Dark Energy and Dark Matter from Rute as Different Manifestations of Vacuum Energy

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Abstract

Dark energy and dark matter are described as different manifestations of vacuum energy within Rute's framework of dimensional symmetry and gravity. In this framework, the bare vacuum energy component exists in a gravitationally inert state where actual gravitational constant $G_o = 0G$, while real particles oscillates between this inert state and the active state where $G_o = 2G$. The background effect of neutrino substrates in the inert state makes $G_o > 0G$ in such state, causing the gravitation of virtual particles with positive pressure appearing as hot and cold dark matter. A non zero component of vacuum energy from the inert state also spills into the gravitationally active state as a cosmological constant form of dark energy. This is due to an energy density constraint and speed limit asymmetry between the two gravitational states that limits the capacity of the inert state to contain all the vacuum energy component. This form of dark energy and dark matter, are parameterized by a common asymmetry parameter Γ which is suppressed in deep gravitational potential wells. The dynamics of this form of dark matter however, is complicated by the flavour and energy dependent parameters of its neutrino substrate resulting in the existence of heavy and light dark matter categories. Rute predicts a curvature supressed Gravitational Wave Reheating (GWR) mechanism in which gravitational waves produce electromagnetic secondaries in the presence of negative pressure such as that from strong magnetic fields and even dark energy. This mechanism may explain Fast Radio Bursts (FRBs) and some other mystery radio signals. Two space based experiments to test GWR and to detect heavy dark matter are briefly discussed.

Keywords:- Rute – Dark Energy – Dark Matter – Neutrino Substrate – Speed Limit Asymmetry – Energy Density Constraint – Vacuum energy.

1. Introduction

Dark energy has remained a mystery since its first discovery in 1998 [1,2]. Several independent observations including the Planck data indicates that dark energy constitutes about 68.3% [3] of the total energy budget of the universe and driving its accelerated expansion. This is in addition to the existing mystery of dark matter which appears to be some invisible but gravitating form of matter that clusters within and around galaxies. Dark matter makes up about 26.8%, while ordinary visible matter makes up 4.6% of the mass-energy content of the universe.

The simplest and most economical solution to explain dark energy already exists in the form of a cosmological constant term (Λ) earlier introduced by Einstein in his field equations and forms a key part of the standard model of cosmology known as the ΛCDM model (Lambda Cold Dark Matter). Λ readily comes from the expected gravitational effect of vacuum energy predicted within the framework of quantum field theory. The problem is the extremely large value of about 120 orders of magnitude expected from our understanding of quantum field theory compared to observation. This is the Λ problem [4].

Supersymmetry (SUSY) models readily provides a cancellation mechanism to reduce the bare Λ to a very small value but supersymmetric partners of the standard model required for cancellation have not been found. There are some string theory models in which vacuum energy is simply relaxed [5], as well as some that resorts to anthropic consideration [6]. There are some models that makes the spacetime metric insensitive to Λ[7,8].

While the efforts to resolve the Λ problem intensified, there had been several alternative approaches that avoids the difficult problem of Λ. Prominent among them are quintessence which involves a slowly evolving scaler field, modified gravity models, unification of dark energy and dark matter. See [9,10] for detailed review. For recent review, see [11,12].

The amount of theoretical and observational efforts that has been applied to understand dark energy and dark matter shows that they require new Physics beyond the existing standard model of cosmology and particle physics.

Attempts to resolve the dark matter mystery can be mainly classified as either a modification of gravity or introduction of new particles beyond the standard model of particle physics. However, both approaches of modified gravity and particle dark matter have failed to provide consistent explainations to the dark matter mystery even though each approach tends to explain some observations and fail at some others.

There is an approach that explains dark matter as gravitational polarization of vacuum energy by baryonic mattter without invoking new particle or modifying gravity in the traditional sense [13]. It is based on the idea that matter and antimatter have opposite gravitational charges. The fundamental problem with this approach is that it requires a violation of the Weak Equivalence Principle and preliminary findings from measurements of antiproton to proton charge to mass ratio implies that matter and antimatter gravitate the same way up to 97% accuracy [14]. The ongoing AEgIS experiment at CERN [15] should provide a definitive test for Weak Equivalence Principle.

The Rute model, takes the speed limit asymmetry approach of resolving the Λ problem of dark enrgy in which the bare vacuum energy component exists only in a gravitationaly inert state where actual gravitational constant is zero. Real standard model particles oscillates between the gravitationally inert state and gravitational active state. A non zero vacuum energy density then emerges in the gravitationaly active state as dark energy due to a key energy density constraint and a speed limit asymmetry.

Rute describes dark matter as a different manifestation of the bare vacuum energy component but doesn't require any polarization of the vacuum by baryons or opposite gravitational charge for antimatter like in [13]. Rather, it depends on the background effect of neutrino substrates on the gravitational constant. Neutrinos, particularly cosmic neutrinos illuminates the background in the gravitationally inert state such that $G_o > 0G$ within the range of their weak interaction, making virtual particles gravitate with positive pressure and appear as light and cold dark matter. High energy neutrinos on the other hand serves as substrates for hot and heavy dark matter, or even hot and light darkmatter for at least one of the neutrino flavours.

