**Elucidation of the mechanism of gravitation based on a fluid mechanical model**

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**Abstract**

The main purpose of this article is to elucidate a mechanical interpretation of the gravitation phenomenon. Additionally, this article unifies Newtonian and general relativity theoretical frameworks using the wave equation, which is the mathematical framework of quantum physics. Here I propose a novel theory, "Equilibrium theory" which asserts that the universe is an infinitesimally large and continuous differential energy density structure - a compressible fluid, as analyzed from a uniform and constant non-associated (fixed) reference frame. Equilibrium theory asserts that the universe is always at equilibrium and is composed of demarcated "compressed fluid" (i.e. matter – planets, objects) and demarcated "stretched fluid" (i.e. photon) of approximately uniform energy density along with demarcated surrounding fluid of differential energy density (i.e. space); thus it is accurately represented using the wave equation, which describes the nature and dynamics of non-discrete and continuous structures.

Dynamics in weak and strong gravitational field results from the energy exchange within the "compressible fluid", resulting in the reconfiguration of the differential energy density within the "compressible fluid", and thus termed motion. Furthermore, dynamics in strong gravitational field (gravitational dynamics) is due to the existence of demarcated surrounding space of differential energy density with increasing magnitude in the direction of motion as analyzed from a uniform and constant non-associated (fixed) reference frame; this differential energy density is induced by the existence of a relatively high energy density structure (i.e matter – planet). Dynamics in weak gravitational field (dynamics in inertial reference frame) is also due to the existence of demarcated surrounding fluid of differential energy density with increasing magnitude in the direction of motion as analyzed from a uniform and constant non-associated (fixed) reference frame; thus it is equivalent to the gravitation phenomenon, albeit transient due to rapid dissipation during perturbations. Equilibrium theory provides a novel framework for elucidating the nature and dynamics of the universe using a fluid mechanical model.

## 1 Introduction

The purpose of this article is to derive Newton's laws of motion and universal gravitation and Einstein's special and general relativity theoretical frameworks using the wave equation based on a "compressible fluid" model of the universe. Most importantly, this article seeks to elucidate the mechanism of the gravitation phenomenon. The reasons why new theories of gravity are needed may be summarized as follows.

Firstly, the mechanism of gravitation remains to be elucidated over three centuries since Newton's publication on gravitation [4–8], and several astronomical and cosmological phenomena that fall within the purview of gravitation, including Hawking radiation, dark matter and dark energy cannot be interpreted by the currently accepted theories of gravitation [1-3]. Secondly, the mechanism of gravitation was not adequately addressed by the introduction of the currently accepted theory of gravitation, the general theory of relativity, which is a phenomenological theory of gravitation [4–6]. Lastly, though progress has been made towards a unified theory for describing the nature and dynamics of the universe, we still do not have a successful unified theory. General relativity describes the nature and dynamics of the universe on the cosmological scale, however at infinitesimally small scale of the universe "quantum scale" general relativity is inadequate [1-3]. Quantum physics provides an accurate description of the nature and dynamics of the universe at the "quantum scale", however it is inadequate for describing the universe beyond the quantum scale; novel theories of the nature and dynamics of the universe may shed light on this puzzle [1-3].

In conclusion, it seems that novel theories of the nature and dynamics of the universe including the gravitation phenomenon are needed in order to address several major challenges in modern physics. Most importantly, it is worth keeping an open mind with respect to all possible theories of the nature and dynamics of the universe and the gravitation phenomenon, before the above mentioned problems have been adequately resolved, as history has shown that the solutions to the greatest challenges in physics (i.e. perihelion precession of Mercury – general relativity and wave-particle duality of light – quantum physics) have been radical departure from the current paradigm and dogma, and occasionally involved individuals that are outside of the mainstream physics community (i.e. Albert Einstein).

Since the publication of Newton's law of universal gravitation, the mechanism of the gravitation phenomenon remains to be elucidated for over three centuries [4-8]. Newton and many other prominent physicists in subsequent generations proposed a mechanism of gravity based on the mechanics of an aether "fluid" pervading space [4-6]. Although Albert Einstein initially abandoned the idea of an aether "fluid" medium pervading space in his earlier publications on the theories of special and general relativity, he later attempted to reconcile the concept of aether with the theory of general relativity as a means of elucidating the mechanism of gravitation [9, 10]. Furthermore, Paul Dirac proposed the idea of a universal and all-pervading aether as a means of unifying quantum physics and general relativity [11]. More recently, Adolphe Martin and others proposed a fluidic model of vacuum to explain the nature and dynamics of the universe and the particles that interact within it [12-14]. Additionally, Xiao-Song Wang also proposed that the universe is filled with an "ideal fluid" called substratum, in which particles exist and interact [15]. Xiao-Song Wang's model of gravitation is based on the assumption that all particles are singularities of a kind of ideal fluid (i.e. sink flow model of particles), a very similar idea was proposed earlier by John Taylor [15, 16]. In this article, I propose a novel theory of the universe and the gravitation phenomenon – Equilibrium theory, which asserts that the universe is a "compressible fluid" in its entirety; it is not made of discrete structures (i.e. particles) in a fluid. Equilibrium theory abandons the notion of discreteness in the universe and introduces the concept of differential energy densities in an energy continuum "compressible fluid" as analyzed from a uniform and constant non-associated (fixed) reference frame.

