

Disruptive Gravity: An Alternative to General Relativity

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Abstract

Viewing gravity as a space-time bending force instead of just a space-time curvature, we come to the conclusion of rest mass relativity. A close analysis of Schwarzschild's metric lead us naturally to the Vacuum Apparent Energy Invariance principle from which we derive the metric equation. Using quantum physics in a curved space-time study, we derive a coherent quantum equation that includes gravity. Applying this theory to cosmology, we can explain galaxies redshift as a delayed gravitational redshift which fully explains Hubble diagrams, including Dark Energy.

Keywords: *Quantum gravity, General relativity, Dark energy, MOND theories*

Introduction

Gravity is currently understood as a space-time curvature. We will first see how gravity can be seen as a force able to bend space-time instead and then derive a new space-time bending equation thanks to a new principle equivalent to Einstein's Equivalence Principle in low-intensity fields.

In this paper, Greek letters range from 0 to 3 (representing space-time) while roman letters range from 1 to 3 (representing space), contravariant coordinates have low indices except for four-potentials and the metric signature is $(+ - - -)$. We use Einstein's summation convention.

A space-time bending force

Einstein's General Relativity states that a body moving through gravity is just following the shortest path in curved space-time. This is summarized by the geodesic equations where the metric $g_{\mu\nu}$ is derived from Einstein's equation. Those equations are derived from the least action principle, with the following Lagrangian:

$$L_0 = -m_0 c \sqrt{g_{\mu\nu} \dot{x}^\mu \dot{x}^\nu}$$

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If gravity were a force, the Lagrangian would be of the form:

$$L = -m_0 c \sqrt{\eta_{\mu\nu} \dot{x}_\mu \dot{x}_\nu} - m_0 \Phi$$

where $\eta_{\mu\nu}$ is Minkowsky's metric and Φ is the gravitational potential.

We know this Lagrangian is not correct since it would lead to incorrect geodesic equations.

How could we get to the same geodesic equations as General Relativity taking into account space-time curvature and a potential term? Let the Lagrangian be of the form:

$$L_\Phi = -mc \sqrt{g_{\mu\nu} \dot{x}_\mu \dot{x}_\nu} - m\Phi$$

As such, we still wouldn't get the same geodesic equations as General Relativity. Is it possible to slightly change it in a physically acceptable way so it becomes equivalent to General Relativity's Lagrangian?

Speed of light cannot be modified since Special Relativity laws wouldn't apply anymore. The only thing that could be changed is the mass of the body.

Let's then write:

$$m = \alpha(\Phi)m_0$$

where m_0 is the rest mass in case of zero potential. So we have: $\alpha(0) = 1$.

For more clarity, let's also write: $s_0 = \sqrt{g_{\mu\nu} \dot{x}_\mu \dot{x}_\nu}$

We then have: $L_0 = -m_0 c s_0$ and $L_\Phi = -\alpha(\Phi)m_0 c s_0 - \alpha(\Phi)m_0 \Phi$

We want to find the same geodesic equations with L_0 and L_Φ .

For General Relativity, we have:

$$\frac{\partial L_0}{\partial x_\kappa} - \frac{d}{dt} \frac{\partial L_0}{\partial \dot{x}_\kappa} = 0$$

For our new Lagrangian, we have:

$$\frac{\partial L_{\Phi}}{\partial x_{\kappa}} - \frac{d}{dt} \frac{\partial L_{\Phi}}{\partial \dot{x}_{\kappa}} = 0$$

Since Φ doesn't depend explicitly on \dot{x}_{κ} we have:

$$-\frac{\partial \alpha(\Phi) m_0 c s_0}{\partial x_{\kappa}} - \frac{\partial \alpha(\Phi) m_0 \Phi}{\partial x_{\kappa}} + \frac{d}{dt} \frac{\partial \alpha(\Phi) m_0 c s_0}{\partial \dot{x}_{\kappa}} = 0$$

