_f^{1-x}}{v^2\;(1-x)^2} - 1\right) k_x'' \Bigg/ \left(v - \frac{k_x'' \; r_f^{1-x}}{v\,(1-x)}\right)^2 \right\} \left(\frac{1}{r^{x-1}}\right) \tag{27}$$

From equations 26 and 27,

$$\epsilon = \left\{ \left(\frac{k_x''}{v\ (1-x)}\right) \Big/ \left(v - \frac{k_x''\ \ r_f^{1-x}}{v\ (1-x)}\right) \right\}^2 \left(\frac{1}{r^{2x-2}}\right) +$$

$$\left\{ \left(\frac{2}{1-x} + \frac{2\Delta v}{v(1-x)} - 1\right) k_x'' \Big/ \left(v - \frac{k_x''\ \ r_f^{1-x}}{v\ (1-x)}\right)^2 \right\} \left(\frac{1}{r^{x-1}}\right) \tag{28}$$

Since, the freeze-out perturbed the universe only slightly away from the equilibrium,

$$\frac{\Delta v}{v} \ll 1$$

Therefore,

$$\frac{2}{1-x} + \frac{2\Delta v}{v(1-x)} - 1 < 0 \tag{29}$$

Moreover, in equation 28, the $\left(\frac{1}{r^{x-1}}\right)$ containing term is much more dominant in controlling the value of ϵ than the $\left(\frac{1}{r^{2x-2}}\right)$ term. Therefore, from equation 28, the addition of an attractive force increases the value of ε while that of a repulsive force decreases ε. On the other hand, from equation 28, the addition of a pair of attractive-repulsive perfect conjugate increases the value of ε without affecting the velocity of the surface. Thus, the accelerated expansion of the universe [4,5] i.e. the decrease in the value ε can happen either through a drop of an attractive state or through an addition of a repulsive state in the series. The aforementioned inference can also be drawn from equation 26. However, the ε may also decrease without affecting the velocity of the surface when a pair of attractive-repulsive perfect conjugate drops out. Since the surface tension force may decrease (see the discussion section) after the freeze-out, the addition of a repulsive force term or drop of an attractive force term in equation 25 is balanced by the decrease in the surface tension force, keeping k_0 constant. However, when a pair of attractive-repulsive perfect conjugate drops out, the surface tension force, the surface tension γ, v and r remain unchanged while ε decreases.

Discussion

While describing the origin of the universe, Mongan[7]describes the puzzle of the existence of dark energy. Dark energy is the vacuum that was created when the hybrid matter froze out. The surface tension force is due to this vacuum. The vacuum is slightly stronger than the cohesive/adhesive forces acting on the surface, keeping the universe slightly away from the equilibrium. Another puzzle described by Mongan[7] is the existence of dark matter. The theory of this paper describes that dark matter is contained in a group of hybrid particles, which reside in the interior of the universe and interact with the cohesive and adhesive forces. Considering cosmic time as the infinite cycles of the origin and end of the universe, the universe may have started with the quantum fluctuation[7] at t=0 having neither the matter nor the dark matter nor the dark energy. Thus, at t=0, k_0=0. At t=0, the cohesive force was infinitely strong, given by $k'_{\infty} \frac{m_i \ m_e}{r^{\infty}}$, while no adhesive force was present. Since at t=0, m_i=0, the magnitude of cohesive force was zero. Thus, from equation 5 or 25, at t=0, $8\pi\gamma r$ also equals zero while $\gamma \rightarrow \infty$ and r=0. Thus, at t=0, all the forces were individually zero and unified to a zero magnitude.

As the dark matter began to freeze out, the vacuum energy was created and the magnitude of k_0 increased from zero while the series of the cohesive and adhesive forces came into existence due to the addition of hybrid matter states that froze out. Since the freeze-out, the particles of different hybrid matter states may collide, annihilating each other and generating pure matter particles of state '0' that interact with a cohesive force given by $\frac{k'_{\infty}}{r^{\infty}}$, which is a zero force. Simultaneously, due to the degeneration of dark matter to the state '0', the surface tension, γ, continues to decrease. The collision and annihilation may continue till all hybrid matter states have converted to the pure matter of state '0' and γ become zero. Simultaneously, the cohesive/adhesive as well as the surface tension force becomes zero in equation 25. Then, the pure matter of state '0' fills the vacuum energy, destroying each other, re-setting the value of k_0 to zero and γ to infinity. Thus, the universe started from no matter, no dark matter, no dark energy, no cohesive/adhesive force, no surface tension force, $k_0 = 0$, and $\gamma \rightarrow \infty$ and ends to the same values of these variables.

