# Fifth fundamental force and unification of fundamental forces

**Raghvendra Singh** (raghvend@iitk.ac.in)
Indian Institute of Technology Kanpur

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# Fifth fundamental force and unification of fundamental forces

Raghvendra Singh*

Department of Chemical Engineering, Indian Institute of Technology Kanpur, India

***Correspondence to:**

Raghvendra Singh, Ph.D.

Assistant Professor

Department of Chemical Engineering

Indian Institute of Technology Kanpur

Kanpur, India, 208016

Tel: 91-512-259 7605

Fax: 91-512-259 0104

Email: raghvend@iitk.ac.in

**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 the surface tension, a property of dark energy. On the other hand, matter particles interact with each other through a cohesive force and with dark matter through an adhesive force. I give a range of the 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]. 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

The compressive force (Fig. 1) acting on the surface of the universe, $F_c$, can be given by Newton's law of universal gravitation as:

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

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

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,

$$F = -G\,\frac{m_i\,m_e}{r^2} + F_s = 0 \tag{2}$$

where, $F_s$ is the outward normal force that must act on the surface.

Equation 2 can be used to determine $F_s$. However, the mass at the surface and the internal mass of the universe are unknown. Here, I describe an alternative method to determine $F_s$. This method is based on an analogy of the universe with a water drop hanging in a vacuum. The force $F_s$ may originate from the surface tension of the universe. Thus, we define the surface tension $\gamma$ and find $F_s$ using the Young-Laplace equation.

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

Equation 3 can be used to determine $F_s$. However, the determination of $F_s$ by equation 3 requires the absolute value of $\gamma$. Since it may be easier to measure the rate of change of $\gamma$, we convert equation 3 into a differential equation.

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

or

$$\left(\frac{4\pi}{3V}\right)^{1/3}\,\frac{dF_s}{dV} - 4\pi\frac{F_s}{S^2} = 8\pi\left(\frac{d\gamma}{dt}\right)\left(\frac{dt}{dV}\right) \tag{5}$$

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

Thus, the inhomogeneous nonlinear first-order differential equation 5 can be solved to find $F_s$.

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 of the universe,

$$F = -G\,\frac{m_i\ m_e}{r^2} + 8\pi\gamma r \tag{6}$$

At t=0, r=0. At t=0, the first term on the right-hand side of equation 6 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 6 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 6 is infinite. Once again, at $t \rightarrow \infty$, F must be zero. Again, the right-hand side of equation 6 must be indeterminate. Thus, at $t \rightarrow \infty$, $\gamma$=0, which means that $\gamma$ 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 6 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 6 are separately zero. Thus with time, while $\gamma$ 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:

$$H = \frac{2v\sin(\theta/2)}{d} = \left(\frac{v}{r}\right) \tag{7}$$

$$\frac{dH}{dt} = -\left(\frac{v}{r}\right)^2 \tag{8}$$

While equations (7) and (8) apply to the equilibrium model, equations (9) and (10) are also applicable to the universe expanding with a net normal force acting on the surface.

$$\frac{dH}{dt} = \frac{1}{3}\left[-\frac{1}{V^2}\left(\frac{dV}{dt}\right)^2 + \frac{1}{V}\frac{d^2V}{dt^2}\right] \tag{9}$$

$$\frac{d^2V}{dt^2} = \left(\frac{\partial}{\partial\gamma}\frac{dV}{dt}\right)\frac{d\gamma}{dt} \tag{10}$$

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 10, $\frac{d^2V}{dt^2}>0$, 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 the progressive degeneration of dark energy into matter. 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, $\gamma$, is ∞ and mass is 0. States '2', '3',…'N', having progressively lower energy and higher mass, 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

$$\dot{n}_0 + 3\,H\,n_0 = -\langle \sigma v_{mol} \rangle \left(n_2 n_3 - n_2^{eq} n_3^{eq}\right) \tag{11}$$

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 Hubble parameter, $\sigma$ is the annihilation cross-section, $v_{mol}$ is Moller velocity, $n_i$ denotes 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**

Since dark matter particles (the hybrid 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→$0^+$, 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→$0^+$, 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.

$$F_{cohesive\&adhesive} = f(r) = m\frac{d^2r}{dt^2} \quad (12)$$

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 (9) and (12),

$$\frac{dH}{dt} = -\frac{1}{r^2}\left(\int_0^t \frac{f(r)}{m} dt + v\right)^2 + \left(\frac{1}{r}\frac{f(r)}{m}\right) \quad (13)$$