Leading to:

$$-\frac{\partial \alpha(\Phi) s_0 / c}{\partial x_{\kappa}} - \frac{\partial \alpha(\Phi) \Phi / c^2}{\partial x_{\kappa}} + \frac{d}{dt} (\alpha(\Phi) \frac{\partial s_0 / c}{\partial \dot{x}_{\kappa}}) = 0$$

It comes:

$$-\alpha(\Phi) \frac{\partial s_0 / c}{\partial x_{\kappa}} - \frac{\partial \alpha(\Phi)}{\partial x_{\kappa}} s_0 / c - \frac{\partial \alpha(\Phi) \Phi / c^2}{\partial x_{\kappa}} + \frac{d \alpha(\Phi)}{dt} \frac{\partial s_0 / c}{\partial \dot{x}_{\kappa}} + \alpha(\Phi) \frac{d}{dt} \frac{\partial s_0 / c}{\partial \dot{x}_{\kappa}} = 0$$

We see the Lagrangian equation of L_0 in the first and last terms of the equation:

$$-\frac{\partial \alpha(\Phi)}{\partial x_{\kappa}} s_0 / c - \frac{\partial \alpha(\Phi) \Phi / c^2}{\partial x_{\kappa}} + \frac{d \alpha(\Phi)}{dt} \frac{\partial s_0 / c}{\partial \dot{x}_{\kappa}} + \alpha(\Phi) / m_0 c^2 \left(\frac{\partial L_0}{\partial x_{\kappa}} - \frac{d}{dt} \frac{\partial L_0}{\partial \dot{x}_{\kappa}} \right) = 0$$

So we have the same geodesic equations as in General Relativity if and only if:

$$-\frac{\partial \alpha(\Phi)}{\partial x_{\kappa}} s_0 / c - \frac{\partial \alpha(\Phi) \Phi / c^2}{\partial x_{\kappa}} + \frac{d \alpha(\Phi)}{dt} \frac{\partial s_0 / c}{\partial \dot{x}_{\kappa}} = 0$$

Parametrizing with the body's proper time, we have: $s_0 = c$.

It comes:

$$-\frac{\partial \alpha(\Phi)}{\partial x_{\kappa}} - \frac{\partial \alpha(\Phi) \Phi / c^2}{\partial x_{\kappa}} = 0$$

Thus:

$$\frac{\partial \alpha(\Phi)(1 + \Phi/c^2)}{\partial x_\kappa} = 0$$

Eventually:

$$\alpha(\Phi) = (1 + \Phi/c^2)^{-1}$$

Gravity is then a space-time bending force if and only if the mass is relative such that:

$$m = m_0/(1 + \Phi/c^2)$$

This is exactly what we wanted. Interpreting gravity as a force able to bend space-time instead of just a space-time curvature.

Mass changes seem to falsify the conservation of energy. For it to remain true, the energy has to be written as:

$$E = mc^2(1 + \Phi/c^2)$$

We generalize this formula as such for a relativistic body:

$$E^2 = (m^2 c^4 + p^2 c^2)(1 + \Phi/c^2)^2$$

With: $m = m_0/(1 + \Phi/c^2)$ and $p = p_0/(1 + \Phi/c^2)$

We are now left with finding how gravity could bend space-time. What physical principle could explain that? Can we derive the metric through a new principle other than General Relativity strong equivalence principle?

Metric Field

Let's postulate that the metric is of the form:

$$g(\Phi) = \begin{pmatrix} g_{00}(\Phi) & 0 \\ 0 & -g_s(\Phi) \end{pmatrix}$$

Where time dilation and spatial curvature are disjoint. Then g_{00} would be a Φ -dependent function and g_s would be the spatial part of the matrix.

In this view, space-time is not bent by matter, but rather by gravitational potential.

Let's derive g_{00} and $\det(g_s)$ first.

Time Dilation

Let's derive g_{00} with two different methods.

We introduce the Apparent Energy as such:

$$E_{app}^2 = (m_0^2 c^4 + p_0^2 c^2)(1 + \Phi/c^2)^2$$

Thus:

$$E_{app} = E_0(1 + \Phi/c^2)^2$$

The apparent energy is the particle's energy under Φ -potential gravity as seen by an observer.