Equation 4 can be used to calculate the surface tension force both during and after the freeze-out. During the freeze-out, $\frac{d\gamma}{dt}$, $\frac{dt}{dV}$ and V had negative magnitudes. Thus, as V decreased further during the freeze-out, from equation 4, the surface tension force increased, reaching a maximum value at the end of the freeze-out. After the freeze-out, both $\frac{d\gamma}{dt}$ and V remained negative while $\frac{dt}{dV}$ became positive. Further, after the end of freeze-out, the magnitude of the $4\pi \frac{F_s}{S^2}$ term may be larger than that of the $8\pi \left(\frac{d\gamma}{dt}\right)\left(\frac{dt}{dV}\right)$ term. Thus, from equation 4, as V increases, the surface tension force decreases, reaching a magnitude of zero when all of the hybrid matter states convert to the pure matter of state '0'. At this point, the pure matter of state '0' and vacuum energy destroy each other, and volume, V, becomes zero. Alternatively, at the end of the freeze-out, the least value of the negative volume became fixed. The hybrid matter was created at the surface of this volume. As the hybrid matter degenerates to the state '0', since the '0' state matter does not interact, it detaches from the surface and creates a positive volume. When all of the hybrid matter converts to the pure matter of state '0', the positive volume becomes the maximum. At this point, the surface tension force becomes zero. Then, the negative volume annihilates the positive volume. However, the freeze-out may not have ended and may continue along with the destruction of the hybrid matter states.

Since the matter of the state '0' does not interact, its free energy change or chemical potential is zero. Therefore, its density in the positive volume must be constant.

Thus,

$$m_i = \rho_0 \left(\frac{4\pi r^3}{3}\right) \tag{30}$$

where, ρ_0 is the density of the matter of state '0'.

On the other hand, the mass at the surface, m_e, is independent of r. Hence, m_e is a constant.

Further, the universe can be considered to be bistable depending on whether we observe the vacuum or the positive volume filled with the matter of the state '0'.

Truncating the series after $\frac{k'_4}{r^4}$ in equation 25,

$$\left(k'_2 + \frac{6\gamma}{m_e\ \rho_0}\right) r^2 + \left(k'_3 - \frac{3k_0}{4\pi\, m_e\ \rho_0}\right) r + k'_4 = 0 \tag{31}$$

Equation 31 presents bistability with the possibility in which the modulus of the negative root is bigger than the positive root, which is true for our universe. It may also present other possibilities not belonging to our universe.

The electrostatic force

Since the particles of state '0' do not interact, they must be uncharged. Thus, the charge of the positive volume, q_i, remains constant.

$$q_i = c_1 \tag{32}$$

From equations 30 and 32,

$$q_i = c_1' \left(\frac{m_i}{\frac{4}{3}\pi r^3}\right) \tag{33}$$

where, c_1 and c_1' are constants.

Further, since the surface is almost a plane, the surface area, S, remains constant. Thus, from Gauss's law,

$$\frac{1}{4\pi r^2}\frac{dq_e}{dt} = \left(\frac{1}{4\pi\varepsilon_0}\ \frac{q_i}{r^2}\right) S \tag{34}$$

or,

$$\frac{dq_e}{dt} = c_2 \tag{35}$$

where, q_e is the charge of the surface of the universe.

Thus, from equation 35,

$$q_e = \frac{c_2\, r}{v} \tag{36}$$

Further, since m_e is a constant,

$$q_e = \frac{c_2' \ r \ m_e}{v} \tag{37}$$

where, c_2 and c_2' are constants.

Therefore, using equations 33 and 37, the Coulomb force, $F_{Coulomb}$, is given as,

$$F_{Coulomb} = \frac{k_4 \ m_i m_e}{r^4} \tag{38}$$

where, k_4 is a positive constant.

The strong force

The two-pion exchange potential, $V^{\pi:\pi}$, caused by the mass of pions, m_π, present in the internal universe is given as[8],

$$V^{\pi:\pi} = -\frac{k_3''' m_\pi^2}{r^5} \tag{39}$$

The two-pion exchange field, $E^{\pi:\pi}$, experienced by the nucleons of the surface and caused by the nucleons of the internal universe is,

$$E^{\pi:\pi} = -\frac{k_3'''' m_\pi^2}{r^6} \tag{40}$$

Further,

$$m_\pi = c_3 m_i \tag{41}$$

where, c_3 is a constant.

Thus, two-pion exchange force caused by the nucleons present in the internal universe on the nucleons present at the surface is

$$F_{\pi:\pi} = -\frac{k_3''''' \ {m_i}^2 \, {m_e}^2}{r^6} \tag{42}$$

From equations 30 and 42,

$$F_{\pi:\pi} = -\frac{k_3 \ m_i m_e}{r^3} \tag{43}$$

where, k_3 is a positive constant.

The strong force involves both two-pion exchange as well as Coulombic interaction. Thus, the strong force, F_{Strong}

$$F_{Strong} = -\frac{k_3\, m_i m_e}{r^3} + \frac{k_4'''\ m_i m_e}{r^4} \tag{44}$$

The weak force

The weak force is between all elementary particles and its range is within subatomic distance. Since the universe is nearly at equilibrium, the distribution of elementary particles at the length scale of the radius of the universe can be assumed to be constant. Therefore, the weak force is a constant represented by k_0. The weak force on any surface drawn in space would be zero because of the uniform distribution of elementary particles around the surface. However, due to the vacuum around one side of the surface of the universe, a net constant force acts on the surface due to the weak force.

