On the physical implications of spacetime, entropy, and matter-energy conversion

Dominic Espree, dominicespree96@gmail.com

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1 Introduction

Quantum gravity is the most profound outstanding question in fundamental physics. How do we describe spacetime itself quantum mechanically? In this article we present a novel approach called "geometrodynamics," which uses the interconnections between space, time, and mechanical entropy. In particular we will show how quantum scattering processes indicate that Lorentz symmetry must be broken, in a way manifested physically through transformation of energy into mass that can no longer be accelerated. Throughout we apply our theoretical ideas to specific physical situations.

2 CPT Violation and Mass-Energy Conversion

A basic question in fundamental physical theory concerns the violation of charge-parity-time (CPT) symmetry. CPT is a property enforced by all basic physical models but fails in nature. Here we provide a physical mechanism for CPT violation.

By converting energy into mass that can no longer be accelerated, in accordance with our novel model of spacetime, we exhibit CPT violation.

Fixing the values of parameters, we have the energy conversion integral

$$\int_0^{1-} E = mc^2 = 8.19 \times 10^{-14} s$$

At the frequency level this is equivalent to

$$\int_{1-}^{0} \lambda = \frac{hc}{E} = 2.14 \times 10^{-12} cm^2$$

Discretizing at the Planck scale, we have

$$\sum_{m \to 0}^{\Delta E} \frac{ch}{\lambda} = 0.511 \times 10^6 \ eV$$

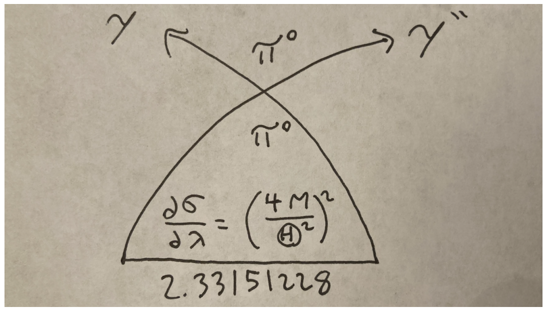

Figure 1: Illustration of pion decay process.

This is a remarkable result. Just to fix ideas, let us imagine a scattering process wherein a positron and an electron annihilate. Schematically this is associated with the physical sequence

$$\left[\left({}^0_1e^- + {}^0_1e^+\right)\right]^2 = \uparrow\uparrow \left(\frac{\Gamma_0'}{\Gamma_0}\right) \downarrow\downarrow = [(e^- + e^+)] \to \gamma \to [(q\bar{q})]^{-1/2}$$

giving us simply 0.5.... This corresponds to the inner product of vectors

$$\vec{\epsilon} \cdot \vec{\epsilon} = 8.181 \times 10^{-30}$$

We also have

$$\vec{\epsilon} \cdot \vec{\epsilon} \cdot \vec{k} = 8.91719 \times 10^{-28}$$

Examining the relative rates, we have the differential equation

$$\frac{d\sigma}{d\rho} = \left(\frac{27\pi^2}{Ⓗ^2}\right)$$

This is summarized in the diagram shown below (Fig. 1).

3 Spacetime Structure: The Sun

We apply our new perspective on spacetime and entropy to a particular reference case, the sun. To high approximation the sun is static and spherical. We have the Newtonian potential at standard radius

$$\Phi = -M/r = -4,173,166.68683$$

and the geometric line element is, applying the revelant spherical and time-translation symmetries,

$$ds^2 = -(1 - 2M/r)dr^2 + (1 + 2M/r)(dx^2 + dy^2 + dt^2)$$
$$= 100.0003146999cm^2 = 1.750745452 \times 10^{58} N/m^2$$