Applied to photons, we have: $h\nu_0 = h\nu_\phi(1 + \Phi/c^2)$.

Thus: $\nu_0 = \nu_\phi(1 + \Phi/c^2)$

which is similar to a gravitational redshift.

From Einstein's gravitational redshift analysis, we have: $\nu_0 = \nu_\phi\sqrt{g_{00}}$

It comes: $g_{00} = (1 + \Phi/c^2)^2$

Let's have a quick look at Schwarzschild's metric:

$$ds^2 = (1 + 2\Phi/c^2)c^2 dt^2 - (1 + 2\Phi/c^2)^{-1} dr^2 - r^2(d\theta^2 + \sin^2(\theta)d\psi^2)$$

We have: $g_{00, schw} = (1 + 2\Phi/c^2)$

The difference is really small: $g_{00} - g_{00, schw} = (\Phi/c^2)^2$ but still noticeable. Precise measurement of gravitational redshift would decide which time dilation factor is the most accurate. This theory could be falsified this way.

Let's now see what g_{00} comparing General Relativity's Lagrangian to a classic lagrangian. That would help us chose between Schwarzschild's result and ours.

The classic lagrangian is:

$$L_c = -m_0c^2 - 1/2 m_0v^2 - m_0\Phi$$

And let's rewrite General Relativity's lagrangian this way:

$$L_0 = -m_0c^2 \sqrt{g_{\mu\nu} \dot{x}_\mu \dot{x}_\nu / c^2}$$

Then, for non-relativistic speeds, we have:

$$L_0 = -m_0c^2 \sqrt{g_{00}} (1 + 1/2 \lambda_{ij} \dot{x}_i \dot{x}_j)$$

with $\lambda_{ij} = c^{-2} g_{ij} / g_{00}$.

Equating both lagrangians, it comes:

$$-m_0c^2 - m_0\Phi = -m_0c^2 \sqrt{g_{00}}$$

And eventually: $g_{00} = (1 + \Phi/c^2)^2$

Schwarzschild's solution would be a first-order approximation while ours seems more precise. But since Schwarzschild's solution is an exact solution of Einstein's equation, if the real physically observed time dilation factor was mathematically different from Schwarzschild's, it would mean that General Relativity's equations are false. There should be a more accurate theory. Since General Relativity derives from the strong equivalence principle only, we should conclude that the strong equivalence principle is false. Therefore, one would rather find a new physical principle to build a new theory upon. Which is the aim of the next section.

Will also see a third way to derive g_{00} applying a new principle which doesn't depend on quantum physics in the next section.

Vacuum Apparent Energy Invariance

We naturally want to change Schwarzschild's metric into the following metric:

$$ds^2 = (1 + \Phi/c^2)^2 c^2 dt^2 - (1 + \Phi/c^2)^{-2} dr^2 - r^2(d\theta^2 + \sin^2(\theta)d\psi^2)$$

This way, in Cartesian coordinates, we would have:

$$\det(g_s) = (1 + \Phi/c^2)^{-2}$$

What could be the physical meaning of this? Let ρ_0 be a mass density:

$$\sqrt{\det(g_s)} = (1 + \Phi/c^2)^{-1} = (1 + \frac{\rho_0\Phi}{\rho_0c^2})^{-1} = \frac{\rho_0c^2}{\rho_0c^2 + \rho_0\Phi} = \frac{\rho_0c^2}{\rho_0c^2(1 + \Phi/c^2)}$$

It's just as if it was the ratio of the apparent energy of virtual vacuum masses under zero gravity potential over the apparent energy of those same masses under Φ -potential gravity.

For an infinitely small space volume = $dx dy dz$, we can write:

$$\sqrt{\det(g_s)} dx dy dz = \frac{\rho_0c^2}{\rho_0c^2(1 + \Phi/c^2)} dx dy dz$$

It comes:

$$\rho_0c^2(1 + \Phi/c^2)\sqrt{\det(g_s)} dx dy dz = \rho_0c^2 dx dy dz$$

So we naturally introduce the Vacuum Apparent Energy Invariance principle (VAEI) as follows:

"The apparent energy of the vacuum is invariant."