The model framework describes a gravitational inversion in a dimensional symmetry that doubles large spatial dimensions with microscopic partners while their interactions are regulated by constraints such as speed constraint and energy density constraints.

This paper is organized as follows. Section 2 discusses the key dimensional symmetry that doubles the number of large spatial dimensions with microscopic partners. It also discusses the speed constraint, the two on and off gravitational states, their speed limit asymmetry and density constraint, which is then applied in section 4 to solve the Λ problem. Section 3 discusses General Relativity in extra dimension S_0 and explore its unique features of gravitational inversion as well as the chain of causality in gravitation. It is shown that the expansion of the timelike S_0 dimension is equivalent to the curvature of our visible spatial dimensions S_1.

Section 4 discusses the emergence of dark energy due to a speed limit asymmetry and energy density constraint discussed in section 2, while in section 5, the key reheating prediction is discussed. Section 6 discusses the gravitation of virtual particles which appears as dark matter due to the background effect of neutrino substrates on the gravitational constant in the inert state. Two space based experiments are proposed in section 7, while summary and conclusion follows in section 8.

2. Dimensional Structure and Symmetry in Rute

In the Rute framework, the number of large spatial dimensions is described by the dimension number S_n such that,

$$S_n = [4n - 1]d \tag{1}$$

where $n = 0, 1, 2, 3, \ldots$

$n = 0$, corresponds to $S_n = -1d$ which is a timelike spatial dimension that is invisible due to speed constraint discussed in section 2.1.

$n = 1$, corresponds to $S_1 = 3d$ which is our visible spatial dimensions.

The dimensional symmetry in Rute doubles large spatial dimensions with microscopic dimensional partners with opposite dimension numbers such that the total dimension numbers of the universe is zero as illustrated in Fig. 1.

While the dimensional partner of S_0, is the Planck size S_P dimension, the dimensional partner of S_1 is denoted S_α. If there is perfect symmetry, $S_\alpha = -3d$.

The volume constraint implies that the large spatial dimensions such as S_1 and S_0 where inflated in the early universe at the expense of their dimensional partners S_α and S_P until they contracted to their microscopic sizes becoming invisible.

This paper focuses on the S_0 dimension and its microscopic dimensional partner S_P as well as their interactions with the visible spatial dimension S_1.

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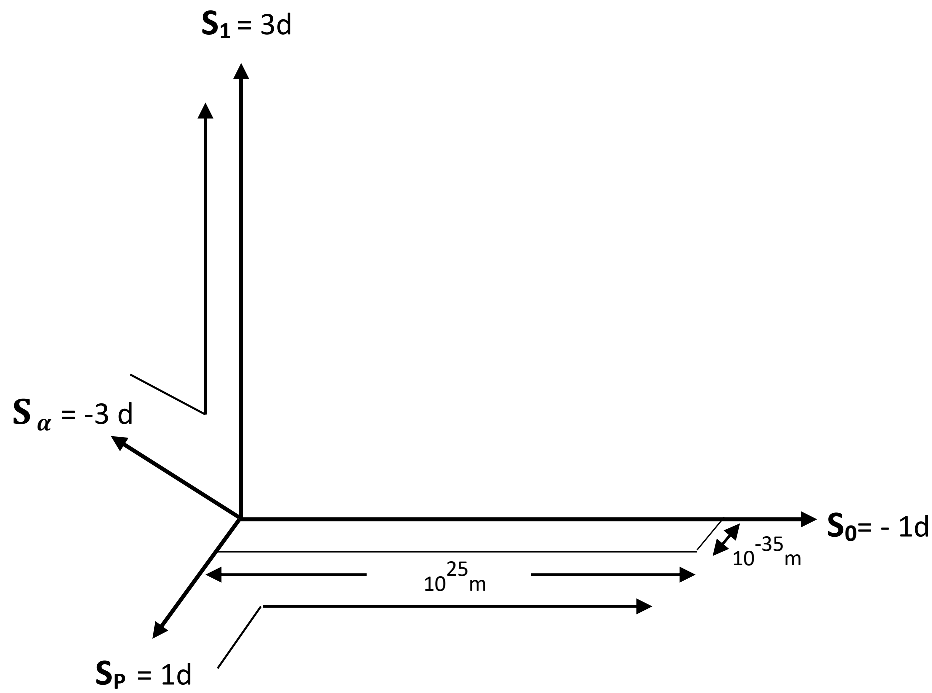

Fig. 1. Dimensional symmetry in Rute showing large spatial dimensions S_1 and S_0 and their microscopic dimensional partners. Gravitational inversion symmetry implies that S_P and S_α were contracted to their minimum microscopic sizes to inflate S_1 and S_0 in the early universe. Before then, they were all comparable in size. The gravitational inversion interaction is now between S_1 and S_0 as illustrated in Fig. 5 in section 3.1.

2.1 Speed constraint and invisibility of S_0

Despite its cosmic size, the S_0 dimension is invisible due to its timelike behavior from the speed constraint illustrated in Eq. (2) and Fig. 2.

The speed constraint requires that a particle's velocity must always equal the maximum speed limit c in the S_1 – S_0 dimension.