## 2 The compressible fluid nature of the universe

The purpose of this section is to prove that the nature of the universe as described by Newtonian and general relativity theoretical frameworks are mathematical approximations of a novel theory, the Equilibrium theory, which proposes a "compressible fluid" model of the universe in its entirety. In this section I prove the "compressible fluid" model of the universe using the Equivalence Relation logic and the well-proven and accepted theories of general relativity and quantum field theory.

**Theorem 1:** Suppose that the universe in its entirety can be approximated as an array of little masses "*m"* of length *L* interconnected by massless springs of length *l*, which compress or stretch due to perturbations. If the length of the spring (*l*) is always far less than the length of the little mass (*L*) ($l \ll L$), taking the limit as the number of little masses "*N"* $\rightarrow \infty$, and $l \rightarrow 0$, yields a smooth and continuous structure, a compressible fluid model as analyzed from a uniform and constant non-associated (fixed) reference frame [17-19]. The nature and dynamics of the "compressible fluid" model of the universe can be mathematically represented using the one-dimensional wave equation [20].

$\rho(x, t) \cdot d^2U/dt^2(x, t) = T(x, t) \cdot d^2U/dx^2(x, t)$ (1)

Where, *"U"* is a demarcated structure of approximately uniform energy density containing a number of little masses "*m*" with interconnected springs of approximately equal length within the compressible fluid. In the absence of perturbations within the demarcated "compressible fluid" structure, the springs are neither compressed nor stretched; the compression of the springs increases the energy density while the stretching of the springs decreases energy density. $\rho(x, t)$ is the energy density at position *x* and time *t* as analyzed from a uniform and constant non-associated (fixed) reference frame and is dependent on energy perturbations in the compressible fluid that induces differential energy densities. $d^2U/dt^2$ is a measure of the rate of change of "*U*" as a function of time *t* within the compressible fluid. $T(x, t)$ is the restoring force at position *x* and time *t* (i.e. Tension) and is dependent on energy perturbations in the compressible fluid that induces differential energy densities as analyzed from a uniform and constant non-associated (fixed) reference frame. $d^2U/dx^2$ is a measure of the rate of change of "*U*" as a function of position *x* within the compressible fluid.

At absolute equilibrium, there is no perturbation within the compressible structure, thus nothing exist. The compression of the "compressible fluid" at position *x* to form the demarcated structure "*U*" is related to the stretching of surrounding regions of the fluid and verse visa. The compression limit of the "compressible fluid" is the smallest possible distance ($l_{smallest}$), to which the spring can be compressed; the structure associated with the compression limit is the high energy density structure prior to the "big bang". The induction of energy exchange within the compressible fluid at "absolute equilibrium" to form the highest possible energy density structure, results in the existence of differential energy density within the compressible fluid. The stretching limit within the "compressible fluid" is the largest possible distance ($l_{largest}$), to which the spring can be stretch; the structure "*U*" associated with the stretching limit is the photon structure. As a consequence of the "compressible fluid" nature of the universe, Equilibrium theory asserts that space is symmetrically compressed towards a point, and the resultant structure is termed "matter" and asymmetrically stretched (i.e. symmetry breaking) at a point, and the resultant structure is termed "photon". Equilibrium theory asserts that the lowest possible energy density structure is the photon and the highest possible energy density structure is the high-energy density structure prior to the "big bang". Furthermore, the existence of a given photon structure is restricted to a specific energy density, as all the perturbation energy is consumed in the existence of the structure within the compressible fluid. A photon structure fluctuates between existence as an asymmetrically stretched and moving structure and non-existence, thus a photon does not have a rest mass.

The “compressible fluid” model of the universe in its entirety, can be visualized as an elastic string with infinitesimally large dimensions and no external energy/force in current state; thus a pulse structure is a relatively high energy density structure of the elastic string (i.e. matter), while portions of the elastic string surrounding the pulse structure are relatively lower energy density structures of the string with differential energy density (i.e. space). Alternatively, perturbations in the “compressible fluid” model of the universe is synonymous to perturbations in air resulting in the existence of differential energy density or pressure in the compressible fluid which is manifested as sound.

**Proof:** If we accept the experimentally validated general theory of relativity [2, 3] and quantum field theory [22-23] as valid descriptions of the nature and dynamics of the universe, then we must also accept that space is related to energy (vacuum/zero point energy), just as mass is related to energy (mass-energy equivalence). Therefore, if mass “a”, space “b” and energy “c” are elements of an encompassing structure “the universe” represented by “set *S”* and if mass “a” and energy “c” are related and energy “c” and space “b” are also related, then we must also accept that mass “a” and space “b” are related. Consequently the binary relation between mass “a” and space “b” over set *S* is transitive. Formally, $\forall a, b, c \in S : (aRc \wedge cRb) \Rightarrow aRb$ (2).