Let's apply this principle to derive $\det(g_s)$ and g_{00} .

At a given point in time t , in an infinitely small volume $dx_1 dx_2 dx_3$ under zero gravity (flat space) with vacuum energy density \mathcal{E}_0 , we have:

$$dE_0 = \mathcal{E}_0 dx_1 dx_2 dx_3$$

and under Φ -gravity potential, we have:

$$dE_\Phi = \mathcal{E}_0(1 + \Phi/c^2) dx_1 dx_2 dx_3$$

Applying VAEI, we have: $dE_0 = dE_\Phi$

It comes:

$$\det(g_s) = (1 + \Phi/c^2)^{-2}$$

Let's apply VAEI in the time domain to have a more rigorous way to find g_{00} .

The reasoning is a bit similar to the one for the derivation of the gravitational redshift. We reason in terms of observational events.

Let E_0 be the total vacuum energy and N be the number of observational events.

The apparent total vacuum energy by time unit for an observer under a global 0-potential is:

$$P_0 = \frac{dNE_0}{dt}$$

The apparent total vacuum energy by time unit for the same observer under a global Φ -potential is:

$$P_\Phi = \frac{dNE_0(1 + \Phi/c^2)}{d\tau}$$

Applying VAEI, we have: $P_0 = P_\Phi$.

It comes:

$$E_0 dN d\tau = E_0 (1 + \Phi/c^2) dN dt$$

With $d\tau^2 = g_{00} dt^2$ it eventually comes:

$$g_{00} = (1 + \Phi/c^2)^2$$

We don't need a quantum argument anymore which is really important for this theory not to be dependent on quantum physics and the energy conservation argument wasn't strong enough since gravitational redshift of photons implying a violation of energy conservation is currently interpreted otherwise.

Space Metric

We still don't fully know g_s . We only know its determinant.

Spherical potential from a point like mass is a special case in which space is only dilated radially. Which gives locally in $(\vec{e}_r, \vec{e}_u, \vec{e}_v)$ basis:

$$ds^2 = A c^2 dt^2 - B dr^2 - du^2 - dv^2$$

Applying the VAEI principle, it comes:

$$A = B^{-1} = (1 + \Phi/c^2)^2$$

In this coordinate system, the spatial part of the metric is local:

$$g_{ruv} = \begin{pmatrix} \beta^2 & 0 & 0 & 0 \\ 0 & \beta^{-2} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

with $\beta = 1 + \Phi/c^2$.

Changing coordinates, we get:

$$g_s = M^T g_{s,ruv} M$$

where M^T is the change of basis matrix from $(\vec{e}_r, \vec{e}_u, \vec{e}_v)$ to $(\vec{e}_1, \vec{e}_2, \vec{e}_3)$. So with $\vec{e}_r = r_i \vec{e}_i$, $\vec{e}_u = u_i \vec{e}_i$, $\vec{e}_v = v_i \vec{e}_i$, we have:

$$M^T = \begin{pmatrix} r_1 & u_1 & v_1 \\ r_2 & u_2 & v_2 \\ r_3 & u_3 & v_3 \end{pmatrix}$$

then:

$$g_s = \begin{pmatrix} r_1 & u_1 & v_1 \\ r_2 & u_2 & v_2 \\ r_3 & u_3 & v_3 \end{pmatrix} \begin{pmatrix} \beta^{-2} & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} r_1 & r_2 & r_3 \\ u_1 & u_2 & u_3 \\ v_1 & v_2 & v_3 \end{pmatrix}$$