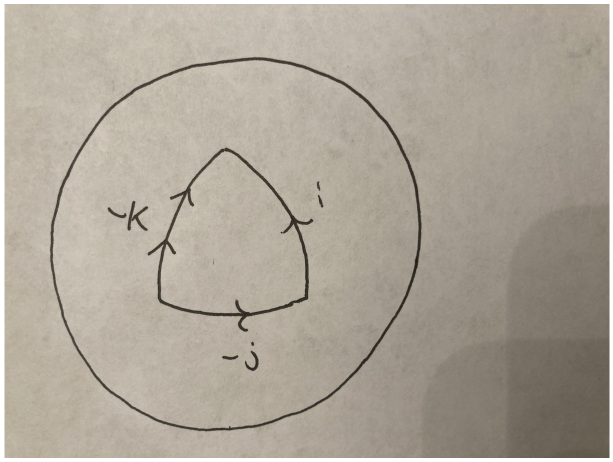

Figure 2: The three-dimensional slice of spacetime curvature

Thus, everywhere outside this region a photon moving along the equatorial plane (where $l = 0$) of this curved spacetime gets deflected. See the picture below (Fig. 2) for an image of a two-dimensional cross-section of this spacetime.

For velocities v compared with that of light in a vacuum, the rapidity is equivalent.

4 Gravitational Deflection and Rutherford Scattering

Consider the classical Rutherford scattering at shallow angles. We have the equality $\textcircled{H} = \textcircled{H}(b)$. In the limit, the small-angle part of the scattering predominates the major part. All the products above come from large-impact parameters, so we have

$$\textcircled{H}(b) = r_T\rho(-2M/r_Tp - \frac{1}{2} = -1.17921666 \times 10^{-48} cm^2$$

Thus, we have that

$$\textcircled{H} = \left(\frac{4M}{\textcircled{H}^2}\right) = 8.857431754 \times 10^{-35}$$

The corresponding differential equation for this process is simply

$$\frac{d\sigma}{d\rho} = \left(\frac{4M}{\textcircled{H}^2}\right)^2 = 1.4484 \times 10^{-52}$$

Alternatively, reducing this algebraic expression, we have

$$\frac{d\sigma}{d\rho} = \frac{M^2}{\pi - \textcircled{H}} = 1.75 + (0.009 + 0.000...)$$
$$= 1.45554426 \times 10^{13} eV$$

5 Summary of Results on Mass-Energy

In our theoretical construct, energy is converted into mass that can no longer be accelerated. Furthermore, virtual particles together with anti-particles created by Wolfgang Pauli exclusion must annihilate. This resolves the breaking of CPT (charge-parity-time) symmetry in fundamental physical law.

As a result of these two basic principles, b mesons and vector mesons produced in pion decay warp the three-dimensional spatial slice, decoupling spacetime (that is, breaking Lorentz invariance or general coordinate invariance in full GR). In a sense this resolves or gets to the core of the basic incompatibility between quantum mechanics and gravity (spacetime). We can only maintain the quantum mechanical S-matrix if we split symmetry of space and time (pick a preferred time direction).

Let us examine some specific scattering processes that fall under this overarching theme. Given two hadrons, we have the process

$$RE = \frac{\Gamma_{e^-} + \Gamma_{e^+} \rightarrow hadrons}{\Gamma_{e^-} + e^+ \rightarrow \mu - \mu f}$$

This gives us $511,000.0000000eV$ up to eight significant figures. This is equivalent to

$$(1 - 2GM) = \Gamma_{capt} = 27\pi M^2 = 5.11x10^{14}eV \sim -6.534172896 \times 10^{16}eV$$

6 Light-Cone Analysis

In any Lorentzian spacetime metric, each point admits a past and future light-cone. These cones describe the regions of spacetime in a causal relationship to said point (either in its future or in its past). The past null cone is locally spanned by the past null vectors. This describes light impinging upon our point. The future cone is likewise locally determined by the future null vectors.

The worldline of any massive particle at our point p has a tangent vector that is future timelike, and thus exists within the future null cone. The equation expressing this relationship is $g_{ab}v^a v^b = 0$, indicating that the length of the null vector in the metric spacetime is zero. See the illustration below (Fig. 3).

