Electrostatic quantum dark energy in a seven-dimensional universe

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Abstract:

This paper explains the dark energy and acceleration of the universe by quantizing the space in the hidden dimensions which provides the basis and background for the gravitational force through the curvature of space-time. Space-time is considered to be made of a four-dimensional elastic grid in a seven-dimensional universe in which matter also expands along with the universe. Each cube of the grid is considered a quantum of hidden three-dimensional space of Planck volume containing Planck charge, which makes the universe seven-dimensional. The dark energy is explained by the electrostatic repulsion between the Planck charges in each quantum of the hidden space. Mathematically, this electrostatic repulsion is related to the Hubble constant to explain the accelerated expansion, dark energy, and the increase in cosmological potential energy of the matter. Expansion of space-time is considered not due to the creation of the new space but due to the stretching of the existing space-time itself like an elastic ruler where the proper length remains constant. As the Hubble constant is decreasing with time, the rate of acceleration of the universe is considered to be decreasing because of the contraction force of the space-time elastic grid opposing the electrostatic repulsion between Planck charges. The apparent violation of the law of energy conservation in the cosmological redshift is properly explained to show that the cosmological potential energy of the matter continues to increase due to the stretching of the space-time and hence the redshift without violating the law of energy conservation. The values of the Planck constant, Gravitational constant, Permittivity of free space, and Boltzmann constant are shown to vary owing to the expansion of the space-time and hence provide falsifiable predictions for this theory. This theory builds a preliminary framework for the relativistic Newtonian gravity as a replacement for the general theory of relativity and the framework for relativistic MOND (Modified Newtonian Dynamics). Overall, this theory proposes a hidden extra dimensional electrostatic background to gravity to explain the curvature of space-time, dark energy, cosmological redshift, and eliminates cosmic inflation, cosmic event horizon, cosmic scale factor (a), critical density (Ω), cosmological constant (Λ) and singularities.
Introduction:

In this theory of electrostatic quantum dark energy in a seven-dimensional universe, Hubble expansion is considered to be due to the stretching of the existing space-time rather than the creation of a new space that is analogous to the markers on an elastic ruler stretching along with the expansion of the ruler, as opposed to the raisin bread model, where matter does not expand along with space. Therefore, the matter is considered to be stretching along with the space-time, or not being diluted with the expansion of the space-time. As the matter also stretches with space, the expansion is non-observable locally but can be observed through the redshift of the light coming from a far-off space of a lower stretch. At the outset, we can see that matter exists in different energy states based on the magnitude of the space-time stretch. The matter continues to move to higher energy states as space-time expands, but the energy of the photon remains the same. Therefore, in a lower stretch space-time, blue light has less energy compared to the same blue light in a higher stretch space-time. Therefore, when light travels from a lower stretch space-time to a higher stretch space-time, it becomes redshifted without violating the law of energy conservation. From this observation, we can conclude that the energy generated by converting the matter based on the mass-energy equivalence formula $E=mc^2$ is time-variant as the potential energy of the mass also increases along with the space-time expansion, whereas the energy of the photon does not change with the space-time expansion, and it does not gravitate as it doesn’t resist the space-time expansion because the mass of the photon is zero but is affected by the gravity of the other objects, which means that the energy of a photon does not curve the space-time around it, but takes the path of the curved space around any matter. So, electromagnetic fields and electromagnetic related potential energies whose forces are mediated by virtual photons do not curve the space-time in this model of the universe.

This theory proposes an absolute inertial frame, a way to identify it and hence revives the concept of relativistic mass. In this theory, only the rest/relativistic mass or the mass density is considered to be responsible for gravitational force (gravitoelectric) and the relativistic mass current density (mass flux) for the gravitomagnetic force. Any other form of energy neither increases the inertial mass nor the gravitational mass in this model of the universe but only the rest/relativistic mass and the relativistic mass flux. Therefore, this theory only satisfies the mass-energy equivalence principle partially but upholds the weak equivalence principle.

The proper distance between any two points in space is considered to remain constant despite the stretching of the space-time, similar to the markers on an elastic ruler. Therefore, the volume of the universe does not change with expansion of space. The expansion of the space-time and matter is considered to be due to electrostatic repulsion between the Planck charges present in the Planck volumes and hence discards dark energy. Space-time is considered to be made of a four-dimensional elastic grid in a seven-dimensional universe. Each cube of the grid is considered to be a quantum of the three-dimensional space of Planck volume containing Planck charge. The space-time membrane acts as a dielectric material between the Planck charges. Matter only exists as a probability wave function ($\Psi$) in the four-dimensional space-time grid but not in the hidden three spatial dimensions. The presence of matter in space-time would increase the force required to expand the space-time grid as the matter also expands along with space. The presence of matter increases the permittivity of space-time and hence reduces the electrostatic repulsion within the grid enveloped by the matter compared to the electrostatic repulsion outside the matter.
As the expansion of the space-time surrounding the matter will be greater than the expansion of the matter due to the permittivity difference and the net compressing force on the matter from the surrounding Planck charges, space-time becomes naturally curved around any mass and hence the gravitational force. So, in this theory, gravitational force is considered as a real force than a fictitious one due to the curvature of space-time as in General theory of relativity. In this theory, the electrostatic potential energy between the Planck charges in the three-dimensional space is considered to be the same as the dark energy, which causes accelerated expansion of the universe. The electrostatic dark energy in the three-dimensional space does not gravitate because this energy itself is the cause of the gravitational force in the four-dimensional space-time enveloping the three-dimensional Planck charges. The constancy of the speed of light should not limit the apparent velocity of the universe in this model, as it considers it to be applicable only for objects moving through space, but not for the expansion of space-time. Beginning from the birth of the universe, the first law of thermodynamics is strictly followed in this model of the universe to uphold the law of conservation of energy, which includes energy conservation in dark energy and cosmological redshift.

This theory proposes a flat or zero-curved, isotropic, and homogeneous universe, where the rate of acceleration will continue to decrease proportionally to the age of the universe, and its velocity only becomes zero after an infinite amount of time. However, the universe will continue to accelerate, but only at a continuously decreasing rate that asymptotes to zero. Invoking the critical density ($\Omega_0 = 1$) or cosmic inflation is not required to explain the flatness in this model of the universe, as the uniform expansion of the whole universe due to electrostatic repulsion explains why the universe is flat rather than closed or open. As there is no increase in the volume of the universe with time, big bang should be replaced with big repulsion. This theory makes the gravity electrostatic background dependent to explain the curvature of space-time, dark energy, and cosmological redshift.

The electrostatic background provides an additional background to the quantum fields on top of the gravitational background which mandates an absolute inertial frame and the universal time which is the Hubble time in this model of the universe. So, this theory makes the universe three layered.

1) Electrostatic or the Power layer
2) Space-time or the Gravitational layer
3) Quantum fields layer

First layer acts as a power or energy source of the universe. Gravitational layer creates gravity and the Quantum fields layer enables matter, energy, and the rest of the fundamental forces of the nature to work on top of the space-time or the gravitational layer.