During the time interval after the freeze-out,

$$2v\left|\int_0^t \frac{f(r)}{m} dt\right| \gg \left(\int_0^t \frac{f(r)}{m} dt\right)^2 \quad (14)$$

For the equilibrium model, $\frac{dH}{dt} = -\left(\frac{v}{r}\right)^2$. Thus, from equation 13, $\frac{f(r)}{m}$ 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 after the freeze-out. The trivial case can be proven by the method of mathematical induction using equation 26. 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,

$$\frac{dH}{dt} = -\left(\frac{v}{r}\right)^2 (1 + \varepsilon) \tag{15}$$

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 15, 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 13 together add a $\pm o\left(\frac{1}{r^{n-1}}\right)$ contribution to $\varepsilon$ (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 +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 $\varepsilon$ 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 $\varepsilon$<<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 $\varepsilon$, 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 $+o\left(\frac{1}{r^{n-1}}\right) > +o\left(\frac{1}{r^{2n-2}}\right)$, 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 $\varepsilon$ 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 $\varepsilon$ 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,

$$r = vt \tag{16}$$

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

$$\frac{f(r)}{m} = k_0''\text{=constant} \tag{17}$$

Then, from equations (13), (16), and (17),

$$\frac{dH}{dt} = -\left(\frac{v}{r}\right)^2\left[1 + \left(\frac{k_0''\, r}{v^2}\right)^2 + \frac{k_0''\, r}{v^2}\right] \tag{18}$$

Since $\varepsilon \ll 1$, $\varepsilon$ 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,

$$\frac{f(r)}{m} = \frac{k_x''}{r^x} \tag{19}$$

Then,

$$\frac{dH}{dt} = -\frac{\left(v - \frac{k_x''\ r_f^{1-x}}{v\,(1-x)}\right)^2}{r^2} - \left(\frac{k_x''}{v\,(1-x)\,r^x}\right)^2 - \left(\frac{2}{1-x} - \frac{2k_x''\ r_f^{1-x}}{v^2\,(1-x)^2} - 1\right)\frac{k_x''}{r^{1+x}} \tag{20}$$

or

$$\frac{dH}{dt} = -\left(\frac{v - \frac{k_x'' \;\; r_f^{1-x}}{v\ (1-x)}}{r}\right)^2 \left[1 + \left\{ \left(\frac{k_x''}{v\ (1-x)}\right) \Big/ \left(v - \frac{k_x'' \;\; r_f^{1-x}}{v\ (1-x)}\right) \right\}^2 \left(\frac{1}{r^{2x-2}}\right) + \left\{ \left(\frac{2}{1-x} - \frac{2k_x'' \;\; r_f^{1-x}}{v^2\ (1-x)^2} - 1\right) k_x'' \Big/ \left(v - \frac{k_x'' \;\; r_f^{1-x}}{v\ (1-x)}\right)^2 \right\} \left(\frac{1}{r^{x-1}}\right)\right] \tag{21}$$

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

In equation 21, for $\varepsilon \ll 1$, x must be greater than 1. Further, in equation 21, 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 29 and 30). 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 $\varepsilon$ 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 $\varepsilon$ cancel.

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

$$\frac{f(r)}{m} = \frac{k_1''}{r} \tag{22}$$

Then,

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

(23)

Since in equation 23, $\varepsilon$ contains the logarithmic term in r, $\varepsilon$ 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,

$$\frac{f(r)}{m} = \frac{k''_x}{r^x} + \cdots \pm \frac{k''_{x-1/2}}{r^{(x-1/2)}} \dots \dots \dots + \frac{k''_\infty}{r^\infty} \qquad (24)$$

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 24, the cohesive and adhesive forces between two dark matter particles of mass $m_1$ and $m_2$ can be given as:

$$f(r) = m_1 m_2 \left(\frac{k'_x}{r^x} + \cdots \pm \frac{k'_{x-1/2}}{r^{(x-1/2)}} \dots \dots \dots + \frac{k'_\infty}{r^\infty}\right); \text{ where, x is a natural number} > 1 \qquad (25)$$

Equation 25 also includes the gravitational force.

Rewriting equation 2,

$$m_i m_e \left(\frac{k'_2}{r^2} + \frac{k'_3}{r^3} + \frac{k'_4}{r^4} \dots \dots \pm \frac{k'_{x-1/2}}{r^{(x-1/2)}} \dots \dots + \frac{k'_\infty}{r^\infty}\right) + 8\pi\gamma r = k_0 \qquad (26)$$

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 $0 \le t < \infty$.