Thus, the unified equation involving the gravitational force, the strong force, the electrostatic force, the surface tension force, and the weak force is given as:

$$m_i m_e \left[\frac{-G}{r^2} + \left(-\frac{k_3}{r^3} + \frac{k_4'''}{r^4}\right) + \left(\frac{k_4}{r^4}\right) \pm \frac{k'_{x-1/2}}{r^{(x-1/2)}} + \frac{k'_\infty}{r^\infty}\right] + (8\pi\gamma r) = k_0 \tag{45}$$

where, k_3 , k_4''' , k_4, and k_0 are positive constants and x is a natural number greater than 1.

In Summary, I identified a surface force to make the fundamental forces together represent the universe and provided equations to find the magnitude of this force. Further, I gave a range for expressions of functional forms of the cohesive and adhesive forces and an equation that unifies all the forces of nature.

Conflict of Interest

The author declares that he has no conflict of interest.

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Figure Legends

Figure 1: Schematic of the universe.

Figure2: Schematic of the universe to find the Hubble parameter.

Figures

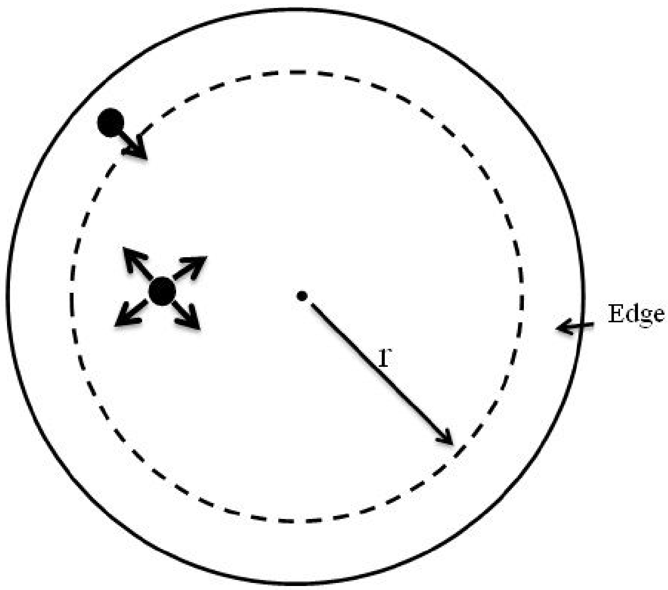

Figure 1

Schematic of the universe.

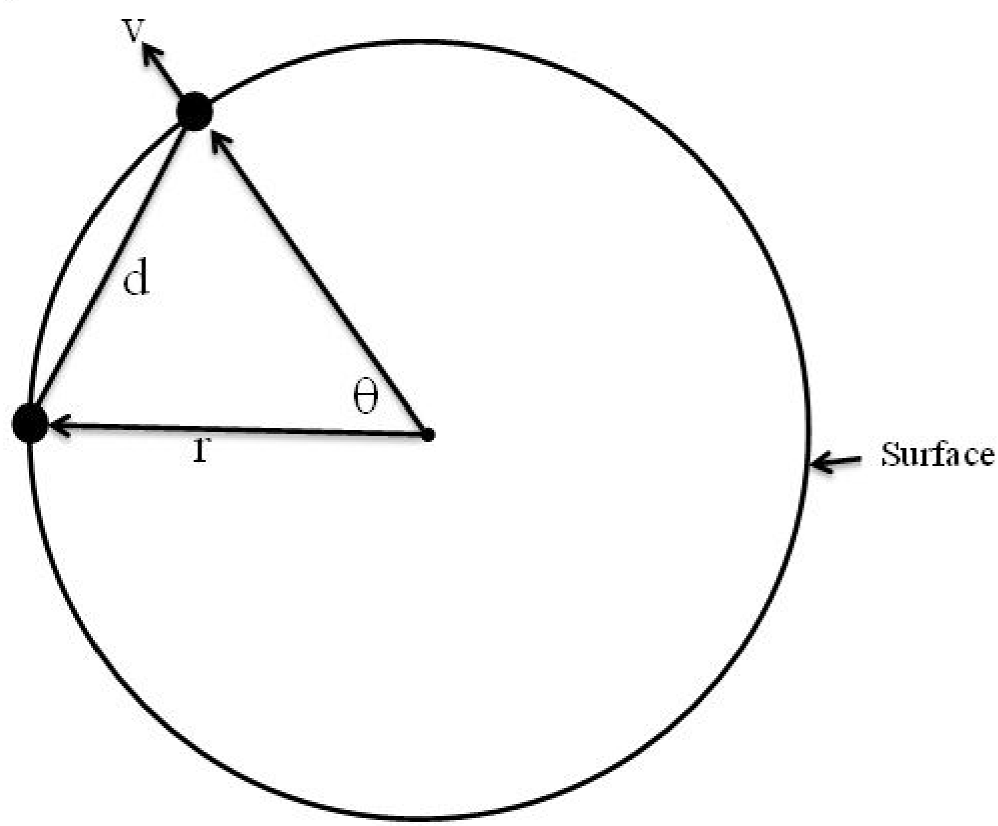

Figure 2

Schematic of the universe to find the Hubble parameter.