

Exists Gravitation Inverse Matter

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Abstract

Existence of gravitation inverse matter in finite space is shown inevitable. As an example, direction of gravitation of rest mass of electron is opposite to that of positron. That is, electron and positron are gravitationally repulsive to each other. The physical space has previously been shown of finite extent. Therefore, if gravitation normal matter is found prevailing in the physical space then, according to the law of mass/charge balance in finite space, the Universe, *i.e.*, the physical space and all that it contains/confines, must be a shell-structured black hole in a higher dimensional space.

Keywords

Geometry of Physical Space, Shell-structured Black Hole, Evolution of the Universe

1. Introduction

The general relativity theory of Einstein [1] has implied finiteness of the physical space [2], and that assumption has been shown true by metrological analysis [3], high-precision atomic clock experiment [4], and celestial observations [5]. This essay aims to demonstrate that, in finite space, the presence of gravitation inverse matter is inevitable. Therefore, if gravitation normal matter is found prevalent in the physical space then, according to the law of mass/charge balance in finite space, the Universe, *i.e.*, the physical space and all the matter/radiation contained/confined within it, must take the form of a shell-structured black hole (SBH) in a higher dimensional space (HDS). This concept provides a natural explanation on how the Universe may have originated without a dramatic event such as the Big Bang.

2. Gravitation Inverse Matter

By the flux conservation theorem of Gauss for gravity, *i.e.*, Gauss gravitation law,

mass enclosed by an enclosure is

$$m = -\oiint_{\text{ESC}} \frac{\mathbf{G} \cdot d\mathbf{S}_{\text{ESC}}}{4\pi G}. \quad (1)$$

Wherein, ESC is a nonlocal simultaneous enclosure of simple connectivity (ESC), which is a simply/singly connected region of space, in gravitation field \mathbf{G} that is caused by mass m , $d\mathbf{S}_{\text{ESC}}$ areal element of ESC, and G the gravitation constant.

Finite space has a unique property that any ESC therein shall divide the space into two partitions on equal footing. That is, with respect to an ESC, no part of the space divided thereby is more privileged than the other part in any and all aspect/detail, *i.e.*, there is no real, physical distinction between inside and outside of an ESC in finite space, because the term inside/outside is only of relative meaning pending on perspective of the subject. Metrologically, mass probe at an ESC can but only probes existence/absence of gravitation field at a point of the ESC, including strength of the field and direction of the force, with respect to the point at the ESC but nothing else. Therefore, according to Equation (1), gravitation masses must exist in both regions of finite space that are equal in amount but opposite in direction of gravitation. Such masses are interdependent on each other, *i.e.*, one cannot exist if the other does not and if one exists then the other must too. Therefore, in finite space, gravitation mass cannot exist alone but must exist in pair. In language of field, static gravitation field line in finite space must possess starting and ending points that are not one and the same point in the space, since such line cannot curl back onto itself or otherwise violation of energy conservation law is inevitable.

To distinguish masses in mass pair, arbitrarily assign the mass probe as of gravitation normal matter (gravitation matter, normal matter). Any object gravitationally attracted to/by the mass probe is then regarded as gravitation normal matter and any object gravitationally repulsed to/by the mass probe as gravitation inverse matter. Accordingly, gravitation interaction among gravitation normal matter is gravitative attraction, gravitation interaction among gravitation inverse matter is gravitative attraction, and gravitation interaction between gravitation normal and inverse matter is gravitative repulsion.

Accordingly, if there exists a particle of normal matter in Rest State (RS) [3] at internal origin of finite space then there must also exist a particle of inverse matter of equal amount in RS at antipode of the origin. Were this not the configuration, gravitative repulsion between the particles would force particles of the pair out of their respective resting state without intervention of others. In gravitation field of such pair, a particle of normal matter at rest shall feel gravitation force according to Newton's law of gravitation. Such force can be understood as due to attraction of the particle of normal matter at the origin, or repulsion of the particle of inverse matter at the antipode, or a combination thereof, since field lines of the field-causing pair are one and the same. Such understanding is, for static field, unaltered even if the particle is in vicinity of a field-causing particle, *e.g.*, at origin or

antipode, since strength of the field of the remote particle is as strong thereat, in fact, exactly the same, as that of the nearby one, due to space lens [5].