Equation 26 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 21, the change in the velocity of the surface, $\Delta v$, after the addition of each state during the freeze-out is

$$\Delta v = -\frac{k''_x \ r_f^{1-x}}{v\ (1-x)} \qquad (27)$$

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 15 and 21,

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

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

From equations 27 and 28,

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

$$\left\{ \left( \frac{2}{1-x} + \frac{2\Delta v}{v(1-x)} - 1 \right) k_x'' \Big/ \left( v - \frac{k_x''\ r_f^{1-x}}{v\ (1-x)} \right)^2 \right\} \left( \frac{1}{r^{x-1}} \right) \tag{29}$$

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

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

Therefore,

$$\frac{2}{1-x} + \frac{2\Delta v}{v(1-x)} - 1 < 0 \tag{30}$$

Moreover, in equation 29, the $\left(\frac{1}{r^{x-1}}\right)$ containing term is much more dominant in controlling the value of $\epsilon$ than the $\left(\frac{1}{r^{2x-2}}\right)$ term. Therefore, from equation 29, the addition of an attractive force increases the value of $\varepsilon$ while that of a repulsive force decreases $\varepsilon$. On the other hand, from equation 21, the addition of a pair of attractive-repulsive perfect conjugate increases the value of $\varepsilon$ without affecting the velocity of the surface. Thus, the accelerated expansion of the universe [4,5] i.e. the decrease in the value $\varepsilon$ 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 27. However, the $\varepsilon$ 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 decreases (see the discussion section) after the freeze-out, the addition of a repulsive force term or drop of an attractive force term in equation 26 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 $\gamma$, $v$ and r remain unchanged while $\varepsilon$ decreases.

**Discussion**

While describing the origin of the universe, Mongan[7]describes the puzzle of the existence of dark energy or vacuum energy, exerting negative pressure. 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 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 6 or 26, 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 or the negative pressure 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 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, $\gamma$, continues to decrease. The collision and annihilation continue till all hybrid matter states have converted to the pure matter of state '0' and $\gamma$ become zero. Simultaneously, the cohesive/adhesive as well as the surface tension force becomes zero in equation 26. Then, the pure matter of state '0' fills the vacuum energy, destroying each other, re-setting the value of $k_0$ to zero and $\gamma$ 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 5 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 5, 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 5, 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. 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,

$$m_i = \rho_0 \left(\frac{4\pi r^3}{3}\right) \tag{31}$$

where, $\rho_0$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 26,

$$\left(k'_2 + \frac{6\gamma}{m_e\ \rho_0}\right) r^2 + \left(k'_3 - \frac{3k_0}{4\pi\, m_e\ \rho_0}\right) r + k'_4 = 0 \tag{32}$$

Equation 32 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.

$$q_i = c_1 \tag{33}$$

From equations 31 and 33,

$$q_i = c_1' \left( \frac{m_i}{\frac{4}{3}\pi r^3} \right) \tag{34}$$

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,

$$\frac{1}{4\pi r^2} \frac{dq_e}{dt} = \left( \frac{1}{4\pi\varepsilon_0} \ \frac{q_i}{r^2} \right) S \tag{35}$$

or,

$$\frac{dq_e}{dt} = c_2 \tag{36}$$

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

Thus, from equation 36,

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

Further, since $m_e$ is a constant,

$$q_e = \frac{c_2' \ r \ m_e}{v} \tag{38}$$

where, $c_2$ and $c_2'$ are constants.

Therefore, using equations 34 and 38, the Coulomb force, $F_{Coulomb}$, is given as,

$$F_{Coulomb} = \frac{k_4 \ m_i m_e}{r^4} \tag{39}$$

where, $k_4$ is a positive constant.

**The strong force**

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

$$V^{\pi:\pi} = -\frac{k_3''' m_\pi^2}{r^5} \tag{40}$$

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,

$$E^{\pi:\pi} = -\frac{k_3'''' m_\pi^2}{r^6} \tag{41}$$

Further,

$$m_\pi = c_3 m_i \tag{42}$$

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

$$F_{\pi:\pi} = -\frac{k_3''''' \ m_i{}^2 \, m_e{}^2}{r^6} \tag{43}$$

From equations 31 and 43,

$$F_{\pi:\pi} = -\frac{k_3 \ m_i m_e}{r^3} \tag{44}$$

where, $k_3$ is a positive constant.

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

$$F_{Strong} = -\frac{k_3 \, m_i m_e}{r^3} + \frac{k_4''' \ m_i m_e}{r^4} \tag{45}$$

**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 $k_0$.

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:

$$m_i m_e \left[\frac{-G}{r^2} + \left(-\frac{k_3}{r^3} + \frac{k_4'''}{r^4}\right) + \left(\frac{k_4}{r^4}\right) \pm \frac{k'_{x-1/2}}{r^{(x-1/2)}} + \frac{k'_\infty}{r^\infty}\right] + (8\pi\gamma r) = k_0 \tag{46}$$

where, $k_3$ , $k_4'''$ , $k_4$, and $k_0$ are positive constants.