It comes:

$$g_s = \begin{pmatrix} \beta^{-2}r_1^2 + u_1^2 + v_1^2 & \beta^{-2}r_1r_2 + u_1u_2 + v_1v_2 & \beta^{-2}r_1r_3 + u_1u_3 + v_1v_3 \\ \beta^{-2}r_2r_1 + u_2u_1 + v_2v_1 & \beta^{-2}r_2^2 + u_2^2 + v_2^2 & \beta^{-2}r_2r_3 + u_2u_3 + v_2v_3 \\ \beta^{-2}r_3r_1 + u_3u_1 + v_3v_1 & \beta^{-2}r_3r_2 + u_3u_2 + v_3v_2 & \beta^{-2}r_3^2 + u_3^2 + v_3^2 \end{pmatrix}$$

And using orthogonal matrices properties:

$$g_s = \begin{pmatrix} (\beta^{-2} - 1)r_1^2 + 1 & (\beta^{-2} - 1)r_1r_2 & (\beta^{-2} - 1)r_1r_3 \\ (\beta^{-2} - 1)r_2r_1 & (\beta^{-2} - 1)r_2^2 + 1 & (\beta^{-2} - 1)r_2r_3 \\ (\beta^{-2} - 1)r_3r_1 & (\beta^{-2} - 1)r_3r_2 & (\beta^{-2} - 1)r_3^2 + 1 \end{pmatrix}$$

Eventually:

$$g_s = I + (\beta^{-2} - 1) \begin{pmatrix} r_1^2 & r_1 r_2 & r_1 r_3 \\ r_2 r_1 & r_2^2 & r_2 r_3 \\ r_3 r_1 & r_3 r_2 & r_3^2 \end{pmatrix}$$

That doesn't depend on the choice of \vec{e}_u and \vec{e}_v . It can be rewritten this way, with $g_{s,ij} = g_{ij}$ for brevity:

$$g_{ij} = \delta_{ij} + (\beta^{-2} - 1) r_i r_j$$

Which is only true for a spherical potential from a point like mass. How can we generalize it to any kind of potential?

The above formula is also locally true for a linear mass distribution along \vec{e}_r passing through the observer's location in space.

Let:

$$B_{ij} = (\beta^{-2} - 1) r_i r_j$$

Let's rewrite the formula this way:

$$g_{ij} = \delta_{ij} + \lambda B_{ij}$$

This way, λ is a renormalization parameter ensuring that $\det(g_s) = \beta^{-2}$ while conserving the basis change invariance. In this special case, we obviously have $\lambda = 1$.

If we are in presence of mass distribution, we want to add up the potential influence from every direction to derive g_s . We then introduce the angular potential distribution $\varphi(\vec{\sigma})$ where $\vec{\sigma}$ is the observed direction. We have:

$$\Phi = \int \varphi(\vec{\sigma}) d\sigma$$

where $d\sigma$ is a solid angle element.

For an infinitely small solid angle in $\vec{\sigma}$ direction, applying the previously derived formula, with $r_i(\vec{\sigma}) = \vec{\sigma}/\|\vec{\sigma}\| \cdot \vec{e}_i$ we have:

$$dB_{ij} = ((1 + \varphi(\vec{\sigma})d\sigma/c^2)^{-2} - 1) r_i(\vec{\sigma})r_j(\vec{\sigma}) = -2\varphi(\vec{\sigma})/c^2 r_i(\vec{\sigma})r_j(\vec{\sigma})d\sigma$$

Integrating over the whole observation sphere we have:

$$B_{ij} = \int -2\varphi(\vec{\sigma})/c^2 r_i(\vec{\sigma})r_j(\vec{\sigma})d\sigma$$

It eventually comes:

$$g_{ij} = \delta_{ij} + \lambda \int -2\varphi(\vec{\sigma})/c^2 r_i(\vec{\sigma})r_j(\vec{\sigma})d\sigma$$