Furthermore, if we accept that all masses “a” in set *S* are related per the theory of general relativity then the binary relation between all masses “a” is reflective. Additionally, if we also accept that all space (spacetime) “b” in set *S* is related per the theory of general relativity, then the binary relation between all space (spacetime) “b” in the universe “set *S*” is also reflective. Formally, $\forall a \in S : aRa$ and $\forall b \in S : bRb$ (3).

Lastly, if we accept the general theory of relativity assertion that the existence/structure and dynamics of mass determines the structure and dynamics of space (spacetime), and this resultant structure of space (spacetime) is manifested as the gravitational field, which in turn describes the structure and determines the dynamics of mass. Therefore, mass “a” and space (spacetime) “b” within the “universe” set *S* are related. Formally, both mass and space are elements of the “universe” set *S* and the existence/structure and dynamics of mass can be described accurately using a function of space (the curvature of spacetime) and verse visa, the structure and dynamics of space (spacetime) can be described accurately using a function of mass (gravitational field or stress-energy tensor induced by the mass). Therefore, the relationship between mass and space (spacetime) per the theory of general relativity fulfills the requirements of a binary relation that is symmetrical [21]. Formally, $\forall a, b \in S, aRb \Rightarrow bRa$. (4).

Per the “Equivalence Relation” logic [21], if a binary relation “R” over an encompassing structure “the universe” represented by “set *S”* is symmetric, transitive and reflective and holds for all elements “*a*” (mass) and “*b*” (space) in set *S*, then “*a*” is equivalent to “*b*” and “*b*” is equivalent to “*a*”. Therefore, mass is space and space is mass, the universe is a “compressible fluid” in its entirety. Most importantly, the binary relation between elements “*a*” (mass) and “*b*” (space) is the function “gravity”. Therefore, it can be proposed that mass (i.e. matter - planets, objects) is a relatively higher energy density demarcated structure of approximately uniform energy density within the compressible fluid, while surrounding space is a relatively lower energy density demarcated structure with differential energy density within the compressible fluid as analyzed from a constant and non-associated (fixed) reference frame. Formally, if we accept, $\forall a, b, c \in S : (aRc \wedge cRb) \Rightarrow aRb$; and $\forall a \in S : aRa$ and $\forall b \in S : bRb$ and $\forall a, b \in S, aRb \Rightarrow bRa$, then $a = b$ and $b = a$. (5) ■

**3 The dynamics of the "compressible fluid" model of the universe**

The purpose of this section is to proof that the dynamics of the universe as described by Newtonian and general relativity theoretical frameworks are mathematical approximations of a fluid mechanical model using the mathematical framework of the wave equation and perturbation theory analytical methods, which describes perturbations in non-discrete and continuous structures (i.e. compressible fluids).

**Theorem 2:** Newtonian and general relativity theoretical frameworks assert that discrete structures (i.e. planets, objects, particles) move in space (spacetime); however, Equilibrium theory asserts that the existence or emergence of differential energy density of increasing magnitude in the direction of motion in the demarcated surrounding space results in the "mapping" of "*U*" to a new "equilibrium position" within the compressible fluid, thus termed motion. No mapping/motion of "*U*" occurs in the absence of differential energy density of increasing magnitude in the direction of motion/mapping, even though the energy density of surrounding fluid decreases as an inverse distance square function from the center of "*U*"; this phenomena results from equal energy density at equal distance from the center of "*U*" as analyzed from a constant and non-associated (fixed) reference frame. The "mapping" of "*U*" (i.e. matter or photon) involves energy exchange which transforms/reconfigures the surrounding space into the demarcated structure "*U*". The energy exchange requirement for the "mapping" of "*U*" increases with increasing energy density of surrounding space and verse visa, until a "non-mappable" surrounding space is encounter, at which point no "mapping" occur.

The existence or emergence of differential energy density of increasing magnitude in the direction of motion/mapping in the demarcated surrounding space drives the motion/mapping of "*U*" via energy exchange due to the tension associated with the existence of the demarcated structure of approximately uniform energy density "*U*". Differential energy density of increasing magnitude in surrounding space is induce by energy from an internal source (i.e. a person(*U*) running) or from an external source (i.e. motion of a person(*U*) due to gravity or being push/pull). The demarcated approximately uniform energy density structure "*U*" is not moving per se, however the energy associated with the existence of "*U*" transforms/maps a different position within the compressible fluid into a similar structure "*U*". The motion of a pulse structure along an elastic string mimics this dynamics, as the energy associated with the existence of the pulse structure is transforming/mapping different positions of the string as "equilibrium position" of the pulse structure changes due to energy exchange between the pulse structure and the surrounding portions of the elastic string. Alternatively, the motion of sound in the compressible fluid - air also mimics this dynamics, as the energy associated with the existence of the high pressure air structure "sound" is transforming/mapping different positions of the compressible fluid as "equilibrium position" of the high pressure air structure changes due to energy exchange between the structure and the surrounding portions of the compressible fluid.