In infinite space, Gauss gravitation law establishes a relationship between gravitation field and mass associated with the field but it does not completely determine distribution of the mass enclosed by ESC with respect to the field at ESC. Therefore, mass particle and uniformly distributed mass of spherical symmetry, including mass shell (MS), are equivalent/indistinguishable under the law. In finite space, however, it is guaranteed that mass object and its counterpart are of identical shape/size/distribution if both parties are in RS in origin-antipode configuration. This guarantee is but a consequence of the flux conservation theorem in finite space, *i.e.*, space lens effect. In addition, if a mass object of uniform spherical distribution is of hollow structure, e.g., MS, then the hollow region inside the object is free of the field of the object as well as that of its inverse matter.

An underlying prerequisite for Gauss gravitation law is that ESC referred to by the law must be a nonlocal simultaneous region in field. However, there is generally no such thing as locally defined common time in field hence nonlocal simultaneity in same [6]. Only on special occasions, e.g., in static field of spherical symmetry, locally defined common time may exist in certain region therein, therefore nonlocal simultaneity may be definable thereat. Therefore, nonlocal simultaneous ESC in Gauss gravitation law must conform to such region, *i.e.*, be spherical and concentric to spherical field.

3. The Law of Mass/Charge Balance in Finite Space

If, instead of mass particle, charge particle in RS in finite space is considered then the analysis is essentially identical to that for mass particle. Accordingly, if there exists a positive charge in finite space then there must also exist a negative charge in same and the latter must be identical to the former in amount but opposite in sign. Such charges are interdependent on each other, *i.e.*, one cannot exist if the other does not and if one exists then the other must too. Therefore, in finite space, charge cannot exist alone but must exist in pair. In language of field, static electric field line in finite space must possess starting and ending points that are not one and the same point in the space, since such line cannot curl back onto itself or otherwise violation of energy conservation law is inevitable.

Therefore, in finite space, charges are and must be in balance hence total charge in the space is neutral, *i.e.*, there can be no net charge of positive or negative type in finite space if summing all charges over the entire space nonlocal simultaneously in Rest Time [3]. Likewise, in finite space, masses are and must be in balance hence total mass in the space is neutral, *i.e.*, there can be no net mass of normal or inverse type in finite space if summing all masses over the entire space nonlocal simultaneously in Rest Time. This is referred to as the law of mass/charge balance in finite space.

Accordingly, if there exists a positive charge in RS at internal origin of finite space then there must also exist a negative charge of equal amount in RS at

antipode of the origin. However, such configuration is metastable due to electrostatic attraction between charges of opposite sign. In electric field of such pair, a negative charge at rest shall feel electrostatic force, which can be understood as due to attraction of the positive charge at the origin, or repulsion of the negative charge at the antipode, or a combination thereof, since field lines of field-causing charges are one and the same. Such understanding is, for static field, unaltered even if the probe charge is in vicinity of a field-causing charge, e.g., at origin or antipode, since strength of the field of the remote charge is as strong thereat, in fact, exactly the same, as that of the nearby one, due to space lens.

In infinite space, the flux conservation theorem establishes a relationship between electric field and charge associated with the field but it does not completely determine distribution of the charge enclosed by ESC with respect to the field at ESC. Therefore, charge particle and uniformly distributed charge of spherical symmetry, including charge shell, are equivalent/indistinguishable under the theorem. In finite space, however, it is guaranteed by space lens effect that charge object and its counterpart are of identical shape/size/distribution if both parties are in RS in origin-antipode configuration. In addition, if a charge object of uniform spherical distribution is of hollow structure, e.g., charge shell, then the hollow region inside the object is free of the field of the object as well as that of its counterpart.