Massless particles like photons have zero velocity component along S_0, while massive particles and antiparticles travel in opposite directions along S_0. This motion along S_0 is quantitatively equivalent to the passage of time such that,

$$c^2 = \mu^2 + \nu^2 \qquad (2)$$

Where μ is particle velocity along S_0, and ν is particle velocity along visible spatial dimension S_1.

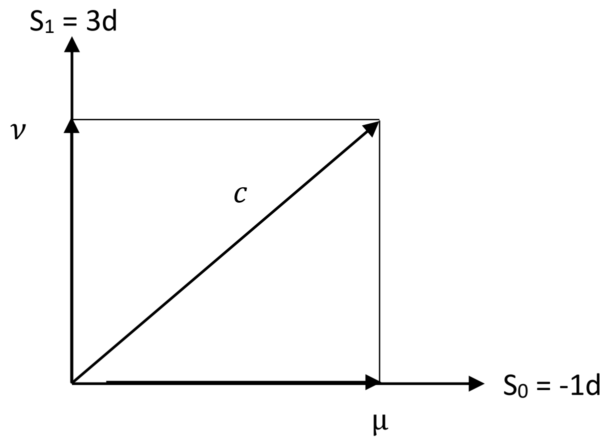

Fig. 2. The speed constraint relationship between visible spatial dimesions S_1 and time like spatial dimesion S_0.

When $\nu \rightarrow 0$, for massive particles, $\mu \rightarrow c$ and conversely, when $\nu = c$ for massless particles, $\mu = 0$ to satisfy the speed constraint.

This suggests that time can be an emergent temporal dimension driven by the velocity of a particle along S_0 dimension. How fast time appears to to pass for a massive particle can be equivalent to the ratio of its S_0 component of velocity μ to the speed limit c as,

$$\frac{1}{\gamma^*} = \frac{\mu}{c} \tag{3}$$

Where γ^* is the equivalent Lorentz factor for the S_0 dimension. Since

$$\mu^2 = c^2 - \nu^2 \tag{4}$$

$$\gamma^* = \frac{1}{\sqrt{1-\frac{\nu^2}{c^2}}} \tag{5}$$

2.2 Speed limit asymmetry

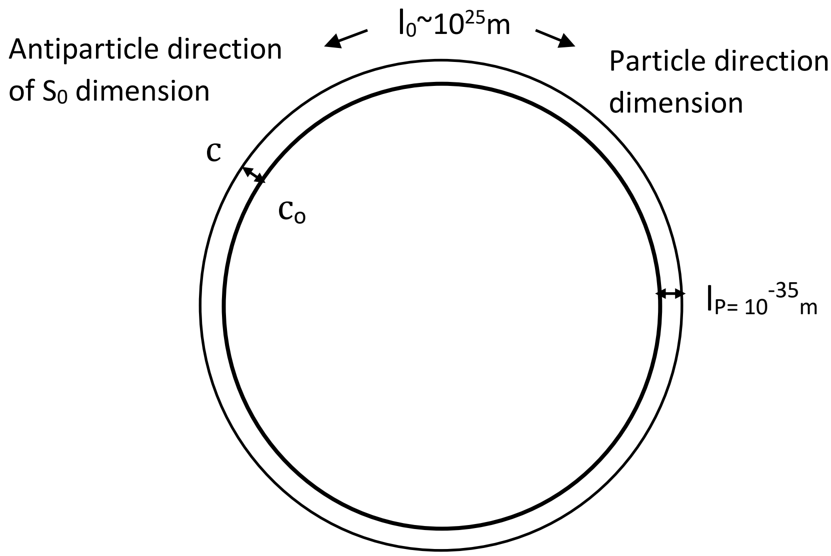

Fig. 3. Ring structure of S_0 - S_P dimensions with two unequal speed limit states C and C_0, at the two ends of S_P dimension.

The asymmetry in speed limits c and c_0 is described by the asymmetry parameter Γ which is the ratio of the Planck size of S_P to the size of S_0 dimension and $0 < \Gamma < 1$

$$\Gamma = \frac{2\pi}{l_o} \tag{6}$$

where l_o (~10^{60}) is the size of S_0 in Planck unit, and the value of the asymmetry parameter in flat spacetime $\Gamma_0 \approx 10^{-60}$. Γ is smaller in curved gravitational potential wells where S_0 expands as explained in section 3. The increase in size Δl_o is proportional to the absolute value of the gravitational potential |Φ| such that,

$$\Delta l_o = \varepsilon|\Phi| \tag{7}$$

where ε is a constant.

We also have the following asymmetry relationship between the two speed limits which is also affected by the dynamics of Γ.

$$C_o = C[1 - \Gamma\,] \tag{8}$$

2.3 Gravitational state oscillation

Standard model particles oscillates between the two speed states which are also opposite gravitational on and off states. This is such that for a particle of energy E, the state life time t_s for such particle is

$$t_s = \frac{4\pi\hbar}{\sqrt{E_P^2 - E^2}} \tag{9}$$

Where $\hbar$ is the reduced Planck constant and E_P is the Planck energy

The oscillation of standard model particles between the two gravitational states $G_0 = 0G$ and $G_0 = 2G$, makes gravity discrete on microscopic spacetime scale. It however appears smooth on macroscopic spacetime scale with an average gravitational constant G.

2.4 Energy density Constraint

The energy density constraint essentially constrains the total energy density in a given volume of space to always equal the upper limit of the Planck density ρ_P.