Additionally, Equilibrium theory asserts that measuring devices are matter, thus their existence and dynamics is not independent of surrounding space or mass. Importantly, Equilibrium theory asserts that the dynamics of "*U*" (i.e. matter or photon) and surrounding space is dependent on the existence and dynamics of measuring devices. However, mass (i.e. matter), surrounding space and measuring devices in weak gravitational fields (dynamics in inertial reference frame) have very similar energy density; within the interval of the radius of a very large and dominant mass (i.e. a planet), the mass density is approximately constant per inverse distance square function of gravity. Therefore, the existence and dynamics of measuring devices have negligible effect on weak gravitational field dynamics. The existence and dynamics of measuring devices also have negligible effect on cosmological scale dynamics due to the infinitesimally large distances between the positions of the dynamics and the positions of the measuring devices. However, Equilibrium theory asserts that the existence and dynamics of measuring devices, which are relatively high energy density structures (i.e. matter) will have significant effect on the "quantum scale", which involves the dynamics of structures such as the photon, whose dynamics is determine exclusively by the energy density of the space in which it exists. Infinitesimally small changes in the energy density of surrounding space, induced by the existence and dynamics of measuring devices determines the dynamics of photons (i.e. wave-particle duality).

Photon existence results from the asymmetrical stretching of the compressible fluid to the lowest possible energy density and away from the "photon" source, thus creating a local energy density differential in the surrounding structure/space, which drives the mapping/motion of the photon structure. Since the "photon" structure is the lowest possible energy density structure within the compressible fluid, it always induces the maximum possible local energy density differential; therefore the rate at which the "photon" structure maps/transforms surrounding structure/space is the maximum possible. Consequently, the speed of light is constant and is the maximum speed limit in the universe. Light fluctuates between "existence in motion" and "non-existence", as all its energy is consumed in the process of existence. As mentioned earlier, light (photon) is the lowest possible energy density structure, whose existence is restricted to a specific energy density and the dynamics of light is determined exclusively by the energy density of the surrounding structure/space being stretched, therefore the dynamics of light is the internal reference for measurements of dimension and time in a given energy density structure/space. Consequently, measurements of dimension and time must be corrected, if performed in a different energy density structure/space/mass than the structure/space/mass being analyzed. Note, as space energy density increases (i.e. space is compressed), the distance between the existence positions of photons is also compressed, with higher frequency and shorter wavelength of photons in the presence of strong gravitational field induced length contraction/time dilation (gravitational blue/red shift) or weak gravitational field dynamics induced length contraction/time dilation (blue/red shift) and verse visa. The frequency of the photons increases in order to compensate for the higher energy density of surrounding space; higher frequency generates higher energy per area, thus compensating for the higher energy density of surrounding space, until a "non-existence" surrounding space is encounter, thus converting the photon structure into a relatively higher energy density structure termed "matter". Most importantly, Equilibrium theory asserts that the force carrier in both strong and weak gravitational field dynamics is the photon structure, which facilitates the exchange of the lowest energy density structure for relatively higher energy density structure in the formation of matter.

The structure of an elastic string with a pulse structure mimics the nature of measurement in the universe as analyzed from a uniform and constant non-associated (fixed) reference frame. If equally spaced makers, placed at fixed locations on an infinitesimally long elastic string that has no pulse, the distance between the markers are equal and thus measurements of dimension and time across the string will be constant. However, if a pulse structure is generated on the elastic string by compression of the string towards a point via energy exchange, and the resulting amplitude of the string varies as a function of inverse distance square from the point; the distance between markers on and around the pulse will contract (i.e. length contraction and time dilation), while the distance between markers furthest away from the pulse will expand, as analyzed from a uniform and constant non-associated (fixed) reference frame. Importantly, the amplitude difference at infinitesimally small distances from the "compressed" point will be infinitesimally small, thus the distance between the markers in this region/interval will be approximately constant as analyzed from a uniform and constant non-associated (fixed) reference frame (i.e. Newtonian approximations of Euclidian space). Additionally, at infinitesimally large distances from the "compressed" point, the distance between the markers in this region/interval will also be approximately constant (i.e. Newtonian approximations of Euclidian space); however there exist a differential region/interval between these two extremes, as analyzed from a uniform and constant non-associated (fixed) reference frame (i.e. Special/General relativity approximations of Lorentzian manifold). Additionally, the mapping/motion of the pulse structure is associated with relatively higher amplitude of the surrounding elastic string in the direction of mapping/motion and relatively lower amplitude of the surrounding elastic string in the opposite direction of mapping/motion, thus the distance between the markers contract in the direction of mapping/motion and expand in the opposite direction of mapping/motion (i.e. Special/General relativity approximations of Lorentzian manifold).

**Proof:** If we accept the validity of Theorem 1, then the universe can be approximated as a "compressible fluid", whose dynamics can be described mathematically using the wave equation (1) [19]. The one-dimensional wave equation for dynamical process involving a demarcated approximately uniform energy density spacetime structure "*U*" yield:
$\rho(x, t) \cdot d^2U/dt^2(x, t) = T(x, t) \cdot d^2U/dx^2 (x, t)$ (1)