If the charge particle in consideration is an electron in RS at internal origin of finite space then there must exist a particle in RS at antipode of the origin having equal amount of charge but with opposite sign. Such particle is commonly known as positron [7]. Electron possesses nonzero rest mass. Therefore, electron is active in gravitation. That is, in addition to electric field, electron also has gravitation field in association. Accordingly, counterpart of electron must also possess nonzero rest mass which is equal in amount but opposite in type with respect to that of electron. Therefore, an electron/positron must be gravitation inverse matter of a positron/electron. Whether rest mass of electron is gravitation normal or inverse matter, *i.e.*, if electron would be gravitationally attracted to or repelled by, e.g., proton (assigned as gravitation normal matter) is a subject of experimentation/observation.

4. Mass Shell

Consider a large set of identical mass particles distributed uniformly in a two dimensional sphere surrounding a core mass of same type centered at origin of a three dimensional space. Such set of mass particles is referred to as a MS. To any member of MS, gravitation attraction from all other members of same is equal to that from half of the other members of the set at the origin. Therefore, work done to relocate a member of MS outward is, under infinite space approximation,

$$\frac{dw}{dr} = \frac{d\epsilon_{MS}}{dr} \approx \frac{m_{MS}}{r^2} f, f \equiv G_{M_0}^{1/2} G_{MS}^{1/2} M_0 + \frac{1}{2} G_{MS} M_{MS}. \quad (2)$$

Wherein, dw is work done to relocate a member of MS in infinitesimal

displacement and velocity, r radius of MS, ϵ_{MS} and m_{MS} rest energy and rest mass of member of MS at rest in field of others, M_0 rest mass of the core mass at rest at the origin, G_{M_0} gravitation constant as measured by the core mass at rest in field of others, G_{MS} gravitation constant as measured by member of MS at rest in field of others, and M_{MS} rest mass of MS at rest in field of MS and others.

By the law of mass energy equivalence of Einstein [8],

$$m_{MS} = \frac{\epsilon_{MS}}{c_{MS}^2} \rightarrow \frac{d\epsilon_{MS}}{dr} = \frac{\epsilon_{MS}}{c_{MS}^2 r^2} f \rightarrow \frac{d\Delta\epsilon_{s,MS}}{dr} = \frac{\Delta\epsilon_{s,MS}}{c_{MS}^2 r^2} f. \quad (3)$$

Wherein, c_{MS} is speed of light in vacuo (SLV) as measured by member of MS at rest in field of MS and others, and $\Delta\epsilon_{s,MS}$ self energy difference of member of MS at rest at MS defining self time of same. By the definition of atomic time (AT) [3],

$$\Delta\epsilon_{s,MS} = \mathcal{N}_i h \mathbb{U}_{AT,MS}^{-1} \rightarrow \frac{d}{dr} \mathbb{U}_{AT,MS}^{-1} = \mathbb{U}_{AT,MS}^{-1} \frac{f}{c_{MS}^2 r^2}. \quad (4)$$

$\mathbb{U}_{AT,MS}$ is unit of AT of member of MS at rest in field of others, \mathcal{N}_i immutable numeral assigned in the definition of AT, and h the Planck constant, which is invariant in centripetal force field [6]. By the definition of SLV defined on AT [9],

$$\mathbb{U}_{AT,MS}^{-1} = \frac{c_{MS}}{\mathcal{N}_c \mathbb{U}_L} \rightarrow \frac{d\beta_{MS}}{dr} = \frac{f}{c_i^2 r^2 \beta_{MS}}, \beta_{MS} \equiv \frac{c_{MS}}{c_i}. \quad (5)$$

\mathcal{N}_c is an immutable numeral assigned in the definition of SLV, and \mathbb{U}_L unit of length, an invariant by metrological analysis [3] [6]. β_{MS} is referred to as Schwarzschild Factor [6], which is in association with member of MS at rest in field of others. c_i is SLV measured/defined in RS free of any field. With Equation (3),

$$\frac{d\epsilon_{MS}}{\epsilon_{MS}} = \frac{d\beta_{MS}}{\beta_{MS}} \rightarrow \epsilon_{MS} = \beta_{MS} \epsilon_i \rightarrow m_{MS} = \frac{m_i}{\beta_{MS}}. \quad (6)$$

ϵ_i and m_i are self/rest energy and self/rest mass of member of MS in RS.