This theory also eliminates the cosmic event horizon and the cosmic scale factor (a) as the proper length, and the volume remains constant despite the expansion of the space-time. Therefore, we should be able to see light from any part of the universe without any distance limit, such as a cosmic event horizon. Cosmological constant $\Lambda$ in the gravitational field equations to factor in the dark energy is not required in this model of the universe as dark energy does not gravitate and is isolated to the electrostatic background which is handled independently from the gravity.
The values of the Planck constant, gravitational constant, Boltzmann constant and permittivity of free space are shown to vary owing to the expansion of the space-time grid proving the existence of an absolute frame of reference and hence provide falsifiable predictions for this theory. The aforementioned constants are also shown to vary with the gravitational potential and in all the moving inertial frames and hence enable us to identify the frames through the change in values of the constants compared to the absolute inertial frame or an inertial frame of a different velocity. Absolute inertial frame is the one where the values of the constants are minimum or maximum depending on how they vary with the gravitational potential or the velocity of the inertial frame. So, this theory completely resolves the twin paradox, the person in the frame with the change in physical constants due to velocity will age less than the one in the frame with no change in the physical constants after they meet. However, this theory upholds the invariance of the speed of light in all frames (internal and non-inertial) and hence upholds the special theory of relativity and Lorentz invariance.

In this theory, the constants that do not change with the expansion of the universe or the change in gravitational potential or the velocity of the frame are the below listed but not limited to.

1) Speed of light  
2) Planck length  
3) Planck time  
4) Planck temperature  
5) Electric charge  
6) Fine-structure constant (\(\alpha\))  
7) Rest mass

Black hole singularities do not exist in this model of the universe as the mass gets converted to pure informational entropy at the event horizon and the space-time terminates at the event horizon and cannot be extended beyond the event horizon as in general theory of relativity as the effective radial length, time and the tangible mass becomes zero at event horizon and hence discards the Riemannian geometry of space-time. Also, charged black holes do not exist in this model of the universe as the permittivity of free space becomes infinity at the event horizon. So, the stationary black holes can only have two properties which are informational (entropic) mass and the angular momentum and hence only partially satisfies the no-hair theorem.

This theory also builds a preliminary framework for the relativistic Newtonian gravity as a replacement for the general theory of relativity and a framework for relativistic MOND (Modified Newtonian Dynamics). Relativistic Newtonian gravity proposed in this theory produces similar or even better results in closed form than the General theory of relativity without using weak field approximations for the below listed.

1) Black hole radius (Schwarzschild radius)  
2) Photon sphere  
3) Gravitational lensing  
4) Perihelion precession of Mercury  
5) Shapiro time delay
This theory updates the Maxwell-like equations for gravity or GEM (Gravitoelectromagnetism) equations to make them work in strong fields as well which can explain the frame dragging effect, orbital precession, geodetic effect, and gravitational waves.

Absolute reference frame and the type of the expansion of the universe proposed in this theory identifies a valid reason for transitioning of Newtonian gravity to MOND at $a_0(\sim 1.2 \times 10^{-10}\text{m/s}^2)$ and hence makes a case for the absolute reference frame. However, this theory establishes that transitioning to deep-MOND regime is only possible in the radial space around the black holes but not around the ordinary matter and hence explains the missing gravitational lensing around the gaseous part of the Bullet cluster (1E 0657-56).

In addition, this new model could act as a precursor to theories explaining baryogenesis and primordial nucleosynthesis based on how the initial extremely high expansion energy of the space-time interacted with the quantum fields to create matter. However, it still needs to be seen if the high value of Gravitational constant $G$ proposed in this theory during the emission of CMB (cosmic microwave background) accounts for the observed anisotropy and the angular power spectrum without the dark matter as high $G$ should produce the same gravitational effect as the equivalent high mass. Also, this theory explains the early formation of the galaxies/objects that were recently observed through the JWST (James Webb space telescope) by proving that they were formed much later than calculated.

**Acceleration of space-time:**

Let us consider two points, A and B, on the space-time fabric. We calculated the apparent outward acceleration of point B when observed from point A based on the redshift of the light coming from point B.

$D =$ Proper distance between points A and B

$\lambda = D$ (let us consider the wavelength of light to be equal to D)

Thus, by the time light travels from point B to point A, its wavelength would have expanded by $D(1+z)$ based on the cosmological redshift phenomenon. Therefore, point B would have apparently moved from its original location by $D(1+z)–D$, which is equal to $Dz$.

The apparent velocity $v$ due to the redshift is given by $v = \frac{Distance}{time} = \frac{Dz}{t}$, where $t$ is the time taken for the light to travel from point B to point A. As the distance between points A and B remains constant, the real velocity of point B is zero. Thus, apparent acceleration $a$ is given by $a = \frac{Dz}{t^2}$.

As space stretches like an elastic ruler, the proper distance between points A and B should always remain the same, irrespective of the apparent acceleration. Therefore, the light should take the same amount of time $t$ to travel the apparent distance of $D(1+z)$, which is actually D owing to the constancy of the speed of light.
Therefore, time $t$ is given by $t = D / c$

So, $v = \frac{Dz}{\left(\frac{D}{c}\right)} = zc$

$$v = zc$$

(1)

and $a = \frac{Dz}{\left(\frac{D}{c}\right)^2} = \frac{zc^2}{D}$

As $v = zc$ has already been established in conjunction with the Hubble law, the above derivation proves that space is stretching like an elastic ruler, where the length and volume remains constant, as opposed to the raisin bread model, where length increases and matter is diluted with the expansion of space-time. Therefore, this theory discards the raisin-bread model of the universe and provides a theoretical basis for $v = zc$ (1) whereas the raisin-bread model does not provide any theoretical reasoning.

Based on the equations $v = H_0D$ and $v = zc$ from Hubble’s law, $\frac{z}{D} = \frac{H_0}{c}$, where $v$ is the apparent receding velocity, $H_0$ is the bubble’s constant, $D$ is the distance, and $z$ is the redshift, and $c$ is the speed of light.

So, the apparent acceleration $a = \frac{H_0}{c} * c^2 = cH_0 = 7.549 \times 10^{-10} \text{ m/s}^2$ which is the current acceleration of the universe for $H_0 = 77.7 (\text{ km/s}) / \text{ Mpc}$ based on the $H_0$ values within the range mentioned in the references (Chen et al., 2019; de Jaeger et al., 2020; Tully et al., 2016). As the universe is stretching with constant volume, there must be length contraction and time dilation in the past which are given by the below.

Cosmological length contraction: $L = \frac{L_0}{(1+z)}$

Cosmological time dilation: $T = \frac{T_0}{(1+z)}$

So, the relativistic acceleration of the universe is the below.

$$a = cH_0 (1+z)$$

(2)

Therefore, point B will always move from point A with an apparent acceleration equal to the above, although the proper distance between the two points always remains the same. As Hubble’s constant decreases over time, the rate of apparent acceleration of the universe or space-time is also considered to decrease over time. As the proper distance between the two points and the volume of the universe always remains constant, acceleration $a = cH_0 (1+z)$ is only considered as apparent.
Velocity of space-time, relativistic acceleration, and the cosmological redshift:

Based on the apparent acceleration of space-time \( a = cH_0(1+z) \), we can calculate the apparent velocity \( v \) of point B from big repulsion (point A) on the space-time fabric based on the cosmological redshift \( z \).

\[
\frac{dv}{dt} = a; \quad dv = a \, dt; \quad dv = cH_0(1+z) \, dt;
\]
\[
\int_0^v dv = \int_0^{t_p} cH_0(1+z) \, dt
\]
\[
\int_0^v dv = c \int_{t_p}^{t_0} \frac{1}{T} (1+\frac{v}{c}) \, dT \quad \text{from (1)}
\]
\[
\int_0^v \frac{1}{(c+v)} \, dv = \int_{t_p}^{t_0} \frac{1}{T} \, dT
\]
\[
\ln(c+v)-\ln(c) = \left[ \ln(T_0)-\ln(t_p) \right]
\]

Planck time \( t_p \) is the minimum age of the universe at the beginning of the big repulsion owing to the quantization of space and time to Planck units. \( T \) is the age of the universe, which is considered to be Hubble time in this model of the universe.

\[
\frac{c+v}{c} = \frac{T_0}{t_p}; \quad 1+\frac{v}{c} = \frac{1}{H_0 t_p}; \quad 1+z = \frac{1}{H_0 t_p}
\]

So, the maximum possible cosmological redshift is

\[
z = \frac{1}{H_0 t_p} - 1 \quad (3)
\]

which is \( 7.36614 \times 10^{60} \) for \( H_0 = 77.7 \,(km/s)/Mpc \), and the maximum apparent recession velocity that is possible is \( 7.36614 \times 10^{60} \) times the speed of the light.