Changes of "*U*" as a function of time ($d^2U/dt^2$) can be accurately represented as a measure of the rate of change in the position of "*U*" as a function of time, since said changes requires energy perturbations (i.e. energy exchange). Furthermore, changes of "*U*" position as a function of time ($d^2U_{position}/dt^2$) can also be represented as a measure of the rate of increase in the energy density of surrounding space in the direction of mapping/motion as a function of position, as motion/mapping of "*U*" is induce by the differential energy density of surrounding space. Importantly, the measurements of time and dimension are equivalent. $T(x, t)$ at the demarcated structure "*U*" is the restoring force, which is manifested as the gravitational force in strong gravitational field dynamics and the inertia force in weak gravitational field dynamics (dynamics in inertial reference frame). Since the wave equation is symmetrical, $T(x, t)$ is equivalent to $\rho(x, t)$; the restoring force "$T(x, t)$" is a measure of the energy density "$\rho(x, t)$" and the energy density "$\rho(x, t)$" is a measure of the restoring force "$T(x, t)$". Changes in "*U*" as a function of position ($d^2U/dx^2$) can be accurately represented as a measure of the rate of change in the dimension of "*U*" as a function of position, since the dimension of "*U*" is a measure of the energy content of "*U*". As demonstrated earlier, the relation between "*U*" (i.e. mass

– matter) and space is the inverse function “gravity”; on the graph of the function, the second derivative corresponds to the curvature of the graph. Consequently, $d^2U_{dimension}/dx^2\ (x, t)$ is a measure of the dimension ($D_u$) of the demarcated structure “$U$” at position “$x$” and time “$t$”. Therefore, $d^2U_{dimension}/dx^2(x, t)=[(1/D_u)(m/m^2)]=[1/D_u(m)]$ (6).

Approximately exact solutions of the wave equation involving a demarcated approximately uniform energy density structure “$U$” within the compressible fluid can be obtained using analytical methods such as “Perturbation theory” [24]. The Approximately exact solution of the wave equation for dynamics using “Perturbation analysis” yields $A \approx A_0 + \epsilon A_1$, where $A_0$ is the known solution to the exactly solvable initial problem and $A_1$ represent the "first-order" perturbation correction. $\epsilon$ is the perturbation parameter, which accurately corrects for small perturbation and can be represented using an algebraic equation based on experimental results and know physical laws [24]. These assumptions are valid for all dynamics in the universe, as the analyzed energy perturbations relative to the energy content of the universe are infinitesimally small and all known dynamics involve only internal energy of the universe (i.e. the law of energy conservation). Additionally, even though the universe is expanding (i.e. space is in a stretching phase) the energy density of the detectable/measurable space/universe including masses (i.e. planets, objects) are changing so slowly that the effect of a stretching universe can be approximated as negligible for analytical purposes.

Analysis of dynamics in strong gravitational field is dominated by the gravitational force, which is the restoring force “$T(x, t)$” in the wave equation and analysis of dynamics in weak gravitational field involves the inertia force, which is also the restoring force “$T(x, t)$” in the wave equation. Strong gravitational field dynamics most often involves dynamics between a very large dominant mass (i.e. Earth) and a very small and negligible mass (i.e. an apple). Therefore, the gravitational acceleration of a negligible mass (i.e. an apple) towards a very large and dominant mass (i.e. Earth) is due to the differential energy density of increasing magnitude in surrounding space around the negligible mass “$U$” induced by the existence of the very large and dominant mass (i.e. Earth). The differential energy density of increasing magnitude in surrounding space around the mass “$U$” in weak gravitational field dynamics (dynamics in inertial reference frame) is transient, as it is rapidly dissipated due to energy exchange in mapping/motion. The differential energy density of increasing magnitude in the direction of motion around the mass “$U$” induces energy exchange due to the tension associated with the existence of the demarcated approximately uniform energy density structure “$U$”; the energy exchange facilitates the motion/mapping of “$U$”.

In gravitational dynamics, the existence of a given “photon” structure is restricted to a specific energy density and the dynamics of photons is determine exclusively by the energy density of surrounding space, therefore the travel path of light approaching from a relatively lower energy density space will curved around a very large and dominant mass as the relatively lower energy density space “existence positions” of the approaching photons will exist along the “curved” path (i.e. General relativity approximations - Einstein Cross). However, the travel path of light in the approximately uniform energy density space of weak gravitational field (dynamics in inertial reference frame) will be approximately uniform, thus traveling along a “straight” path (i.e. Newtonian approximations).

The exact solution for the restoring force “$T(x, t)$” associated with “$U$” during perturbations yields: $T \approx T_0 + \epsilon T_1 \approx \epsilon T_1$. The initial condition restoring force/tension “$T_0$”

associated with the demarcated structure "*U*" (i.e. matter – planets, objects) is approximately zero for both weak and strong gravitational field dynamics as energy density is approximately uniform and constant at equal distance from the center of the demarcated structure "*U*" in the absence of perturbations. This assertion is equivalent to Newton's first law of motion, no change in state/dynamics of a mass occurs in the absence of an external force. Perturbation is defined as the existence of differential energy density of increasing magnitude in the direction of motion/mapping in surrounding space. Perturbation is induced by the existence of a very large and dominant mass for strong gravitational field dynamics, while in weak gravitational field dynamics, perturbation results from the existence of transient differential energy density of increasing magnitude in the direction of motion/mapping, which is induced by internal energy from "*U*" (i.e. a person running) or from an external energy source (i.e. motion of a person due to pushing/pulling).