By specification, the core mass is in RS. Therefore,

$$G_{M_0} = G_i, M_{MS} \equiv \sum_j m_{MS,j} = \sum_j \frac{m_{i,j}}{\beta_{MS}} = \frac{M_i}{\beta_{MS}} \rightarrow \frac{d\beta_{MS}}{dr} = \frac{G_{MS} M_i}{c_i^2} \frac{1 + \eta \sqrt{G_i/G_{MS}} \beta_{MS}}{2\beta_{MS}^2 r^2}, \eta \equiv \frac{2M_0}{M_i} \geq 0. \quad (7)$$

M_i is the sum of rest/self mass of all members of MS dispersed in RS, and G_i gravitation constant as measured in RS free of any field. It has been shown that [6]

$$G_{MS} = \frac{G_i}{\beta_{MS}^4} \rightarrow \frac{d\rho_{MS}^{-1}}{d\beta_{MS}} = -\frac{2\beta_{MS}^6}{1 + \eta\beta_{MS}^2}, \rho_{MS} \equiv \frac{r}{r_{g,MS}}, r_{g,MS} \equiv \frac{G_i M_i}{c_i^2}. \quad (8)$$

$r_{g,MS}$ is characteristic length of the field of MS as measured with members of MS dispersed in RS. Solution of Equation (8) is obtainable. Accordingly, β_{MS} is an analytical function of ρ_{MS} and parameter η .

From perspective of a foreign mass particle outside of MS,

$$\rho_f \equiv \frac{r_f}{r_{g,f}}, r_{g,f} \equiv \frac{G_i}{c_i^2}(M_0 + M_{MS}), \beta_{g,f} \equiv \frac{c_{f,0,g}}{c_i}, \rho_{SS,f} = 4 \rightarrow r_{SS,f} = 4r_{g,f}. \quad (9)$$

Wherein, r_f is the distance between foreign mass particle and center of the field of M_0 and MS in RS, and $r_{g,f}$ characteristic length of the field of M_0 and MS in RS. $\beta_{g,f}$ is the Schwarzschild Factor in association with the foreign mass particle at rest in the field, and $r_{SS,f}$ radius of Schwarzschild Sphere (SS) of the field as measured by foreign mass particle at rest in the field.

At formation of static black hole of MS,

$$r_{SS,f} = r_{SS,MS} \rightarrow \rho_{MS,SS} = 4 \frac{M_{MS,SS}}{M_i} = 2\eta + \frac{4}{\beta_{MS,SS}}. \quad (10)$$

$r_{SS,MS}$ is radius of SS of MS as measured by foreign mass particle at rest in the field, $M_{MS,SS}$ and $\beta_{MS,SS}$ are rest mass of MS and Schwarzschild Factor of member of MS at formation of static black hole of MS. With the solution of Equation (8),

$$\begin{aligned} \frac{\beta_{MS,SS}}{2 + \eta\beta_{MS,SS}} &= \frac{\eta(1 - \beta_{MS,SS}^4) - 4(1 - \beta_{MS,SS})}{\eta^2} \\ &+ \frac{4}{\sqrt{3}\eta^{7/3}} \tan^{-1} \left[\frac{\sqrt{3}\eta^{1/3}(1 - \beta_{MS,SS})}{2 - \eta^{1/3}(1 + \beta_{MS,SS}) + 2\eta^{2/3}\beta_{MS,SS}} \right] \\ &+ \frac{2}{3\eta^{7/3}} \ln \left[\frac{(1 + \eta^{1/3})^2}{1 - \eta^{1/3} + \eta^{2/3}} \left(1 - \frac{3\eta^{1/3}\beta_{MS,SS}}{(1 + \eta^{1/3}\beta_{MS,SS})^2} \right) \right] \end{aligned} \quad (11)$$

Therefore, $\beta_{MS,SS}$ is solvable as a function of η alone.