For \( H_0 < H_D \),

\[
1+z = \frac{H_D}{H_0} = \frac{1}{H_0(\frac{1}{H_0} - \frac{D}{c})} = \frac{c}{c-H_0 D} \quad (4)
\]

Where, \( \frac{1}{H_D} \geq t_p \) and \( H_D \) is the Hubble’s constant when the light was emitted at distance \( D \).

So, the relativistic Hubble law is the below based on (1) and (4).

\[
v = H_0D(1+z) = \frac{H_0 D}{(1-\frac{H_0 D}{c})} \quad (5)
\]
Acceleration at the beginning of the universe (big repulsion) is the below.

\[
a = cH_0(1+z) = cH_0 \frac{1}{H_0 t_p} = \frac{c}{t_p} = 5.56 \times 10^{51} \text{ m/s}^2 \text{ from (2) and (3)}
\]

Acceleration of the universe at distance D from the present is the below.

\[
a = cH_0(1+z) = cH_0 \left( \frac{c}{c-H_0D} \right) \text{ from (2) and (4)}
\]

We can see in the table below that the redshift (z) values match the regular Hubble’s formula and the new relativistic formula for low values of D. The new formula restricts the maximum cosmological redshift to \(7.36614 \times 10^{60}\) owing to model of the universe being considered. As shown in the table below, the z values differ from each other as D increases or as the time traveled by the light approaches the age of the universe. Therefore, Hubble law \(v = H_0D\) is only accurate up to moderate distances as it is the limiting case of the relativistic Hubble law. We can also see that the new z-values in Table I are in line with the accelerating model of the universe.

### Table I (Cosmological redshift values)

<table>
<thead>
<tr>
<th>(D) (meters)</th>
<th>(\frac{H_0D}{c})</th>
<th>(\frac{H_0D}{c-H_0D})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1\times10^{10})</td>
<td>8.3994291420\times10^{-17}</td>
<td>8.3994291420\times10^{-17}</td>
</tr>
<tr>
<td>(2\times10^{15})</td>
<td>1.6798858284\times10^{-11}</td>
<td>1.6798858284\times10^{-11}</td>
</tr>
<tr>
<td>(3\times10^{20})</td>
<td>2.5198287426\times10^{-6}</td>
<td>2.5198350921\times10^{-6}</td>
</tr>
<tr>
<td>(~5.9527854\times10^{25})</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>(1\times10^{26})</td>
<td>0.8399429142</td>
<td>5.2477708815</td>
</tr>
<tr>
<td>(1.19\times10^{26})</td>
<td>0.9995320679</td>
<td>2136.0622240085</td>
</tr>
<tr>
<td>(~1.1905570\times10^{26})</td>
<td>1</td>
<td>7.3661442125\times10^{60} (Maximum /Big repulsion)</td>
</tr>
</tbody>
</table>
Age of the universe is 12.58 billion years which is the Hubble time. As the proper distance and the volume remains constant, the maximum observable universe is only 12.58 \times 2 billion light years across which is 25.16 billion light years for \( H_0 = 77.7\,(km/s)/Mpc \).

Important formulas: based on (4)

<table>
<thead>
<tr>
<th>Time since the big repulsion to the emission of light ((T_b))</th>
<th>Time since the emission of light ((T_z))</th>
<th>Distance vs Redshift</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_b = \frac{1}{H_0(1+z)} )</td>
<td>( T_z = \frac{1}{H_0} \frac{z}{1+z} )</td>
<td>( D = \frac{zc}{H_0(1+z)} )</td>
</tr>
</tbody>
</table>

So, the light from the galaxy HD1 with cosmological redshift \( z=13.27 \) (Zhe et al., 2022) should have emitted after 0.8 billion years since the big repulsion, possibly giving enough time for it form as a galaxy and hence resolving the issue with the early formation of galaxies/objects that were recently observed through the JWST.
Variable constants $G$, $h$, $\varepsilon_0$ and $k_B$ and the mass increase:

As the speed of light is constant, the Planck length and Planck time are considered constants. Therefore, the product of the gravitational constant $G$ and Planck constant $h$ is considered to be constant. As the Planck charge ($q_p = \frac{e}{\sqrt{\alpha}}$) is conserved, Alpha ($\alpha$) or the fine-structure constant is considered to be constant. Therefore, the product of the Planck constant $h$ and permittivity of free space $\varepsilon_0$ is considered to be constant. As the Planck temperature is considered to be constant, the product of the gravitational constant $G$ and Boltzmann constant $k_B$ is considered to be constant. Based on the above, we can calculate how constants $G$, $h$, $\varepsilon_0$ and $k_B$ change over time. Using the law of conservation of energy, we can calculate the values of $G$, $h$, $\varepsilon_0$ and $k_B$ in the past and in the future.

Cosmological redshift \[ z = \frac{\lambda_{\text{obs}} - \lambda_{\text{emit}}}{\lambda_{\text{emit}}} \quad \text{or} \quad \lambda_{\text{obs}} = \lambda_{\text{emit}} (1 + z) \] (7)

As the energy is conserved in cosmological redshift, \[ E = \frac{hc}{\lambda_{\text{obs}}} = \frac{h_p c}{\lambda_{\text{emit}}} \] (8)

Here, $h$ is the current Planck constant and $h_p$ is the old Planck constant when the age of the universe was Planck time $t_p$.

\[ z = \frac{1}{H_0 t_p} - 1 \quad \text{from (3), and} \quad h = h_p (1 + z) \quad \text{based on (7) and (8)} \] (9)

As $hG = h_p G_{t_p}$, $h\varepsilon_0 = h_p \varepsilon_{t_p}$ and $k_B G = k_{Bp} G_{t_p}$

\[ h = h_p (1 + z) = h_p \left( \frac{1}{H_0 t_p} \right) \] (10)

\[ G = \frac{G_{t_p}}{(1 + z)} = G_{t_p} \left( H_0 t_p \right) \] (11)

\[ \varepsilon_0 = \frac{\varepsilon_{t_p}}{(1 + z)} = \varepsilon_{t_p} \left( H_0 t_p \right) \] (12)

\[ k_B = k_{Bp} (1 + z) = k_{Bp} \left( \frac{1}{H_0 t_p} \right) \] (13)

Below are the values of $G_{t_p}$, $h_{t_p}$, $\varepsilon_{t_p}$, $k_{Bp}$ in MKS units when the age of the universe was Planck time $t_p$, based on the current values of $G$, $h$, and $\varepsilon_0$ for $H_0 = 77.7$. 
As the factor \((1+z)\) in all the above four constants changes directly in proportional to mass \((M)\) in the dimensional formulas, it follows that, \(m_0 = m_z(1+z)\), where \(m_0\) is the current mass and \(m_z\) is the original mass when the light was emitted in the past at cosmological redshift \(z\). However, the mass increase due to the expansion of the space-time should be only seen as increase in cosmological potential energy of the mass but not the change in rest mass. Rest mass remains constant. This is analogous to the relativistic mass of an object moving with some velocity with constant rest mass.