ρ_P is only obtainable in the gravitational active state where the speed limit is c while the bare vacuum energy component exists in the inert state with lower speed limit and hence lower Planck density ρ_{P0}

$$\rho_P^2 = \rho_m^2 + \rho_{vac}^2 \tag{10}$$

where ρ_{vac} is the vacuum energy density, and ρ_m is the total baryonic matter density.

The key significance of this is in the emergence of non zero Λ dark energy in section 4. However, such energy density constraint implies a Planck density limit to the density of black holes like that suggested in [16], where Planck stars replaces black hole singularities.

3. General Relativity in S_0 dimension

Solution of Einstein’s field equations in 1+1 dimension is being used as a pedagogical tool [17, 18] and reveals some interesting properties of the equations in such dimensionality.

In this section, the focus is on general relativity in -1+1 dimension which has some inverted features not seen 1+1 dimensionality because of the negative spatial dimension. The negative dimension number of the S_0 dimension gives it some timelike features such as appearance of positive energy density as negative energy density and the inversion of positive pressure to negative pressure.

Eintein’s field equations in S_0 can be expressed as

$$G_{\mu\nu}^* + \Lambda^* g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}^* \tag{11}$$

Where $G^{*}_{\mu\nu}$ is the equivalent curvature term in S_0 dimension. Λ^{*} is the equivalent cosmological constant and $T^{*}_{\mu\nu}$ is the stress energy tensor as seen in S_0 dimension.

In -1+1 dimensionality, just as in 1+1, the curvature term $G^{*}_{\mu\nu}$ is zero, and Eq. (11) becomes

$$\Lambda^{*} g_{\mu\nu} = \frac{8\pi G}{c^4} T^{*}_{\mu\nu} \tag{12}$$

Which is essentially a linear algebraic equation and can be further decomposed into a spatial and a time component which is not feasible in 3 +1 dimensionality [18].

3.1 Features of General Relativity in S_0 dimension

The negative one dimensionality of S_0 confers on it some unique features such as:

i. **Positive energy density in S_1 = Negative energy density everywhere in S_0**

An energy density associated with a given Planck volume of 3d space S_1 appears as an equivalent negative energy density everywhere along S_0 dimension associated with it as a positive cosmological constant as illustrated in Fig. 4.

ii. **Positive Pressure in S_1 = Negative Pressure in S_0**

Any form of positive pressure in S_1 appears as Negative pressure in S_0 for the same reason of negative dimensionality. The result is a positive cosmological constant expansion of S_0.

iii. **Negative Pressure in S_1 = Positive Pressure in S_0**

The same negative dimensionality causes the inversion of negative pressure in S_1 appearing as positive pressure in S_0 driving its negative cosmological constant conraction.

The result is that the curvature of S_1 ($G_{\mu\nu}$) is equivalent to the cosmological constant expansion of S_0 as illustrated in Fig. 5 such that,

$$G_{\mu\nu} + \Lambda^{*} g_{\mu\nu} = 0 \tag{13}$$

And a positive cosmological constant term ($\Lambda g_{\mu\nu}$) in S_1 is equivalent to a negative cosmological constant term ($-\Lambda^{*} g_{\mu\nu}$) in S_0 such that,

$$\Lambda g_{\mu\nu} - \Lambda^{*} g_{\mu\nu} = 0 \tag{14}$$

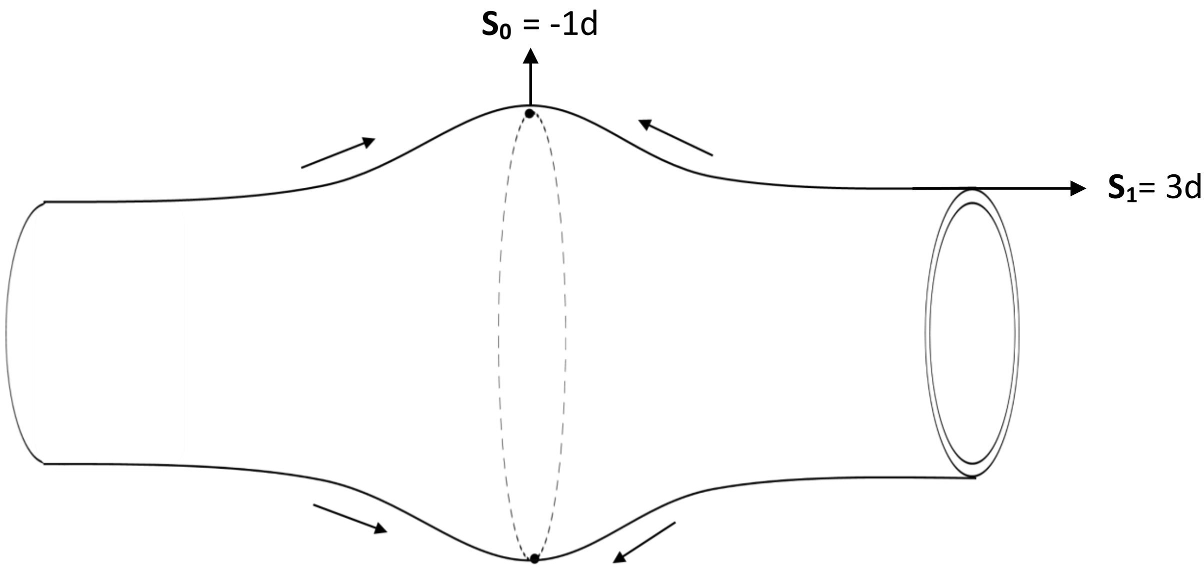

Fig. 4. A gravitational well in S_1 is inverted into a gravitational hill with the expansion of S_0 by a test particle. The test particle is replicated about 10^{25} times everywhere along S_0 dimension like time.