Therefore, $T_u = [\rho_u \cdot (d^2U/dt^2)]/(d^2U/dx^2) = [\rho_u \cdot (D_u) \cdot (d^2U/dt^2)] = M_u \cdot (d^2U/dt^2)$ (7)

The analysis of the gravitational force "$T_u$" on the demarcated structure "*U*" yields:

$T_u\ (N) = M_u \cdot (d^2U/dt^2) = [M_u(kg)] \cdot [a_u(m/s^2)] \cdot [\epsilon] = [M_u(kg)] \cdot [\mu_g(m/s^2)] \cdot [\epsilon]$ (8)

"$M_u$" is the mass of the demarcated approximately uniform energy density structure "*U*" analyzed in the gravitational dynamics at position "*x*" and time "*t*". The mass density "$\rho(x, t)$" of the compressible fluid in the absence of perturbation is approximately constant and uniform at equal distance from the center of "*U*" and decreases as a function of inverse distance square from the center of "*U*" as analyzed from a constant and non-associated (fixed) reference frame; therefore, no motion/mapping is induced. The existence of a very large and dominant mass within the vicinity of the structure "*U*" induces differential energy density over the surrounding space which increases as a function of inverse distance square towards the center of the large and dominant mass as analyzed from a uniform and constant non-associated (fixed) reference frame, and results in the gravitational acceleration of "*U*". Importantly, the relatively smaller and negligible mass (i.e. an apple) has infinitesimally small effect on the mass density "$\rho(x, t)$" over the space of the gravitational dynamics and can be accurately approximated as negligible; thus the differential mass density "$\rho(x, t)$" over the space of the gravitational dynamics as analyzed from a constant and non-associated (fixed) reference frame is only dependent on the very large and dominant mass (i.e. Earth). Furthermore, the gravitational acceleration of the very large and dominant mass (i.e. Earth) in response to the existence of a negligible mass (i.e. an apple) is infinitesimally small as the negligible mass has negligible effect on the energy density of the surrounding space.

The mapping/motion of demarcated structure "*U*" to the emergent equilibrium position in gravitational dynamics results from energy exchange mediated by the differential energy density of surrounding space due to the tension associated with the existence of the approximately uniform energy density structure "*U*". $d^2U/dt^2$ is a measure of changes in the position of "*U*" as a function of time ($d^2U_{position}/dt^2$) in gravitational dynamics, since changes in the position of "*U*" as a function of time requires energy perturbations. Thus, $d^2U/dt^2$ is the gravitational acceleration of the demarcated structure "*U*" ($a_u$), and is proportional to the rate at which the energy density of the surrounding space increases as a function of position, since the energy exchange requirements for motion/mapping of demarcated structure "*U*" is mediated exclusively by this differential energy density of surrounding space. Furthermore, the measurement of time and distance/dimension are equivalent and are related by a constant, the speed of light. The above assertion on gravitational acceleration is equivalent to the "equivalence principle" of general relativity. Einstein's statement of the equivalence principle is as quote "A little reflection will show that the law of the equality of the inertial and gravitational mass is equivalent to the assertion that the acceleration imparted to a body by a gravitational field is independent of the nature of the body. For Newton's equation of motion in a gravitational field, written out in full, it is: (Inertial mass) · (Acceleration) = (Intensity of the gravitational field) · (Gravitational mass). It is only when there is numerical equality between the inertial and gravitational mass that the acceleration is independent of the nature of the body". Most importantly, it can also be deduced from the above statement that the acceleration of a body in gravitational dynamics and the intensity of the gravitational field are also equivalent. As mentioned previously, the mass/energy density of space is a measure of the intensity of the gravitational field, thus the differential mass/energy density of surrounding space is a measure of gravitational acceleration. Therefore, $d^2U/dt^2$ is the standard gravitational parameter $\mu$ induced by the existence of a very large and dominant mass (*M*) divided by the square of the distance(*d*) over the gravitational space ($d^2U/dt^2 = d^2U_{position}/dt^2 = [\mu/d^2]\cdot[\epsilon] = \mu_g\cdot[\epsilon]$). The distance over the gravitational space is restricted to the center of "*U*" (i.e. center of the apple) and the center of the very large and dominant mass (i.e. center of Earth) because at that position of space the energy density is uniform, thus gravitational acceleration is zero. The energy density difference between different matter-mass structures (i.e. planets, objects) is infinitesimally small and thus approximated as negligible for analytical purposes. Therefore, the increase in the mass/energy density of space in the direction of motion/mapping of the gravitational dynamics induced by the existence of a very large matter-mass (*M*) is a function of a constant, the Gravitational constant [$G=6.67\times10^{-11}\ N\cdot(m/kg)^2$]. The standard gravitational parameter $\mu$ is equivalent to the mass of the very large matter-mass (*M*) multiply by the Gravitational constant "*G*" ($G\cdot M$). Importantly, the Gravitational constant "*G*" incorporates the constant "*c*" (speed of light) for conversion of distance (*d*) to time (*t*). In conclusion, acceleration in gravitational dynamics results from energy exchange mediated exclusively by the differential energy density of surrounding space; thus, the gravitational acceleration is independent of the mass of "*U*" and is exclusively dependent on the mass of the very large and dominant matter-mass and the distance over the gravitational space.