Change in mass can be observed by converting \(m_0\) and \(m_z\) to energy, which is the observed energy difference in the cosmological redshift. So, the energy of a photon does not increase with the space-time expansion whereas the potential energy of a mass increases with the expansion which perfectly explains the observed energy difference in the cosmological redshift. Similarly, for gravitational redshift, change in mass is manifested as the gravitational potential energy \((U)\). Rest mass remains constant. Similar to cosmological redshift, change in mass in gravitational redshift is also associated with the change in physical constants \(G, h, \varepsilon_0\) and \(k_B\). So, the energy of a photon does not change when moving against the gravity but the gravitational redshift which is the decrease in frequency of the photon is due to the increase in Planck constant \((E=h\nu)\). This proves that photons do not curve the space-time by themselves but takes the path of any curved space.

So, the Gravitational potential energy \(U\) of mass \(m\) is

\[
U = -(m(1+z)-m)c^2 = -mzc^2, \quad \text{where, } m(1+z) \text{ is the mass at infinity} \tag{14}
\]

\[
\boxed{U = -mzc^2} \tag{15}
\]

\[
\frac{U}{m} = \phi = -zc^2 \tag{16}
\]

Where, \(z\) is the gravitational redshift, and \(\phi\) is the gravitational potential.

Change in mass with velocity which is the relativistic mass is also associated with change in the physical constants \(G, h, \varepsilon_0\) and \(k_B\). A person moving along with the mass will not observe the change in mass but observes the change in the above physical constants. But a stationary observer with respect to the moving mass will observe the increase in mass with no change in the physical constants.
So, both the observers will see the same thing in two different ways enabling the moving observer to know that the inertial frame is moving though the laws of physics are the same in both the frames.

For example, in this theory, a mass \( M \) moving with enough relativistic velocity to satisfy the Schwarzschild radius \( R \) can become a black hole. A person moving along with the mass will see it becoming a black hole too due to the increase in gravitational constant instead of relativistic mass as the mass remains constant in the moving inertial frame. So, both the stationary and the moving observers will see the mass \( M \) becoming a black hole in two different ways respectively and hence upholding Lorentz invariance.

From stationary observer’s perspective: \( R = \frac{2G(M\gamma)}{c^2} \)

From moving observer’s perspective: \( R = \frac{2(G\gamma)M}{c^2} \)

Where, \( \gamma \) is the Lorentz factor.

<table>
<thead>
<tr>
<th>Gravitational (from infinity)</th>
<th>( G(1+z) )</th>
<th>( \frac{h}{1+z} )</th>
<th>( \varepsilon_0(1+z) )</th>
<th>( \frac{k_B}{1+z} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relativistic</td>
<td>( G(1+z) )</td>
<td>( \frac{h}{1+z} )</td>
<td>( \varepsilon_0(1+z) )</td>
<td>( \frac{k_B}{1+z} )</td>
</tr>
<tr>
<td>( G\gamma ) or ( G \gamma )</td>
<td>( \frac{h}{\gamma} )</td>
<td>( \varepsilon_0 \gamma )</td>
<td>( k_B \gamma )</td>
<td></td>
</tr>
</tbody>
</table>

Where, \( z \) is the gravitational and relativistic redshifts respectively.

For example, Planck constant due to the cosmological redshift after 10 years from now would be \( h(1+\delta z) \) from (10). Where, \( \delta z \) is the change in cosmological redshift value after 10 years from now. \( (1+\delta z) = \frac{H_0}{H_1} \) using (4). Where, \( H_1 \) is the Hubble constant after 10 years from now.

\( \delta z \) values:

- After 10 years: \( 7.9463103517 \times 10^{-10} \)
- After 50 years: \( 3.9731551758 \times 10^{-9} \)
- After 100 years: \( 7.9463103517 \times 10^{-9} \)
The accuracy of the values given below depends on the accuracy of the current values of $h$, $G$, $\varepsilon_0$, $k_B$ and $H_0$.

Table III (Change in physical constants due to cosmological space-time expansion)  

<table>
<thead>
<tr>
<th>Years</th>
<th>$\frac{G}{(1+\delta z)}$</th>
<th>$h(1+\delta z)$</th>
<th>$\frac{\varepsilon_0}{(1+\delta z)}$</th>
<th>$k_B(1+\delta z)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$6.67430 \times 10^{-11}$</td>
<td>$6.62607015 \times 10^{-34}$</td>
<td>$8.8541878128 \times 10^{-12}$</td>
<td>$1.380649 \times 10^{-23}$</td>
</tr>
<tr>
<td>+10</td>
<td>$6.67429999 \times 10^{-11}$</td>
<td>$6.62607015 \times 10^{-34}$</td>
<td>$8.85418780 \times 10^{-12}$</td>
<td>$1.38064900 \times 10^{-23}$</td>
</tr>
<tr>
<td>+50</td>
<td>$6.67429997 \times 10^{-11}$</td>
<td>$6.62607017 \times 10^{-34}$</td>
<td>$8.85418777 \times 10^{-12}$</td>
<td>$1.38064900 \times 10^{-23}$</td>
</tr>
<tr>
<td>+100</td>
<td>$6.67429994 \times 10^{-11}$</td>
<td>$6.62607020 \times 10^{-34}$</td>
<td>$8.85418774 \times 10^{-12}$</td>
<td>$1.38064901 \times 10^{-23}$</td>
</tr>
</tbody>
</table>

Therefore, this theory provides falsifiable predictions by predicting the change in Planck’s constant, gravitational constant, permittivity of free space and Boltzmann constant due to space-time expansion. Similar change in the values of the above physical constants can be observed and calculated in the gravitational field and in the relativistic frames using the factor $(1+z)$. Where, $z$ is the gravitational redshift and the relativistic redshift respectively.

In the below table, we can see the similarity between the transverse relativistic mass increase, gravitational mass increase and the cosmological mass increase. In all the three cases, mass increases by a factor of $(1+z)$ proving that there is a change in mass associated with the redshifts mentioned in the below table. Here, $m_0$ is the observed mass and $m_z$ is the original mass at the point of the emission of photon.

Table IV (Mass increase formulas)

<table>
<thead>
<tr>
<th>Transverse relativistic mass increase</th>
<th>Gravitational mass increase</th>
<th>Cosmological mass increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_0 = m_z (1+z) = m_z \frac{1}{\frac{1}{v^2} - \frac{c^2}{c^2}}$</td>
<td>$m_0 = m_z (1+z) = m_z \frac{1}{\sqrt{1 - \frac{2GM}{Rc^2}}}$</td>
<td>$m_0 = m_z (1+z) = m_z \left( \frac{c}{c - H_0 D} \right)$</td>
</tr>
</tbody>
</table>
Acceleration of the universe due to electrostatic repulsion:

In this theory of electrostatic quantum dark energy in a seven-dimensional universe, the expansion of the space-time is due to the electrostatic repulsion between the Planck charges in the Planck volumes of the seven-dimensional space.

Acceleration at the beginning of the big repulsion is

\[ a = c H_0 (1 + z) = \frac{c}{t_p} \] from (2) and (3)

which can be reformulated as \( \sqrt{\rho_{p} G_{tp}} \) where, \( \rho_{tp} \) is the Planck energy density and \( G_{tp} \) is the gravitational constant when the age of the universe was \( t_p \).

As acceleration \( a \) is directly related to the Planck energy density \( \rho \), it proves the proposed model of the universe having Planck charges in Planck volumes which exactly gives the Planck energy density \( \rho_{tp} \) in the hidden three-dimensional space of the seven-dimensional universe.