This metric solution is easily verified in the case of a point-like mass distribution. In the case of a homogeneous and isotropic mass distribution cross-terms are null so we have:

$$g_{ij} = (1 + \Phi/c^2)^{-2/3}I$$

In case of a Newtonian potential in a static mass distribution no need for solid angles formalism. Adding up the potential influence from every mass, with $r_i = \vec{r}/r \cdot \vec{e}_i$ for brevity, we have:

$$g_{ij} = \delta_{ij} + \lambda \int \frac{2G\rho(\vec{r})}{rc^2} r_i r_j dV$$

Gravitational Field Tensor

Gravitation seen as a force is very similar to electromagnetism. A direct analogy gives us the gravitational potential as a Lorentzian vector:

$$G_\mu = (\Phi/c, \vec{G})$$

And the gravitational tensor as:

$$G_{\mu\nu} = \partial_\mu G_\nu - \partial_\nu G_\mu = \begin{pmatrix} 0 & -E_G^x/c & -E_G^y/c & -E_G^z/c \\ E_G^x/c & 0 & B_G^z & -B_G^y \\ E_G^y/c & -B_G^z & 0 & B_G^x \\ E_G^z/c & B_G^y & -B_G^x & 0 \end{pmatrix}$$

The lagrangian becomes:

$$L = -m_0(1 + \Phi_0/c^2)^{-1}c \sqrt{g_{\mu\nu}\dot{x}_\mu\dot{x}_\nu} - m_0(1 + \Phi_0/c^2)^{-1}\dot{x}_\mu G_\mu$$

Where we now separate the vacuum potential Φ_0 from the particle's gravitational potential. Einstein's statement of equality of inertial and gravitational mass is not necessary anymore. And the potential is not necessarily a Newtonian one analogous to electromagnetism, leaving open doors to modified Newtonian gravity laws. If it was, we would have the equivalent of Maxwell equations for gravity. The last thing, gravitational waves are not dependent on a gauge choice contrary to General Relativity since the potential is Lorentzian by definition.

Electromagnetism

Any potential could be added to the Lagrangian, so including electromagnetism is pretty straightforward.

Let A_μ be the electromagnetic four-potential. Including electromagnetism contribution to the Lagrangian, we have:

$$L = -m_0(1 + \Phi_0/c^2)^{-1}c\sqrt{g_{\mu\nu}\dot{x}_\mu\dot{x}_\nu} - m_0(1 + \Phi_0/c^2)^{-1}\dot{x}_\mu G_\mu - q\dot{x}_\mu A_\mu$$

We see that the stronger the gravity field, the lesser the influence of other forces. Other forces can be neglected if gravity is strong enough.

Quantum Gravity

Gravity being a force again, we now have a coherent way to blend gravity into the quantum realm. What follows is based on Fock's equation (V. Fock, Z. Phys. 57, 261 (1929)) as a curved space-time version of Dirac equation:

$$[i\gamma^\mu(\partial_\mu - \Gamma_\mu - ieA_\mu) - m].\psi = 0$$

Were Γ_μ are the generalized gamma matrices defining the covariant Clifford algebra (H. Tetrode, Z. Phys. 50, 336 (1928))

$$\gamma_\mu\gamma_\nu + \gamma_\nu\gamma_\mu = 2\gamma_{\mu\nu}$$

were $g_{\mu\nu}$ is the space-time metric, whose signature is (+ - - -), Γ_μ is the spinorial affine connection and A_μ is the electromagnetic four-vector potential.

In order to take into account gravity, we just write $m = m_0(1 + \Phi_0/c^2)^{-1}$ and we take into account the gravitational four-vector potential G_μ . We get:

$$[i\gamma^\mu(\partial_\mu - \Gamma_\mu - ieA_\mu - i(1 + \Phi_0/c^2)^{-1}m_0G_\mu) - m_0(1 + \Phi_0/c^2)^{-1}].\psi = 0$$

This way, we finally have a coherent quantum gravity equation! It only concerns 1/2-spin charged particles though. Same work should be done for quantum electrodynamics and quantum field theory in general.

Cosmology

Let's see how global vacuum gravitational potential evolves in a homogeneous and isotropic universe. The potential is induced by the mass in a ct radius sphere where t is the age of the universe. Space dilation can be neglected in weak field approximation. We have:

$$\Phi_0 = \int_0^{ct} \varphi(r)\rho(t - r/c).4\pi r^2 dr$$

Where $\rho(t)$ is the universe matter density at time t and $\varphi(r)$ is the potential of the gravitational field by the mass unit at a distance r . In the special case of Newton's law, it would be $-\mathcal{G}/r$. Time dilation is neglected in the integral in weak field approximation and $\rho(t - r/c).4\pi r^2 dr$ is obviously not dependent on space dilation.