If net mass enclosed by MS is none then $\eta = 0$. Accordingly,

$$\frac{1}{\rho_{MS}} = \frac{2}{7}(1 - \beta_{MS}^7) \rightarrow 8\beta_{MS,SS}^7 + 7\beta_{MS,SS} - 8 = 0. \quad (12)$$

This resolves to $\beta_{MS,SS} \approx 0.831$, *i.e.*, Schwarzschild Factor at SS of MS is ~83% of that in RS if net mass enclosed by SS of MS is none. In any case,

$$\frac{\epsilon_{s,MS,SS}}{\epsilon_i} = \frac{\epsilon_{f,MS,SS}}{\epsilon_i} = \frac{c_{MS,SS}}{c_i} = \beta_{MS,SS}, \frac{m_{MS,SS}}{m_i} = \frac{1}{\beta_{MS,SS}}. \quad (13)$$

All attributes with subscript “MS, SS” are associated with the entity existing at SS, that are not much different from the corresponding attributes in RS if η is small. While SLV at SS of MS may be ~83% of that in RS, other parameters/constants, *e.g.*, G_i , Planck constant, etc., are unaltered, and laws of physics are identical except some of them may be constrained by the lesser dimension. Further, $\beta_{MS,SS}$ depends on η alone and, in case $\eta = 0$, is constant, *i.e.*, independent of mass at the SS and/or size of the SS.

No particle at SS can escape from SS, including photon, since particle cannot travel at speed exceeding local SLV [3], which is zero at SS normal to SS. Therefore, MS at SS fits the definition of a black hole [6]. A unique feature of MS at SS

is that such black hole is of shell structure, *i.e.*, having one lesser dimension in geometry, therefore differ from regular ones. Yet matter/radiation at SS is confined thereat. Therefore, SS of MS is a finite subspace, wherein, objects and behaviors thereof are similar to their corresponding entities in HDS except confined by lesser dimension; laws of physics are identical to that in HDS except maybe confined by lesser dimension; some of the physical parameters/constants are identical while others are somewhat different.

Subspace is not genuine space but a region therein, and region of space is not closed. If foreign mass particle approaches SS of MS from outside, self energy of the particle shall be reducing, self mass increasing, and velocity of its motion approaching local SLV. At the moment of landing at SS, velocity of foreign particle shall reach local speed limit at SS along surface normal as well as transverse direction at landing site, and both are zero because $\beta_{g,f} = 0$. Therefore, landing of foreign particle at SS is soft touchdown. That is, regardless of initial velocity/direction, both normal and transverse velocities of foreign particle at landing site of SS must be zero, even though speed limit within the subspace is nonzero. From perspective of SS, such shall be observed as peculiar event, happening from time to time with no cause from within, that new mass comes into being from nowhere, accompanied by characteristic motionlessness at first emergence of such entity within SS. Therefore, total mass/energy contained/confined in SS is not conserved entity in the region and size of SS may be measured as truly expanding due to such event.

From Expression (13), rest energy of new comer is less than that in RS by $\beta_{MS,SS}$ regardless of the landing process. On the other hand, total energy of the entity is conserved during the process. Therefore, excess part of the energy must be gained by MS at SS in other forms.