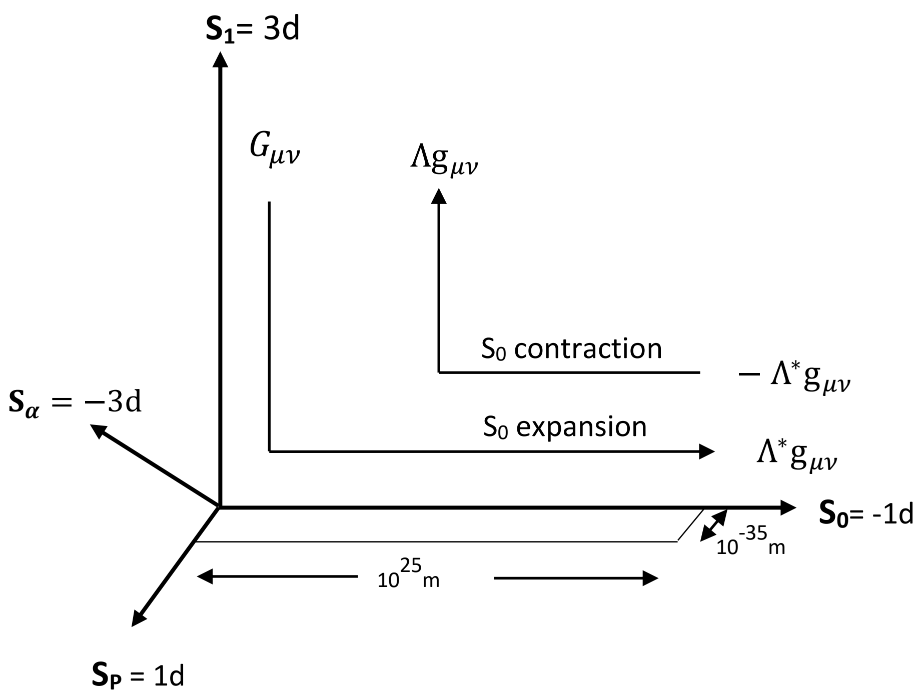

Fig. 5. Gravitational inversion. A positive cosmological constant expansion of S_0 is equivalent to curvature of S_1. Also, a negative cosmological constant contraction of S_0 is equivalent to a positive cosmological constant expansion of S_1.

3.2 Gravitational chain of causality

The inversion of gravitation discussed in the previous section suggests that fundamentally, gravity is the expansion or contraction of S_0 dimension. This then manifests in an inverted form as curvature or expansion of S_1 dimension as illustrated in Fig. 5.

The existence of graviatational on and off states acts as a filter in this gravitational chain of causality enabling real particles to gravitate while while virtual particles are inert.

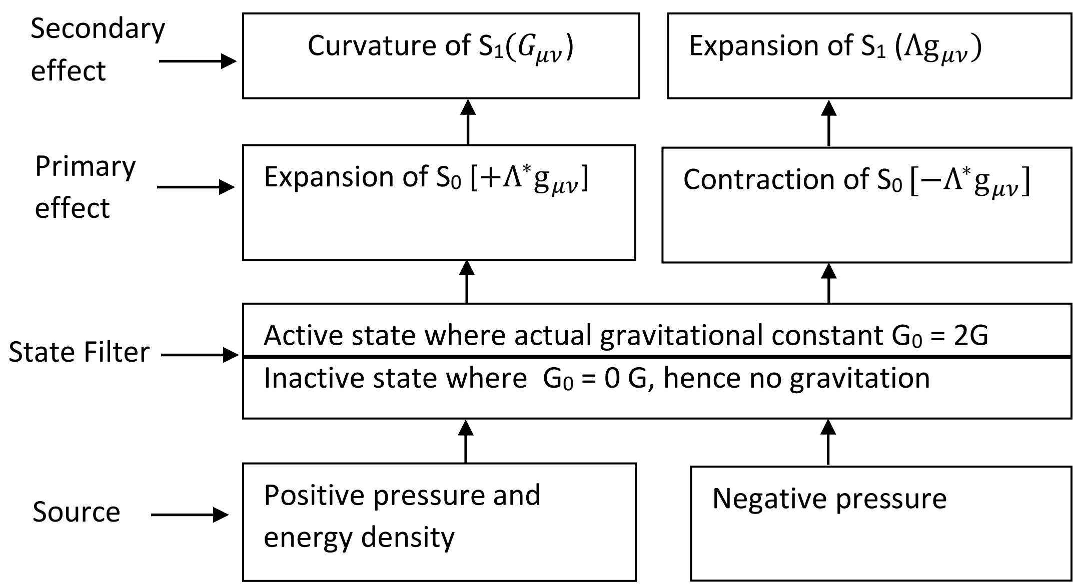

Fig. 6. Gravitational chain of causality: gravity at a more fundamental level is about expansion or contraction of S_0 which manifests invertedly in S_1 as curvature or expansion respectively. Also gravitation of particles depends on if they are in gravitationaly active or inert state.