So, \( \frac{c}{t_p} = \sqrt{\rho_{tp} G_{tp}} \) which can be generalized to the below.

\[ a^2 = \rho G \] (19)

So, the product of the net electrostatic energy density of the universe in the hidden three dimensions and the gravitational constant is equal to the square of the acceleration of the universe.

\[ \rho = \text{Electrostatic energy density of the universe responsible for acceleration} \]
\[ G = \text{Gravitational constant} \]
\[ a = \text{Current acceleration of the universe which is } c H_0 \]

Planck energy \( E_p = \frac{1}{4 \pi \epsilon_0} \frac{e^2}{\alpha(l_p)} = \sqrt{\frac{\hbar c^5}{G}} \) where \( l_p \) is the Planck length.

When the age of the universe was Planck time \( t_p \), the energy density of the hidden three-dimensional space \( \rho_{tp} \) of the universe was \( \frac{E_p(t_p)}{(l_p)^3} \).

\[ \rho_{tp} = \frac{1}{4 \pi \epsilon_0} \frac{e^2}{\alpha(l_p)^4} = \sqrt{\frac{\hbar c^5}{G_{tp}}} \] (20)

\[ \rho_{tp} G_{tp} = \frac{1}{4 \pi \epsilon_0} \frac{e^2}{\alpha(l_p)^4} G_{tp} = \left( \frac{c}{t_p} \right)^2 = a^2 \]
\[ G_p = \frac{G}{H_0 t_p} \] from (11)

\[ \rho_r G_p = \frac{\rho_p G}{H_0 t_p} = \left(\frac{c}{t_p}\right)^2 \]

\[ \rho_p = \frac{H_0 c^2}{G t_p} \] (21)

So, \( \rho_p = 6.29 \times 10^{52} \text{ J/m}^3 \), which can be generalized to the below.

\[ \rho G(1 + z) = (cH_0(1 + z))^2 \]

\[ \rho = \frac{(cH_0)^2(1 + z)}{G} = \frac{(cH_0)^2}{c - H_0 D} \] from (4)

Current electrostatic energy density \( \rho \) responsible for the acceleration of the universe can be found by setting \( D = 0 \) or \( z = 0 \).

\[ \rho = \rho_p H_0 t_p = \frac{\rho_p}{1 + z} = \frac{(cH_0)^2}{G} = 8.54 \times 10^9 \text{ J/m}^3 \] which resolves to (19).

As the universe is accelerating due to electrostatic repulsion, the electrostatic potential energy in the hidden three-dimensional space is gradually transferred to the four-dimensional space-time grid and stored as potential energy. As the elastic space-time grid resists expansion, the rate of acceleration gradually decreases to follow \( a = cH_0 \) that will asymptote to zero. As the total energy is conserved, potential energy density of the four-dimensional space-time grid \( \rho_g \) is the below.

\[ |\rho_g| = \rho_p - \rho \] (22)

As \( \rho \) decreases with time and \( \rho_{tp} \) being constant, the potential energy density of the four-dimensional space-time grid \( \rho_g \) will continue to increase till infinity owing to the declining permittivity of free space \( \varepsilon_0 \).
Total number of dimensions = 3D + 4D = 7D

Fig 1

Matter in the 4D Space-time grid curves the space-time around it due to the electrostatic repulsion outside the matter being greater than inside as mass also increases/expands along with space-time.

Fig 2

Expansion of the 4D Space-time grid will maintain the Planck volume of each cube and hence the total volume and the proper distance remains constant. Expansion is similar to the stretching of an elastic ruler where the length remains constant.

Fig 3
Temperature of the universe:

Internal energy $U$ of black-body photon gas is given by

$$U = \left( \frac{8\pi^5 k^4}{15h^3 c^3} \right) VT^4.$$ Where, $k =$ Boltzmann constant, $h =$ Planck constant, $c =$ Speed of light,

$$V = \text{Volume and } T = \text{Temperature. (Leff, 2002)}$$

As $h = h_i (1+z)$, $k = k_i (1+z)$, volume $V$ of the universe being constant through length contraction, upholding the law of conservation of energy and CMB being a black-body radiation, the maximum possible temperature of the universe when the age of the universe was $t_p$ is given by the below based on the above formula for $U$.

$$U = \left( \frac{8\pi^5 k^4}{15h^3 c^3} \right) VT^4 = \left( \frac{8\pi^5 \left( \frac{k}{1+z} \right)^4}{15 \left( \frac{h}{1+z} \right)^3 c^3} \right) \frac{V}{(1+z)^3} T_{tp}^4$$

Here, $V \frac{1}{(1+z)^3}$ should not be seen as reduction in volume but as cosmological length contraction. $T_{tp} = T(1+z)$, which can be generalized to the below.

$$T = T_0 (1+z) \quad (23)$$

As $T_0 = 2.725$ K and the maximum cosmological redshift $z$ is $7.4 \times 10^{60}$ from (3), $T_{tp} = 2 \times 10^{61}$ K. As the $T_{tp}$ value is greater than the Planck temperature, the maximum possible temperature of the universe is the Planck temperature which is $1.416784 \times 10^{32}$ K. However, it does not mean that this was the temperature at the time of the big repulsion but only the maximum possible temperature. As the CMB was emitted after the initial $t_p$ of the big repulsion, the original temperature of the CMB when it was first emitted should be less than $T_{tp}$. The future temperature of CMB radiation can also be calculated using the above formula. For example, the CMB temperature after $10^7$ years from now would be $2.722$ K, but the CMB photon density should remain the same as the volume of the universe remains constant.

As the interaction of the electrostatic expansion energy with the quantum vacuum fluctuations to create matter at the time of big repulsion will be the same throughout the space-time, the created primordial elementary particles, atoms and its attributes like temperature, density should be uniform throughout the space-time without having the particles to interact with one another and hence eliminates the cosmic inflation, horizon problem, flatness problem and explains the uniformity of CMB radiation. However, minor fluctuations in the density of the created particles due to the randomness of the quantum vacuum fluctuations and the subsequent concentration of the matter due to gravity could explain the temperature anisotropy. However, angular power spectrum of the CMB still needs to be explained through BAO (Baryon acoustic oscillations) and high gravitational constant without dark matter.
**Absolute frame of reference:**

Four-dimensional space-time grid proposed in this theory acts as an absolute inertial frame. As the physical constants\((G, h, \epsilon_0\) and \(k_B\)) change with the change in gravitational potential and velocity. Any frame of reference that is not absolute can be easily identified by knowing the values of the physical constants. Physical constants change in the gravitational field and due to velocity according to the formulas given in Table II (17).

So, in the gravitational field, absolute reference frame is the one at infinite distance from the mass generating the gravitational field and the values of the physical constants changes as we move from infinity towards the mass. Currently known values of the physical constants are the values of the absolute reference frame at infinity in the gravitational field. For example, gravitational constant would be higher near a mass than away from the mass and the Planck constant would be lower near a mass than away from the mass.

As Hubble constant decreases due to the space-time expansion, the values of the physical constants of the absolute inertial frame needs to be updated to keep up with the expansion. Change in physical constants of the absolute inertial frame due to cosmological expansion are given in Table III (18). Also, the universal time in this theory is the time in the absolute inertial frame which is the Hubble time.

Similarly, a frame moving with a velocity, will have a higher gravitational constant and a lower Planck constant compared to the absolute inertial frame. However, a green color photon will still be green in both the frames with different Planck constants due to time dilation in the moving frame. Also, this theory upholds both the postulates of the special theory of relativity in all inertial frames.

For example, in this theory, Newton’s law of gravitation is invariant in all inertial frames. Consider two masses each of mass \(m\) separated by distance \(r\) moving with velocity \(v\) in an inertial frame. Time dilation of the moving masses in the stationary reference frame compensates for the time dilation of the observer in the moving reference frame. So, the observers in both the stationary and the moving reference frames will observe the same acceleration \(a\) due to gravity.