Let Gal_1 and Gal_2 be two galaxies at a distance D away from each other. An observer in Gal_1 at time t_0 would see Gal_2 as it was in the past at the time $t_0 - D/c$. The gravitational potential of Gal_1 and the gravitational potential of Gal_2 at the time it's being observed are then:

$$\Phi_{0,Gal_1} = \int_0^{ct_0} \varphi(r)\rho(t_0 - r/c).4\pi r^2 dr$$

$$\Phi_{0,Gal_2} = \int_0^{ct_0 - D} \varphi(r)\rho(t_0 - r/c).4\pi r^2 dr$$

With the time dilation factor the observed redshifted frequency is:

$$\omega = \frac{\sqrt{g_{00,Gal_1}}}{\sqrt{g_{00,Gal_2}}} \omega_0$$

It comes:

$$\omega = \left(1 + \frac{\Phi_{0,Gal_2} - \Phi_{0,Gal_1}}{c^2}\right) \omega_0$$

Thus:

$$\omega/\omega_0 - 1 = \int_{ct_0-D}^{ct_0} \varphi(r)\rho(t_0 - r/c).4\pi r^2 dr$$

And eventually:

$$\omega/\omega_0 - 1 = 4\pi/c^2 \int_0^D \varphi(ct_0 - r)(ct_0 - r)^2 \rho(r/c) dr$$

One could integrate and have the exact solution but it's easier to compare the distance derivative of the redshift to the observational data. We have:

$$\frac{d(\omega/\omega_0 - 1)}{dD} = 4\pi/c^2 \cdot \varphi(ct_0 - D)(ct_0 - D)^2 \rho(D/c)$$

For very small distances, observational data show that $\frac{d(\omega/\omega_0 - 1)}{dD}$ is constant (Hubble law). Given that $\varphi(ct_0 - D)(ct_0 - D)^2 = \varphi(ct_0)(ct_0)^2$ in that case, $\rho(D/c)$ must be constant. If ρ evolved in the early universe, it must have been in time no greater than the time light would take to reach the nearest galaxies.

Let's write $\rho(D/c) = \rho_0$ and $h(r) = \varphi(r)r^2$

For small distances compared to the size of the universe, we have:

$$h(ct_0 - D) = h(ct_0) - D \cdot h'(ct_0)$$

It comes:

$$\frac{d(\omega/\omega_0 - 1)}{dD} = 4\pi/c^2 \cdot (h(ct_0) - D \cdot h'(ct_0))$$

Eventually:

$$\omega/\omega_0 - 1 = 4\pi t_0^2 \rho_0 \varphi(ct_0) - 4\pi \rho_0 h'(ct_0)/c^2 \cdot D^2/2$$

This is equivalent to Hubble's law with an acceleration term. From Hubble diagrams, we deduce $h'(ct_0) < 0$, which is verified for a Newtonian potential.

That gives a good explanation of Hubble diagrams with no need for any kind of Dark Energy.

Redshift is related to Hubble's constant as follows:

$$\omega/\omega_0 - 1 = -v/c = -H_0 D/c$$

Identifying it to our formula, we have:

$$H_0 = -4\pi t_0^2 c \rho_0 \varphi(ct_0)$$

If we could measure redshifts in smaller distances, we would be able to have more accurate information about $\rho(t)$. A way to do so would be sending a signal and making it bounce back to where it has previously been emitted. The global gravitational potential will have changed and redshifted the signal [1].