$$d^2U_{position}/dt^2 = [a_u(m/s^2)]\cdot[\epsilon] = [\mu_g\,(m/s^2)]\cdot[\epsilon] = [M(kg)\cdot G(m^3/kg\cdot s^2)/d^2(m^2)]\cdot[\epsilon] \quad (9)$$

Importantly, it should be noted that the measurement of dimension and time is a function of the energy density of a given space, thus the measurements of dimension and time over a differential energy density space structure will be differential, and therefore measurements must be corrected for deviation from uniformity using the perturbation parameter "$\epsilon$". The perturbation parameter "$\epsilon$" for gravitational dynamics = $\sqrt{(1-2G\cdot M/d\cdot c^2)}$, which is a measure of the differential energy density (i.e. curved) space structure induced by the existence of a very large and dominant mass (*M*), thus allowing correction for measurements of dimension and time in the demarcated gravitational space as analyzed from a non-associated constant and uniform (fixed) reference-frame. As mentioned earlier, "*c*" represents the maximum speed of limit in the universe.

At $d \approx$ radius of a very large and dominant mass $\approx 0$ (undefined) per shell theorem [7], the energy density of surrounding space becomes approximately uniform and constant. Additionally, per the inverse distance square function of gravity (energy density), the energy density at relatively very small distances from the center of a very large and dominant mass becomes approximately uniform and constant. Consequently measurements of dimension and time over the space are approximately uniform and constant, thus $\epsilon \approx 1$. At $d \rightarrow \infty$, the surrounding space energy density also becomes approximately uniform and constant; consequently measurements of dimension and time over the space are also approximately uniform and constant, thus $\epsilon \approx 1$. The above conditions ($\epsilon \approx 1$) describe Newtonian theoretical and mathematical approximations of gravitational dynamics (Newton's universal law of gravitation) [2, 3]; however the energy density over the interval between these extremes is highly differential, thus the perturbation parameter "$\epsilon$" corrects for the differential measurements of distance and time, which accounts for the theoretical and mathematical approximations of general relativity [7, 8].

Importantly, the direction of mapping/motion and the location of the observer in strong gravitational field dynamics (i.e. gravitational dynamics) determines $\epsilon$, with $\epsilon = \epsilon < 1$ for mapping/motion away from an observer in a relatively higher energy density space and towards a relatively lower energy density space (gravitational red shift, length expansion, time contraction – the energy density of the space between the observer and "$U$" is decreasing) while $\epsilon = (1/\epsilon) > 1$ for mapping/motion towards an observer in a relatively higher energy density space and away from a relatively lower energy density space (gravitational blue shift, length contraction, time dilation – the energy density of the space between the observer and "$U$" is increasing).

Dynamics/perturbations in weak gravitational field (dynamics in inertial reference frame) involves the inertia force, which is also the restoring force "$T(x, t)$" in the wave equation, and thus equivalent to the gravitational force.

The analysis of the inertia force "$T_u$" on the demarcated structure "$U$" yields:

$$T_u\ (N) = M_u \cdot (d^2U/dt^2) = [M_u(kg)] \cdot [a_u(m/s^2)]\cdot[\epsilon] \quad (10)$$

"$M_u$" is the mass of the demarcated approximately uniform energy density space structure "$U$" at position "$x$" and time "$t$" during perturbation in weak gravitational field. The mass density "$\rho(x, t)$" of space in weak gravitational field is approximately uniform and constant in the absence of perturbations as analyzed from a non-associated constant and uniform (fixed) reference-frame, per Theorem 1 and per the inverse distance square law of gravity.

$d^2U/dt^2$ is a measure of changes in the position of "$U$" as function of time in weak gravitational field dynamics, since changes in the position of "$U$" as function of time requires energy perturbations (i.e. energy exchange). $d^2U/dt^2 = d^2U_{position}/dt^2$ is the acceleration ($a_u$) of the demarcated structure "$U$" in weak gravitational field dynamics, which is a measure of the rate of transformation/reconfiguration of surrounding space at position "$x$" as a function of time "$t$" in order to form the demarcated structure "$U$".