**Table V (Invariant acceleration due to Newtonian gravity)**

<table>
<thead>
<tr>
<th>Masses aligned perpendicular to the direction of motion</th>
<th>WRT stationary reference frame</th>
<th>WRT moving reference frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>((\gamma m)a = F = \frac{G(\gamma m)(\gamma m)}{r^2} ; a = \frac{G(\gamma m)}{r^2})</td>
<td>(a = \frac{(G\gamma)m}{r^2})</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Masses aligned parallel to the direction of motion</th>
<th>WRT stationary reference frame</th>
<th>WRT moving reference frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\gamma^3 ma = F = \frac{G(\gamma m)(\gamma m)}{\left(\frac{r}{\gamma}\right)^2} ; a = \frac{G(\gamma m)}{r^2})</td>
<td>(a = \frac{(G\gamma)m}{r^2})</td>
<td></td>
</tr>
</tbody>
</table>
**Relativistic Newtonian theory of gravity:**

In the theory, the presence of mass increases the permittivity of the four-dimensional space-time grid and hence reduces the electrostatic repulsion within the grid enveloped by the mass compared to the electrostatic repulsion outside the mass. As the contraction of the space-time grid within mass will be greater than the contraction outside due to the permittivity difference and the net compressing force on the matter from the surrounding Planck charges, space-time becomes naturally curved around any mass and hence the gravitational force. So, in this theory, gravitational force is considered as a real force than a fictitious one as in General theory of relativity.

Change in gravitational constant $G$ in the gravitational field is similar to the change in the gravitational constant due to cosmological space-time expansion. So, we can take the Newton’s law of gravitation and introduce the variable $G$ and gravitational length contraction to come up with a relativistic law. Here, the change in gravitational potential energy is not included as part of mass as it does not cause additional gravitational force, only the rest and relativistic masses cause gravitational force in this theory.

$$F = \frac{G(1+z)Mm}{R^2} = (1+z)^3 \frac{GMm}{R^2} \text{ using (17)}$$

Where, $G$ is the gravitational constant at infinity. As the space-time grid shrinks as we move from infinity towards the mass, length contraction is included for $R$ which is the distance between the masses $m$ and $M$.

$$\frac{dU}{dR} = F = (1+z)^3 \frac{GMm}{R^2} = \left(1 - \frac{U}{mc^2}\right)^3 \frac{GMm}{R^2} \text{ using (15)}$$

$$\int_{0}^{U} \left(\frac{1}{mc^2 - U}\right)^3 dU = \frac{GMm}{(mc^2)^3} \int_{\infty}^{R} \frac{1}{R^2} dR$$

$$\frac{1}{2(mc^2 - U)^2} - \frac{1}{2(mc^2)^2} = -\frac{GMm}{(mc^2)^3} \frac{1}{R}$$

Dividing the denominator by $(mc^2)^2$ on both sides.

$$\frac{1}{2\left(1 - \frac{U}{mc^2}\right)^2} - \frac{1}{2} = -\frac{GMm}{mc^2} \frac{1}{R}$$

$$\frac{1}{2(1+z)^2} - \frac{1}{2} = -\frac{GMm}{mc^2} \frac{1}{R} \text{ using (15), after solving, we get}$$
As the above gravitational redshift matches with the redshift from Schwarzschild solution of the Einstein’s field equations without using weak field approximation, it validates this theory, the concept of variable physical constants and proves the existence of absolute reference frame. Also, the below formulas for the gravitational force and the gravitational potential energy are not approximations but complete solutions that work in both strong and weak gravitational fields for non-rotating stationary spherical masses without using weak field approximation as in general theory of relativity. If there is kinetic energy of the particles within the masses, the respective relativistic masses should be used instead of the rest masses M and m to get accurate results.

\[ 1 + z = \left( \frac{1}{1 - \frac{2GM}{Rc^2}} \right)^{\frac{3}{2}} \]  \hspace{1cm} (24)

\[ z \text{ becomes infinity at } R = \frac{2GM}{c^2} \text{ in (24) which gives the Schwarzschild radius without using weak field approximation.} \]

Relativistic gravitational force \( F \) for \( M \geq m \):

\[ F = (1 + z)^3 \frac{GMm}{R^2} = \left( \frac{1}{1 - \frac{2GM}{Rc^2}} \right)^{\frac{3}{2}} \frac{GMm}{R^2} \]  \hspace{1cm} (25)

Relativistic gravitational potential energy \( U \) for \( M \geq m \):

\[ U = -mc^2 = -m \left( \frac{1}{\sqrt{1 - \frac{2GM}{Rc^2}}} - 1 \right) c^2 \]  \hspace{1cm} (26)

For weak gravitational fields, (26) reduces to the regular Newtonian gravitational potential energy and hence validates this theory.

\[ U = -m \left( 1 - \frac{2GM}{Rc^2} \right)^{\frac{1}{2}} - 1 c^2 \approx -m \left( 1 + \frac{GM}{Rc^2} - 1 \right) c^2 = -\frac{GMm}{R} \]

Relativistic gravitational potential \( \phi \) for \( M \geq m \):

\[ \phi = \frac{U}{m} = -zc^2 = -\left( \frac{1}{\sqrt{1 - \frac{2GM}{Rc^2}}} - 1 \right) c^2 \]  \hspace{1cm} (27)
The maximum potential energy that can be gained by a mass $m$ at radius $R$ from mass $M$ is

$$U_{\text{max}} = m(1 + z)c^2 = m \left( \frac{1}{1 - \frac{2GM}{Rc^2}} \right) c^2$$ from (14)

As the energy is conserved in the freefall motion of mass $m$ in the gravitational field, the velocity of mass $m$ can be derived from the maximum potential energy. Through dimensional analysis, energy at any point during the freefall must be of the form

$$m \left( \frac{1}{1 - \frac{v^2}{c^2}} \right) c^2$$

So, $v^2 = \frac{2GM}{R}$ ; $v = \sqrt{\frac{2GM}{R}}$ which is the velocity of mass $m$ in freefall motion from the point of the maximum potential energy which is also the escape velocity $v_e$. As the freefall motion is inertial, Lorentz factor $\gamma$ is directly realized from the energy conservation which is $\sqrt{\frac{1}{1 - \frac{v^2}{c^2}}}$ and hence this theory upholds the special theory of relativity in inertial frames. As $G(1+z)$ varies in the gravitational field, the additional relativistic mass from $\gamma m$ in freefall motion does not cause additional gravitational force which is also proven through the energy conservation in freefall motion. When there is a variation in $G$, variation in mass is not considered to cause additional gravitational force as the mass change is the effect of the changing gravitational potential energy which does not cause additional gravitational force. However, at constant $G$, both the rest and relativistic masses are considered to cause gravitational force.