Uniform specification of distribution of members of MS leads to spherical symmetry of SS of MS. Therefore, the SS is not flat and curvature of any point of the subspace is identical. However, if the distribution is not uniform, e.g., due to gravitative attraction among members of MS, then the SS shall deviate from perfect sphere and regions of relatively higher mass densities shall protrude outwards while regions of relatively lower mass densities recess inwards, all with respect to the spherical average. Therefore, local curvature of the SS shall correlate with local mass density, as similarly assumed in the general relativity theory of Einstein [1]. However, for SS of MS, such correlation is not unique but effected by mass and distribution inside and outside the SS.

While MS at SS shall exert gravitation influence to outside the SS, such effect/cause is unaware of by/imperceptible to observer at SS, since such occurs in higher dimension. Mass entity inside/outside SS shall also exert influence to masses at SS, which is observable from within SS as mass motion/distribution at SS with no cause from within. Further, MS at SS is an extended object. Therefore, if the black hole has intrinsic spin and/or is not in RS, then there shall be spin of the MS with respect to Rest Frame [3], and that shall cause distortion of the SS from spherical symmetry, which is observable from within the SS as anisotropy of

the subspace.

5. The Universe

By the law of mass/charge balance in finite space, total mass in finite space must be balanced. It is unknown yet if total mass in the physical space is balanced or not, which might be inferable from observing clustering of galaxies in the physical space during epoch. However, if gravitation normal matter is found prevailing in the physical space then the space cannot be genuine finite space but a finite subspace of HDS. If the space is a finite subspace then normal matter and radiation contained therein is confined therein. Therefore, the Universe would have to be a SBH in HDS, *i.e.*, a three-dimensional MS at SS in space of higher dimension.

If the physical space is a SS of MS then

$$R_e = 4r_{g,f} \rightarrow M_0 + M_{SS} = \frac{c_i^2}{4G_i} R_e. \quad (14)$$

R_e is external radius of the SS, M_0 the mass enclosed by the SS, and M_{SS} the mass contained/confined in the SS. With internal radius of the physical space measured at 1.0 billion light years [5], if $\eta = 0$,

$$V_{SS} = 2\pi^2 R_e^3, \pi R_e \equiv 2R_i \rightarrow \sigma_{SS} \equiv \frac{M_{SS}}{V_{SS}} = \frac{c_i^2}{32G_i R_i^2} \approx 281 \frac{m_{p,i}}{\text{m}^3}. \quad (15)$$

V_{SS} is volume of three-dimensional SS, R_i internal radius of the SS, σ_{SS} mean mass density in the SS, and $m_{p,i}$ rest mass of proton in RS. Thus, if net mass enclosed by the SS were none then mean mass density in the SS would be ~ 281 protons per cubic meter. On the other hand, assuming average spacing between galaxies in the physical space is ~ 3 million light years and average galaxy mass is $\sim 10^{10}$ solar masses, then mean mass density in the physical space is about half a proton per cubic meter. Therefore, most of the masses are enclosed by, instead of contained in, the physical space, if the physical space is indeed a SS of MS.

6. Discussion

In finite space, existence of gravitation inverse matter is inevitable. Therefore, if gravitation normal or inverse matter is found prevailing in the physical space then, by the law of mass/charge balance in finite space, the Universe has to be a SBH. If the Universe is indeed a SBH then evolution of the Universe shall become comprehensible with the known laws of physics without needing a dramatic event. For instance, an ordinary mass object in HDS shall attract masses of the same type in its vicinity by gravity. If/when Condition (14) is met, those masses at R_e from the center of the field shall form a SBH, which is of one lesser dimension than that of the HDS. Masses inside the SBH shall continue to fall towards the center of the field, and that shall cause the SBH and outer SBHs, if any, to expand, due to the increase of the rest masses of the falling bodies [6]. The falling masses may form an inner SBH if Condition (14) is met, or join an existing inner SBH, or to the core, causing the growth of such entities. Therefore, it is natural to have

multiplicity of SBHs surrounding one and the same core mass. In addition, the law of $E = mc^2$ was assumed valid in HDS, e.g., in Equation (3). Therefore, under this assumption, the HDS must be a finite space or a finite subspace [3] in space of even higher dimension.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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