The relatively permanent existence of the bare vacuum energy component in the gravitationally inert state ensures that it does not gravitate. This partly solves the cosmological constant problem. The second part of the problem about the non zero value is addressed in the next section.

4. Emergence of non zero Cosmological Constant

The asymmetry in speed limit described in Eq. (8) between the two gravitational states also reflects in the values of their Planck densities such that

$$\rho_{P0}^2 = \rho_P^2[1 - \Gamma^4] \tag{15}$$

Where ρ_{P0} is the lower Planck density in C_0 state and ρ_P is the Planck density in the C state.

The existence of the bare vacuum energy component in the lower C_0 state implies that

$$\rho_{vac} = \rho_{P0} \tag{16}$$

Which is less than the Planck density and the energy density constraint requires that the total vacuum energy density should be equal to the Planck density in the absence of matter.

Since the gravitationally inert lower speed state lack the capacity to contain all the vacuum energy components, a small component spills into the gravitationally active state as dark energy.

$$\rho_{DE} = \rho_P \Gamma^2 \tag{17}$$

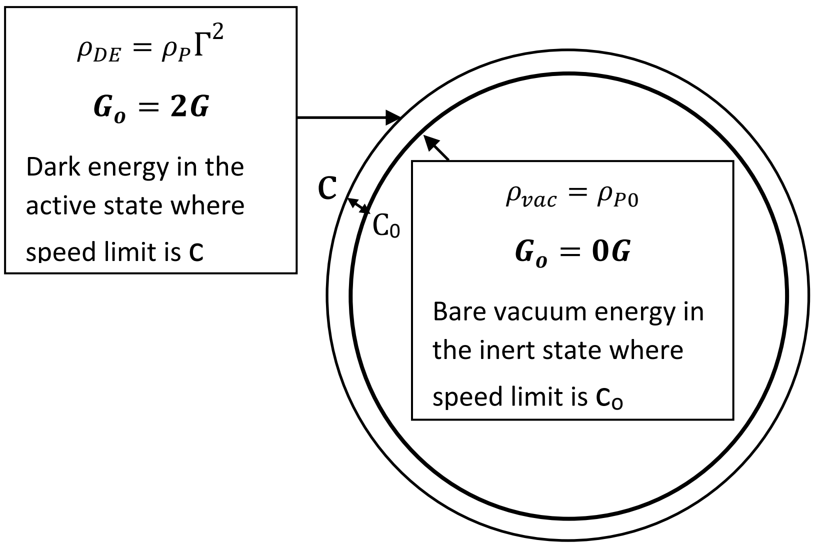

Fig. 7. While the bare vacuum energy component occupy the gravitationaly inert state C_0 to its limit, there has to be a component ρ_{DE} in the gravitationaly active state C to satisfy the energy density constraint so that the total vacuum energy density equals the Planck density ρ_P. The lower Planck density ρ_{P0} is associated with speed state C_0.

And since Γ is suppressed with the expansion of S_0 in the gravitational well of massive objects (Eq. (6) and Fig. 4), the density of this form of dark energy varies spatially according to this suppression. The deeper the gravitional well the more the suppression. And substituting the value of Γ from equation (6),

$$\rho_{DE} = \frac{4\pi^2 \rho_P}{l_0^2} \tag{18}$$

Where l_0 is the size of S_0 dimension in Planck unit, which increases with the absolute value of the gravitational potential Φ according to Eq. (7).

5. Gravitational Wave Reheating (GWR) Prediction

The propagation of gravitational waves along the visible 3d space S_1 should naturally vibrate any extra spatial dimension such as the S_P and S_0 dimensionsions. Stretching of S_P dimension during Such vibration will cause the creation of real photons out of vacuum energy. This is the Gravitaional Wave Reheating (GWR) mechanism of Rute.

However as illustrated in Fig 8, the expansion of S_0 dimension in gravitational potential wells suppresses the possible stretching of S_P dimension resulting in a threshold value of strain h and frequency f_g below which reheating cannot occure .