Let t_{signal} be the time for the signal to come back. Doing the same reasoning as previously done in the case of galaxies, we have:

$$\omega = \frac{\sqrt{g_{00,t}}}{\sqrt{g_{00,t-t_{signal}}}} \omega_0$$

It comes:

$$\omega = \left(1 + \frac{(\Phi_{0,global,t} + \Phi_{0,local,t}) - (\Phi_{0,global,t-t_{signal}} + \Phi_{0,local,t-t_{signal}})}{c^2}\right) \omega_0$$

Since the local potential is not time-dependent, we have:

$$\Phi_{0,local,t} - \Phi_{0,local,t-t_{signal}} = 0$$

So we just have to replace D by ct_{signal} in the previous equations:

$$\omega/\omega_0 - 1 = 4\pi/c^2 \int_0^{ct_{signal}} \varphi(ct_0 - r)(ct_0 - r)^2 \rho(r/c) dr$$

It comes:

$$\omega/\omega_0 - 1 = 4\pi t_0^2 \varphi(ct_0) \int_0^{ct_{signal}} \rho(r/c) dr$$

In other words after a variable change:

$$\omega/\omega_0 - 1 = H_0/\rho_0 \int_0^{t_{signal}} \rho(t)dt$$

Plotting $\omega/\omega_0 - 1$ against t_{signal} we can derive $\rho(t)$ as:

$$\rho(t_{signal}) = \rho_0/H_0 \frac{d(\omega/\omega_0 - 1)}{dD}$$

It's quite wonderful that there is a theoretical way to "see" the early stages of the creation of the universe.

Using the average mass density of the early universe, we can rewrite the redshift this way:

$$d\omega = t_{signal}H_0 \frac{\langle \rho(t_{signal}) \rangle}{\rho_0} \omega_0$$

This could possibly be detected through laser interference modulation using a large interferometer. The path difference δ and t_{signal} are directly related: $t_{signal} = \delta/c$. One can then choose t_{signal} to have constructive interferences such as:

$$t_{signal} = 2n/\omega_0$$

This is to better see the modulation phenomenon. Let's assume that $\langle \rho(t_{signal}) \rangle / \rho_0 = 1$. It's possible to have laser frequencies of about $\omega_0 = 10^{16} Hz$. Hubble constant is approximately $H_0 = 7 \times 10^{-18} s^{-1}$. With a length of about 3 km for the interferometer, we can have a maximum difference path of 6 km thus $t_{signal} = 2 \times 10^{-5} s$. That gives us:

$$d\omega = 1.4 \times 10^{-6} s^{-1}$$

It's about $2 \times 10^5 s$ oscillating period. It's roughly 8 days only! The longer the oscillating period, the lesser the average universe mass density before t_{signal} [2].

Conclusion

This theory can be proven less accurate than General Relativity by fine measurements of the gravitational redshift. It could either falsify this theory or falsify General Relativity.

We never mentioned the Quantum Vacuum. This theory could have been created without knowing the existence of Quantum Vacuum, thus predicting its very existence. Quantum Vacuum being neutral, an electric field wouldn't induce any potential energy since negative and positive charges would nullify their potential energy. Quantum Vacuum being isotropic, its potential vector is null, justifying the fact that we only took into account the scalar potential throughout the whole paper.

Magnetic fields could change Quantum Vacuum energy since particles spins would tend to line up with field lines and thus have negative potential energy.

This theory is compatible with any violation of the weak equivalence principle and any non-newtonian gravity potentials. The last important thing to mention is the retraction of the metric on the potential. Space dilation implies a modification of the way the potential is derived which in turn implies a modification of the space dilation until a balance is found. The maths of this effect can be done in the case of a spherical potential leading to really interesting discussions which are off topic.

The last section about cosmology is quite disruptive. Contrary to Einstein's equations, our theory doesn't imply an expanding universe but can predict what we observe and interpret as being an expansion as it also gives a natural explanation to what we interpret as Dark Energy. This theory says nothing about the very early moments of the universe though. But as you saw at the end of the last section, we have a powerful way to investigate these moments through what one may call Signal Bouncing Gravitational Redshift.

As you can imagine, there is a lot more to say about this. It implies many things about the nature of Quantum Vacuum, of gravity, or even of time itself but this is not the topic of this paper. The topic was to show how to interpret gravity as a force turning its quantization into a trivial thing given all the previously done research about quantum physics in curved space-time.

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