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.**

**Figure 2: Schematic of the universe to find the Hubble parameter.**

# Figures

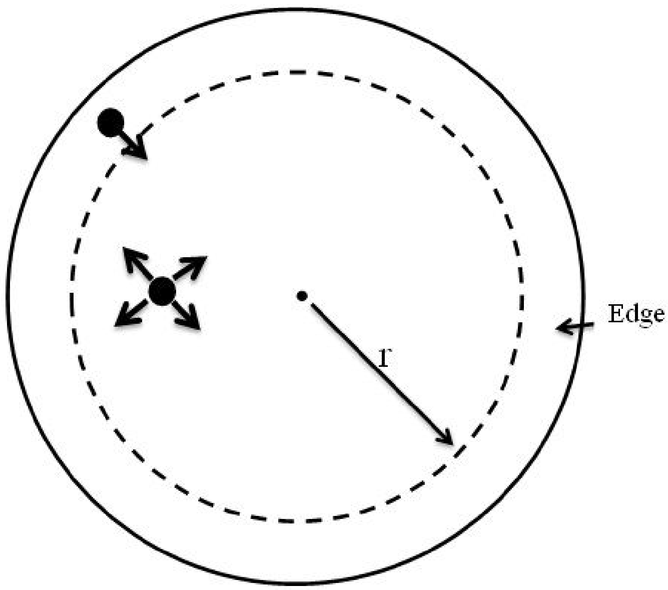


**Figure 1**

Schematic of the universe.

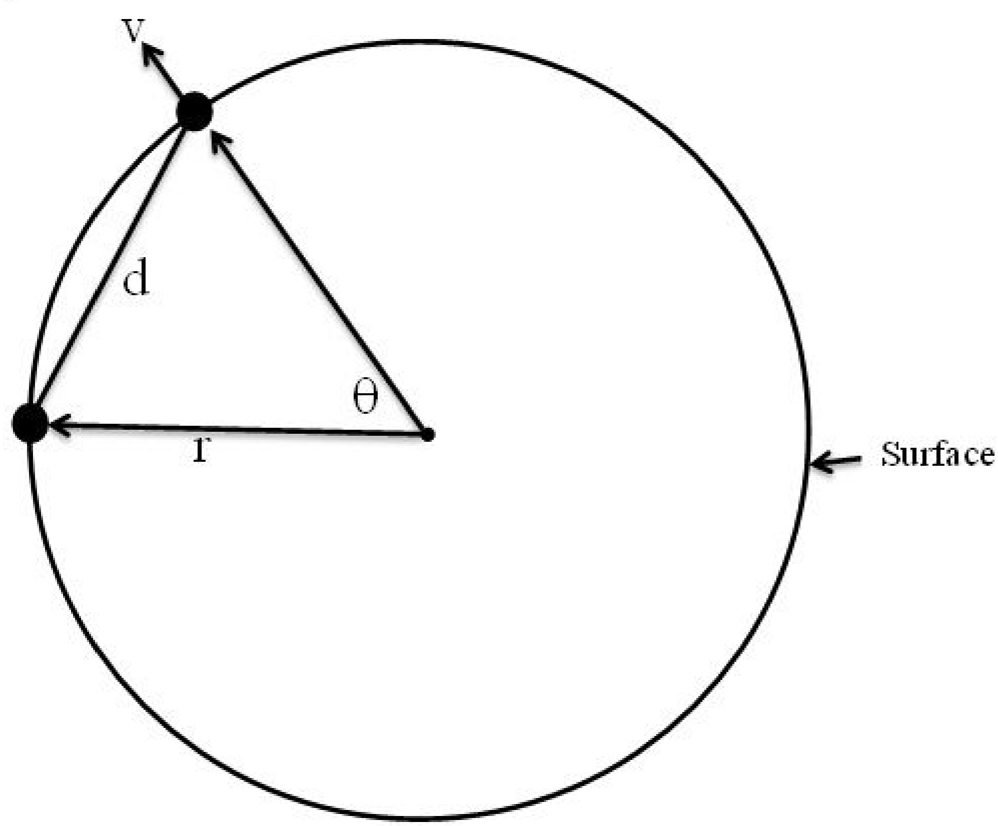


**Figure 2**

Schematic of the universe to find the Hubble parameter.