Length contraction, time dilation and mass change in the gravitational field are given by

$$L = \frac{L_\infty}{(1 + z)} ; \quad T = \frac{T_\infty}{(1 + z)} ; \quad m = \frac{m_\infty}{(1 + z)}$$

where $L_\infty$, $T_\infty$ and $m_\infty$ are the absolute length, absolute time, and the maximum mass respectively at infinity. (28)

As radial length $L$, $T$ and $m$ becomes zero at Schwarzschild radius, space-time terminates at the event horizon of a black hole. Black hole singularities do not exist in this model of the universe as the mass becomes zero and gets converted to the equivalent pure informational entropy at the event horizon. Space-time terminates at the event horizon and cannot be extended beyond the event horizon as in General theory of relativity as the effective radial length, time and the tangible mass becomes zero at event horizon and hence discards the Riemannian geometry of space-time. Also, charged black holes do not exist in this model of the universe as the permittivity of free space becomes infinity (from (17)) at the event horizon. So, the stationary black holes can only have two properties which are informational (entropic) mass and the angular momentum and hence only partially satisfies the no-hair theorem.
Photon sphere:

As the photon takes the curved path around the black hole due to the space-time curvature, matching the fictitious acceleration due to gravity for photon with the centripetal acceleration gives the radius of the photon sphere as predicted by the general theory of relativity. Here, the forces are considered to be fictitious as photon does not curve the space-time by itself but only takes the path of a curved space-time.

\[
(1+z)^3 \frac{GM}{R^2} = \left(\frac{c^2}{R \frac{1}{1+z}}\right) \quad \text{using (25), solving this using (24) we get the radius of the photon sphere.}
\]

\[
\left(\sqrt{\frac{1}{1-\frac{2GM}{Rc^2}}}\right)^2 \frac{GM}{Rc^2} = 1
\]

\[
R = \frac{3GM}{c^2}
\]  

Gravitational lensing:

As the angle of deflection \(\theta\) for photon sphere is \(\pi\) radians owing to the symmetry of the sphere, we can calculate the angle of deflection for any radius \(R\) by replacing 1 in (29) with \(\tan\left(\frac{\pi}{4}\right)\),

\[
\left(\sqrt{\frac{1}{1-\frac{2GM}{Rc^2}}}\right)^2 \frac{GM}{Rc^2} = \tan\left(\frac{\pi}{4}\right)
\]

\[
\theta = 4\tan^{-1}\left((1+z)^2 \frac{GM}{Rc^2}\right) = 4\tan^{-1}\left(\sqrt{\frac{1}{1-\frac{2GM}{Rc^2}}}\right)^2 \frac{GM}{Rc^2}
\]

For \(\theta = 2\pi\), we get \(R = \frac{2GM}{c^2}\) - which is the Schwarzschild radius and hence validates the above equation. So, light bends onto itself at event horizon of a black hole and does not travel beyond it as in general theory of relativity and hence provides another proof that space-time ends at event horizon and non-existence of singularity. For weak gravitational fields, angle of deflection in (31) reduces to \(\theta = \frac{4GM}{Rc^2}\) - which is same as the deflection predicted by the general theory of relativity. So, the equation (31) predicts the angle of deflection in a closed form that works in both strong and weak gravitational fields better than the general theory of relativity without using any approximations or higher order terms.
**Perihelion precession of Mercury:**

From Kepler’s second law,

\[ dA = \frac{1}{2} r^2 d\theta, \text{ where } dA \text{ is the change in the area swept out by the orbiting mass, } d\theta \text{ is the change in angle and } r \text{ is the radius.} \]

Let \( dA' \) be the area from the absolute reference frame perspective where the length and time are absolute.

Multiply the above equation on both sides by \( dt' \) and apply length contraction (using (28)).

\[
\frac{dA'}{dt'} = \frac{1}{2} \left( \frac{r}{1+z} \right)^2 \frac{d\theta}{dt'}
\]

Apply time dilation (using (28)). Where \( dt' \) is the absolute time and \( dt \) is the local time.

\[
\frac{dA'}{dt'} = \frac{1}{2} \left( \frac{r}{1+z} \right)^2 \frac{d\theta}{dt(1+z)} = \frac{1}{2} \frac{r^2}{dt} \frac{d\theta}{dt(1+z)} = \frac{1}{2} r^2 \frac{d\theta}{dt} \left( 1 - \frac{2GM}{Rc^2} \right)^{3/2} \approx \frac{1}{2} r^2 \frac{d\theta}{dt} \left( 1 - \frac{3GM}{Rc^2} \right)
\]

by ignoring the higher order terms. Comparing this equation with the non-relativistic one, we get

\[
d\theta' = d\theta \left( 1 - \frac{3GM}{Rc^2} \right)
\]

Polar equation of the ellipse is

\[
R = \frac{a(1-\varepsilon^2)}{1-\varepsilon \cos \theta}
\]

\[
\theta' = \int_0^{2\pi} \left( 1 - \frac{3GM}{c^2 a(1-\varepsilon^2)} \right) d\theta
\]

\[
\theta' = 2\pi - \frac{6\pi GM}{c^2 a(1-\varepsilon^2)}, \text{ second term gives the precession angle } \Delta \phi \text{ of the perihelion per revolution.}
\]

Where, \( M \) is the mass of the sun, \( a \) is the semi-major axis of Mercury and \( \varepsilon \) is the orbital eccentricity.

\[
\Delta \phi = \frac{6\pi GM}{c^2 a(1-\varepsilon^2)}
\]

Solving the above, we get perihelion precession of 43"/century which is same as predicted by the general theory of relativity (Park et al., 2017).
Solutions to the orbital motion can also be obtained by solving the below Lagrangians.

**One-body problem:**

\[
L = T - V = \frac{1}{2} mx^2 + mz^2 \quad \text{(Using (15))}, \text{ where } z \text{ is gravitational redshift.}
\]

**Two-body problem:**

\[
L = T - V = \frac{1}{2} \mu x^2 + mz^2, \text{ where } \mu \text{ is the reduced mass.}
\]

**Shapiro time delay:**

We can calculate the gravitational time delay of light passing by a mass like sun. As the gravitational length contraction and gravitational time dilation go together in this theory, we can calculate the effective speed of light as observed by an observer on earth as the light from a distant object passes nearby the sun and reaches the earth.

Speed of light is constant at every point in space in the gravitational field as the length contraction would be compensated by the time dilation. So, \[\frac{\text{Distance}}{\text{Time}} = c \quad \text{(speed of light) remains constant.} \]

However, a stationary observer would see a change in the speed of light w.r.t his own reference frame as the light goes through the gravitational field. Here, the time expansion is applied instead of contraction as the time delay is observed from the observers frame of reference whose local time is faster than the time near the sun. So, the length contraction and time expansion do not cancel out in the observer’s reference frame and hence produce a time delay according to this theory which is called Shapiro time delay.

Effective speed of light as experienced by the stationary observer is \[\frac{\text{Distance}}{\text{Time}(1+z)} = \frac{c}{(1+z)^2}. \]

\[
\frac{dx}{dt} = c \left(1 - \frac{2GM}{Rc^2}\right) \quad \text{using (24), where } R \text{ is the distance between the sun and the travelling photon.}
\]

Neglecting the deflection of the light near the sun, the path of the light from A to B would be a straight line.
Consider the equation:

\[
dt = \frac{1}{c} \left( \frac{1}{1 - \frac{2GM}{Rc^2}} \right) dx \approx \frac{1}{c} \left( 1 + \frac{2GM}{\sqrt{x^2 + b^2 c^2}} \right) dx
\]

by ignoring the higher order terms, where, \( b \) is the impact parameter. Integrating on left side from \( T_A \) to \( T_B \) and on right side from \( X_A \) to \( X_B \).

\[
\int_{T_A}^{T_B} dt = \int_{X_A}^{X_B} \frac{1}{c} \left( 1 + \frac{2GM}{\sqrt{x^2 + b^2 c^2}} \right) dx
\]

Second term gives the additional one-way time delay \( \Delta t \) of the light coming from point A as observed by an observer at point B which better fits the experimental data than the Schwarzschild metric of general theory of relativity (Pössel, 2019, Page 8).

\[
\Delta t = \frac{2GM}{c^3} \ln \left( \frac{X_B + \sqrt{X_B^2 + b^2}}{X_A + \sqrt{X_A^2 + b^2}} \right)
\]

Relativistic gravitoelectromagnetism (GEM) and Poisson equations:

Relativistic GEM and Poisson equations can be generated by multiplying the gravitational constant \( G \) with \((1+z)^3 \) (25). \( z = \frac{\phi}{c^2} \) (16). So, the relativistic GEM and Poisson equations are the below which can explain the frame-dragging effect, orbital precession, geodetic effect, and gravitational waves.
Relativistic GEM equations:

Relativistic Maxwell-like GEM equations can be generated by replacing $G$ with $G \left(1 - \frac{\phi}{c^2}\right)^3$ similar to the below relativistic Poisson equation.