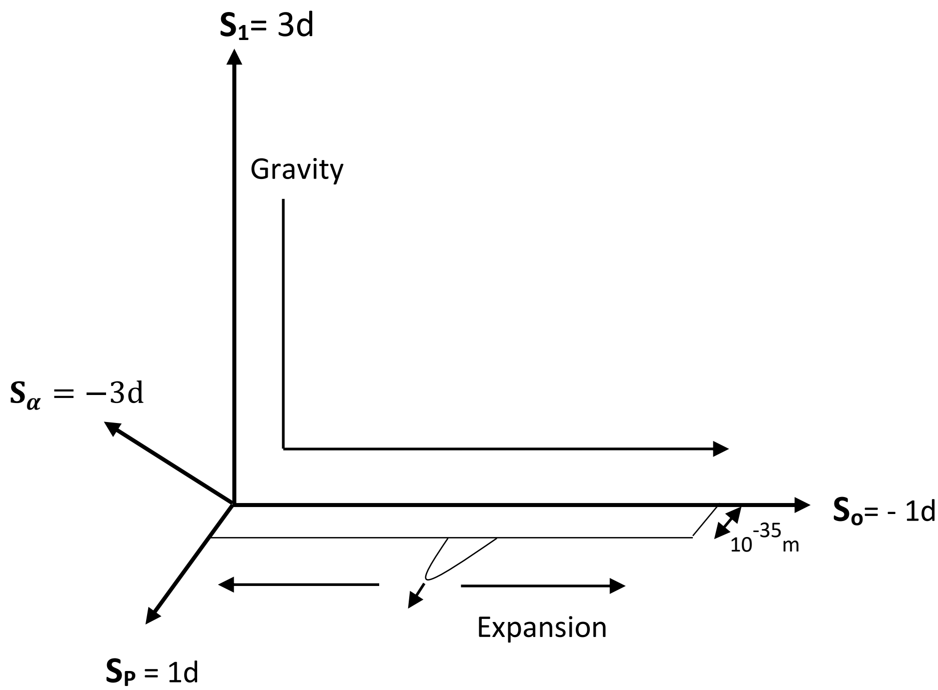

Fig. 8. The expansion of the S_0 dimesion in gravitational potential wells, suppresses the possible stretching of S_P dimension by gravitational waves oscillations.

5.1 Energy Scale of Reheat Photons

The maximum energy E_{max} of the reheat photons that can be emited in the resulting spectrum once the threshold is exceeded can be described by

$$E_{max} = \frac{E_P\left(hf_g - H_0^*\right)}{f_g} \tag{19}$$

where E_P is the planck energy. f_g is the gravitational wave frequency and h is the strain and both represent the threshold that has to be exceeded for reheating to occure. That is Eq. (19) is only valid if $hf_g > H_0^*$

H_0^* is the equivalent Hubble parameter describing the expansion rate of S_0 dimension associated each planck volume of space in a gravitational potential well . It is proportional to the absolute value of the gravitational potential Φ and hardens the S_P dimesions against gravitational wave vibration.

5.2 Magnetic Softening of the S_P Dimension

The magneto-curvature coupling aspect of general relativivity was explored based on its tendency to flatten curvature and even dampen gravitational waves in Ref. [19]. The key aspects of this coupling, is the vector nature of the magnetic field and the magnetic tension that tends to straighten the field lines against distortion by curved spacetime background.

Essentially the distortion of the field lines by curved background or a passing gravitational wave causes a backreaction from such magnetic field, flattening the curvature or ripples in the fabric of spacetime. This dampens the gravitational wave amplitude and energy, and can be seen as the hardening of the visible spatial dimensions against gravitational oscillation.

Within the Rute framework, the expansion rate H_0^* of the S_0 dimension is a measure of spatial curvature. Therefore the flattening of spacetime curvature suppresses H_0^* in Eq. (19), resulting in the softening of S_P dimension which becomes more sensitive to gravitational wave oscillation.

In essence, a strong manetic field like that obtainable around magnetars, softens the S_P dimension by lowering the threshold strain and frequency required for reheating to occure for incident gravitational waves.

Strictly from energy conservation perspective, the energy lost by gravitational waves passing through a strongly magnetized region has to be released in some form and Rute's GWR provides the mechanism for converting the gravitational wave energy into electromagnetic one.It is expected that the brief burst of electromagnetic waves radiated while the gravitational wave passes through a strongly magnetized region such as magnetars, encodes information about the incident gravitational waves. These burst of electromagnetic radiation can appear as Fast Radio Burst (FRBs) or even Gamma Ray Burst (GRBs) depending on source proximity or strain and frequency of the incident gravitational waves, making magnetars possible astrophysical gravitational wave detectors.

6. Dark Matter from Vacuum Energy

The bare vacuum energy component should always be gravitationally inert with its existence in the $G_0 = 0G$ state where the gravitational field is effectively swiched off. However, in this framework, particle substrates of the standard model such as neutrinos affects their background while in the inert state such that $G_0 > 0G$.

Within such background in the inert state, neutrinos provides some gravitational illumination described by Eq. (20) that enables virtual particles to gravitate with positive pressure appearing as dark matter.

$$G_\nu = \beta^2 \Gamma^2 \phi \mathrm{G} \tag{20}$$

Where G_ν is the neutrino substrate induced gravitational constant in the inert state. β is a dimesionless parameter that varies with neutrino energy scale. $1 \leq \beta \leq 10^{60}$. ϕ is a flavour parameter that varies with the 3 neutrino flavours such that $0 < \phi \leq 1$. Γ is the same asymmetry parameter involved in the emergence of dark energy.

With the expression of Γ in equation (6), equation (20) becomes,

$$G_\nu = \frac{4\pi^2 \beta^2 \phi G}{l_0^2} \tag{21}$$

Where l_0 is the size of the S_0 dimension (in Planck unit) which increases with the absolute value of the gravitational potential Φ, hence the suppression of dark matter effect in deep gravitational potential wells. The value of G_ν falls off quickly within the range of the weak interaction.