Importantly, it should be noted that the measurement of dimension and time is a function of the energy density of a given space, thus the measurements of dimension and time associated with "$U$" in weak gravitational field dynamics will be differential during perturbations. Therefore, measurements must be corrected for deviation from uniformity using the perturbation parameter "$\epsilon$". The mass/energy density of surrounding space increases in the direction of mapping/motion and verse visa, as analyzed from a non-associated constant and uniform (fixed) reference-frame. Furthermore, the mass of "*U*" will be differential during perturbations as energy is exchange with surrounding space. The perturbation parameter "$\epsilon$" for weak gravitational field dynamics = $\sqrt{(1-v^2/c^2)}$. The perturbation parameter "$\epsilon$", is a measure of the transient energy density differential in the surrounding space of "*U*" in weak gravitational field dynamics, thus allowing corrections for measurements of distance and time. In the algebraic equation, $v$ is the velocity of "*U*" ($dU/dt = dU_{position}/dt$). Since the energy density of space is approximately uniform and constant in weak gravitational field in the absence of energy perturbations, energy perturbation is require for motion/mapping; thus the velocity of mass "*U*" is a measure of the energy exchange in weak gravitational field dynamics (dynamics in inertial reference frame). The velocity of mass "*U*" is due to transient increases in the energy density of surrounding space in the direction of motion/mapping (i.e. blue shift), thus inducing a new equilibrium position of "*U*", which is termed motion. The mapping of "*U*" to the emergent equilibrium position results from energy exchange mediated by the transient differential energy density of surrounding space due to the tension associated with the existence of the demarcated structure of approximately uniform energy density "*U*". The energy exchange results in the rapid dissipation of the differential energy density and the restoration of an approximately uniform energy density surrounding space. "*c*" is the speed of light in vacuum, which is the speed limit in the universe. The speed of light is induced by the maximum allowable differential energy density space surrounding in the universe, thus it is the energy density differential limit. As the mass density "$\rho(x, t)$" increases, measurements of time dilate, while measurements of length contract as analyzed from a non-associated constant and uniform (fixed) reference-frame and verse visa. Measurements of time and distance/dimension remain uniform and constant in a uniform and constant energy density space as analyzed from a non-associated constant and uniform (fixed) reference-frame.

As $v \rightarrow 0$, very little energy is exchange between "*U*" and the surrounding space, thus $\epsilon \approx 1$, and measurements of dimension and time are approximately uniform and constant. The above condition ($\epsilon \approx 1$) describes Newtonian theoretical and mathematical approximations of dynamics in inertial reference frame (Newton's second law of motion) [2, 3]. Furthermore, the equilibrium nature of the "compressible fluid" model of the universe is manifested as Newton's third law of motion, every action results in equal and opposite reaction. Importantly, as $v \rightarrow c$, very large amounts of energy is exchange between "*U*" and the surrounding space, thus the surrounding space energy density becomes highly differential; therefore the perturbation parameter "$\epsilon$" corrects for the differential measurements of distance/dimension and time, which accounts for the theoretical and mathematical approximations of special relativity. Importantly, the direction of mapping/motion and the location of the observer in weak gravitational field dynamics (dynamics in inertial reference frame) determines $\epsilon$, with $\epsilon = \epsilon < 1$ for mapping/motion away from an observer (red shift, length expansion, time contraction – the energy density of the space between the observer and "*U*" is relatively decreased) while $\epsilon = (1/\epsilon) > 1$ for mapping/motion towards an observer (blue shift, length contraction, time dilation – the energy density of the space between the observer and "*U*" is relatively increased). ■

## 6 Conclusions

Dynamics in weak and strong gravitational fields are currently described using the Newtonian and general relativity theoretical and mathematical frameworks; however, there are limitations associated with these frameworks in describing dynamics at infinitesimally small-scale “quantum scale” of the universe. Furthermore, currently accepted theories of gravitation (general relativity) can’t explain several astronomical and cosmological phenomena (i.e. black holes, dark matter). Here, I demonstrate that both Newtonian and general relativity theoretical and mathematical frameworks are approximations of a novel theory, the “Equilibrium theory”, which is mathematically represented using the wave equation. Equilibrium theory asserts that the universe in its entirety is a continuous differential energy density structure, a “compressible fluid” as analyzed from a uniform and constant non-associated (fixed) reference frame. Furthermore, Equilibrium theory asserts that the universe is always at equilibrium (i.e. the law of energy conservation). A major feature of the “compressible fluid” model of the universe is that dynamics in strong and weak gravitational fields are mediated by energy exchange within the “compressible fluid”. The force carrier (i.e. energy exchange structure) of the gravitational and inertia force is the “photon” structure, which is the lowest possible energy density structure, whose existence is restricted to a specific energy density; thus it fluctuates between existence and non-existence (i.e. transformation into matter) [25]. Importantly, the gravitational field structure and the electromagnetic field structure are equivalent, as they are both induced by the dynamics of the “photon” structure [25]. The gravitational field structure involves space (i.e. compressible fluid) with relatively disordered and non-uniform energy flow (i.e. fluid flow) while the electromagnetic field structure involves space (compressible fluid) with relatively ordered and uniform energy flow (i.e. fluid flow).

The predictions/results of quantum physics including non-locality, wave-particle duality, complementarity, quantum entanglement etc. are in agreement with Equilibrium theory, as Equilibrium theory asserts that the universe is an “compressible fluid” in its entirety, which is composed of differential energy densities within a non-discrete and continuous structure as analyzed from a uniform and constant non-associated (fixed) reference frame. Most importantly, Equilibrium theory reinterprets the wave function in quantum physics as a mathematical representation of differential energy densities within a non-discrete and continuous structure (compressible fluid model) and not probability densities of discrete structures. Equilibrium theory also demonstrate that the existence and dynamics of measuring devices is not independent of surrounding space, thus measuring devices will significantly affect dynamics on the “quantum scale” but have negligible effect (i.e. infinitesimally small effect) on dynamics beyond the “quantum scale”. Lastly, quantum physics is currently described using the mathematical framework of the wave equation, thus Equilibrium theory provides a novel theoretical and mathematical framework for elucidating the nature and dynamics of the universe at both the “quantum” and “cosmological” scales.

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