Relativistic Poisson equation:

$$\nabla^2 \phi = 4\pi G \left(1 - \frac{\phi}{c^2}\right)^3 \rho,$$

where $\rho$ is the mass density.

Space-time interval ($ds^2$):

Space-time interval in the Minkowski space is given by $ds^2 = -c^2 dt^2 + dr^2 + r^2 (d\theta^2 + \sin^2 \theta d\phi^2)$. Applying the gravitational length contraction and time dilation (24) (16), we get the equivalent of the Schwarzschild metric for this theory.

$$ds^2 = \frac{c^2 dt}{(1 + z)^2} + \frac{dr^2}{(1 + z)^2} + \frac{r^2}{(1 + z)^2} (d\theta^2 + \sin^2 \theta d\phi^2)$$

OR

$$ds^2 = -c^2 dt^2 \left(1 - \frac{2GM}{rc^2}\right) + dr^2 \left(1 - \frac{2GM}{rc^2}\right) + r^2 \left(1 - \frac{2GM}{rc^2}\right) (d\theta^2 + \sin^2 \theta d\phi^2)$$

Applying the cosmological length contraction and time dilation (4), we get the equivalent of the FLRW metric of the flat space-time for this theory.

$$ds^2 = -c^2 dt^2 \left(1 - \frac{H_0D}{c}\right)^2 + \left(1 - \frac{H_0D}{c}\right)^2 (dx^2 + dy^2 + dz^2)$$
MOND (Modified Newtonian dynamics):

As the relativistic effect becomes insignificant at lower accelerations, we can ignore the relativistic factor \((1+z)^3\) from (25) for the gravitational force in the deep-MOND regime. However, a relativistic Poisson equation for MOND can be generated. This theory proposes that MOND regime can only be present around a black hole but not around ordinary masses like gas, stars etc. In the absence of black holes, gravitational field around ordinary masses will always be Newtonian at any acceleration. So, the cutoff acceleration for MOND regime which is \(a_0(\sim 1.2 \times 10^{-10} \text{ m/s}^2)\) is only applicable for the area around a central black hole but not for the ordinary masses. Each cell in the below figure 5 of the curved space around the black hole represents Planck volume with Planck charge. Radial length becomes zero at event horizon but will continue to expand to follow the relativistic Newton’s law of gravitation as we move away from the black hole. Also, the number of Planck volumes on the circumference remains constant at any radius from the event horizon.

To understand the reason for transitioning of the Newtonian regime to MOND regime at \(a_0\), we can flatten the above curved space which is depicted in the below figure 6. As the relative Planck volume cannot increase more than the maximum allowed by the expansion of the universe, the relative size of the Planck volume should remain constant after \(a_0\) which is the case in the below figure 6.
Once the space becomes curved as is the case around the black hole, the Planck volumes beyond $a_0$ also gets curved and hence the relative Planck volumes would also gradually increase as the stretching of the space-time would continue to increase beyond $a_0$ due to the curvature as the circumference farther to the $a_0$ should stretch more than the nearer one. However, the rate of change in the Planck volume for $a < a_0$ is less than the rate of change for $a > a_0$. So, the Newtonian law of gravitation switches to MOND law of gravitation at $a_0$.

Let us consider an elastic rubber band stretched around a cylinder, the radial force exerted by the rubber band on the cylinder would be $\frac{1}{2\pi}$ times the tension in the rubber band owing to the circumference of the cylinder given by $2\pi r$. As the current acceleration of the universe is $cH_0$ (2) as per this theory, the radial acceleration at $a_0$ should be $\frac{cH_0}{2\pi}$ which is $\sim 1.2 \times 10^{-10}$ m/s$^2$ as per the above analogy. Here, the whole universe is acting like a rubber band wrapped around the black hole at $a_0$. Also, we can see that the space-time grid ends at the event horizon of the black hole and does not extend into it as in general theory of relativity.

The below figure 7 represents the distortion of the space-time grid around ordinary matter. As the matter is present only in the four-dimensional space-time grid, it is depicted in red in the middle of the figure 7. Each cube in this figure is of one Planck volume with Planck charge. As the number of circumferential Planck volumes and the respective area increases radially as we move away from the matter, cutoff acceleration like $a_0$ is not applicable and the Newton’s law of gravitation can be applied at any acceleration without using any modification like MOND in the absence of black holes. This explains the reason why expected gravitational lensing is not observed around the gaseous part of the Bullet cluster (1E 0657-56) but around the galactic matter as it is subjected to MONDian gravitational lensing due to the presence of black holes at the centers of the galaxies.
MONDian gravitational lensing:

MOND gravitational law is given by the below

\[ F = \frac{GM}{r^2} f\left(\frac{r}{r_o}\right) \]  

(Sanders & Mcgaugh, 2002)

\[ f(x) \rightarrow 1 \text{ for } x \ll 1, \quad f(x) \rightarrow x \text{ for } x \gg 1 \text{ and } r_o \text{ is the radius at which } a = a_0. \]

In the deep-MOND regime, fictitious gravitational force experienced by a photon can be equated to the fictitious centripetal acceleration of the photon to find the lensing formula around a spherical stationary black hole.

\[ a = \frac{GM}{r_o r} = \frac{c^2}{r} \]

\[ \frac{GM}{r_o c^2} = 1, \text{ replacing 1 with } \tan\left(\frac{\pi}{4}\right) \text{ as in (31), we get the below gravitational lensing equation in the deep-MOND regime.} \]

\[ \theta = 4 \tan^{-1} \left( \frac{GM}{r_o c^2} \right) \approx \frac{4GM}{r_o c^2} = \frac{4\sqrt{GMa_0}}{c^2} \]

So, in the absence of EFE (external field effect), the gravitational deflection angle \( \theta \) remains constant at any radius in the deep-MOND regime. As the dark matter has not been detected in the galaxy NGC 1052-DF2 (Van Dokkum et al., 2018), this theory predicts that the galaxies that do not have dark matter should not have black holes at its centers or anywhere in the galaxies.

Relativistic Poisson equation for MOND:

Poisson equation based on AQUAL is given by the below.

\[ \nabla \left[ \mu \left( \frac{\nabla \phi}{a_0} \right) \nabla \phi \right] = 4\pi G \rho \]  

(Mamon et al., 2005), this equation can be converted to a relativistic one by multiplying G with \((1+z)^3\) (25). As \( z = \frac{\phi}{c^2} \) (16), relativistic Poisson equation is given by the below.

\[ \nabla \left[ \mu \left( \frac{\nabla \phi}{a_0} \right) \nabla \phi \right] = 4\pi G \left( 1 - \frac{\phi}{c^2} \right)^3 \rho \]
References:


Sanders, R. H., & McGaugh, S. S. (2002). *MODIFIED NEWTONIAN DYNAMICS AS AN ALTERNATIVE TO DARK MATTER.*


Methods:
The computations in this paper were performed by using Maple™. Maple 2020.2. Maplesoft, a division of Waterloo Maple Inc., Waterloo, Ontario. Maple is a trademark of Waterloo Maple Inc.