β can be expressed as

$$\beta = 1 - (^{\upsilon}/_{c})^2 \Gamma_0^{-1} \tag{22}$$

Where Γ_0 is the value of Γ in flat spacetime, and υ is neutrino velocity.

While hot dark matter is the form of dark matter that can be produced by relativistic neutrinos, cosmic neutrinos are unrelativistic. Such non relativistic cosmic neutrino substrates should be further slowed down by the Higgs like drag from its self induced gravitational ineraction with virtual particles within its background. This enhaces the clustering of cosmic neutrino substrates and the gravitating virtual particles in their background appear as cold dark matter.

The gravitational potential suppression of G_ν enables this substrate dependent form of dark matter to have hybrid behavior by mimicking modified gravity form of dark matter such as Modified Neutonian Dynamics (MOND) while also exhibiting some particle behavior of its neutrino substrates like the gravitational polarization of vacuum energy approach [13] and superfluid dark matter described in [20].

6.1 Categories of neutrino substrate dependent dark matter

Heavy and light dark matter are two categories of neutrino substrate dependent dark matter that exists within the Rute frame work depending on the neutrino energy scale and flavour.

i. **Heavy dark matter**

From Eq. (21), an extremely high energy neutrino with a flavour parameter $\phi \sim 1$, can induce a gravitational constant G_ν close to 10^{-15} G in the gravitatinaly inert state where the bare vacuum energy resides. With the gravitation of vacuum energy of the order of $10^{93} kgm^{-3}$, within the range of the weak interaction, it can manifest as heavy dark matter with an equivalent gravitational parameter of a small black hole with mass of a small asteroid outside the deep gravitational potential wells of planets, stars and galactic centres. As the high neutrino substrate changes to a flavour with $\phi \sim 0$ or falls into the gravitational potential well of a planet like Earth, this effect is suppressed to making it become a lighter form of dark matter.

ii. Light dark matter

Non relativistic neutrinos particularly cosmic neutrinos can induce G_ν close to 10^{-120} G in the gravitatinaly inert state, resulting in light and cold dark matter with a density close to dark energy clustered within and around galaxies. Such light dark matter which should dominate the total dark matter density, can only be detected through the CMB, gravitational lensing and the dynamics of galactic and extra galactic large scale structures.

7. Space Based Observations and Experimental Tests

Expected results from the trio of the JWST, Euclid and upcoming Roman telescope are expected to provide precision measurements of dark energy density as well as the dynamics of dark matter. Such precision measurements should glean out the predicted suppression of dark energy density in the deep gravitational potential wells of baryonic matter like it does to dark matter.

Two space based experiments are proposed. One is to test the GWR prediction of Rute and the other to specifically detect heavy dark matter.

i. Magnetic Payload in deep space

The deployment of an interstellar spacecraft with a five to ten tesla magnetic payload should provide a good test for Rutes reheating prediction discussed in section 5. As the spacecraft leaves the gravitational potential well of the sun, up to 50 AU, and the negative pressure from the magnetic field of the payload further flattens curvature, the threshold strain and frequency is significantly lowered. A strong gravitational wave exceeding the threshold, should trigger a radio flash which can be detected with ground based radio telescopes like CHIME.

ii. Heavy dark matter detection experiment

Heavy dark matter, although represents a minority of the total dark matter component, should be detectable with a space based nanogram resolution digital scale measuring the gravitational attraction between two lead plates.
A 6U cubesat (Dark cube) carrying such a payload can be deployed to High Earth Orbit (HEO) or a bigger space craft to the edge of the solar system.

Heavy dark matter with the gravitational parameter of a small asteroid mass black hole riding on a high energy neutrino substrate, and passing through the lead plates should make them briefly attract strongly. This attraction is then measured by the nanogram resolution digital scale as the sensor.

8. Summary and Conclusion

Rute provides an elegant framework for the resolution of the cosmological constant problem of dark energy and the nature of dark matter. In doing so it provides deeper insights into the dimensional strcture of spacetime and chain of causality involved in gravitation. Specifically, it places the bare vacuum energy component in a state where the gravitational field is swithed off with actual gravitational constant $G_0 = 0G$, while real standard model particles oscillate between this gravitationally inert state and the active state.

Due to an energy density constraint and a speed limit asymmetry that limits the capacity of the inert state to contain all the vacuum energy component, a small component spills into the active state as dark energy. The asymmetry parameter emerges from a key dimensional symmetry and it is the ratio of the size of the spatial equivalent of time S_0 and its microscopic partner S_P.

The illuminating effect of neutrino substrates particularly cosmic neutrinos, induces non zero gravitational constant in the inert state, providing gravitation for virtual particles which appears as dark matter. This baryonic substrate dependent form of dark matter can exhibit a hybrid characteristics of particle dark matter and modified gravity form of dark dark matter like superfluid dark matter [20]. It also indicates a possible link between the value of G and the weak interaction.

The reheating prediction in which gravitational waves produce electromagnetic secondaries with negative pressure from strong magnetic fields of magnetars and dark energy might be the sources of Fast Radio Bursts (FRBs) [21, 22] and Excess Radio Background (ERB) [23].

In conclusion, the Rute framework offers new physics explanations for dark energy and dark matter as different manifestations of vacuum energy that can be tested with space based experiments and provides deep insights into the dimensional structure of spactime and gravity.

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