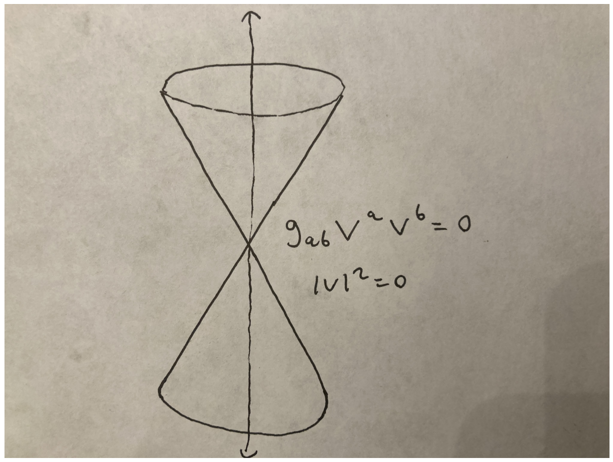

Figure 3: Light-cone geometry

7 Hyperbolic Geometry

It is natural to consider the infinity-point of any given spacetime geometry. In the hyperbolic spacetime geometry, the infinity $\rho \equiv \infty$ represents $c(=1)$. By the triangle law in the hyperbolic context, lengths in different directions are given by rotating exactly one-half the angle. Thus we have the equation

$$A\phi = \frac{2\pi}{1 - 6M/r_0 \frac{1}{2}} = -3.728105353533 \times 10^{-9} cm^2$$

This is illustrated in the diagram below.

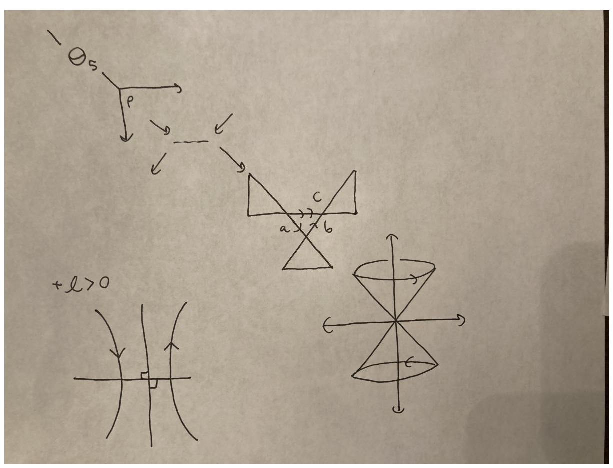

Figure 4: Recursive spacetime process

8 Application to the ADM Formalism

The ADM formalism is a natural way to formulate general relativity in the Hamiltonian context. We define a infinite-dimensional phase space of metric configurations on foliated slices, and use the Einstein-Hilbert action to derive the Hamiltonian. The canonical moments are given by functional derivatives $\pi_{ijTRUE} = \frac{\delta action}{\delta g_{ij}}$

In our geometrodynamic theory the canonical momenta are conjugate to the g_{ij} field coordinate. The Hamiltonian reduces to

$$= \frac{\pi_{ij}}{16\pi}, \pi_{ij} = g1/2(g_{ij}Trk - k_{ij})$$

$$= -8.1000000000000x10^{19}$$

This is a convenient representation as π_{ij} are canonical coordinates. That is, the π_{ij} of ADM are more convenient as the funamental coordinates than the field coordinates.

Expressing these terms in field components, we have the result

$$H_{True} = H(\pi_{ijTRUE} g_{ij}) = 1.5444218859x10^{-8}$$

If we incorporate a canonical supersymmetry, we obtain the "super-Hamiltonian"

$$H/16\pi = 3.072529717 \times 10^{-10}$$

which gives us

$$H(\pi_{ij}, g_{ij}) = g - 1/2(Tr\mu^2 - 1/2Tr\mu^2) - g1/2R$$

Incorporating the values of the known constants, we have the spacetime curvature

$$= 3.3706770372 \times 10^{20} eV$$

Let us imagine a scattering process in an ADM spacetime, where we take the canonical foliation. The energy of this scattering process is given by

$$Ⓗ = \frac{4M}{b} = 3.3722566 \times 10^{82} eV$$

Thus, we have the potential at radius r given by

$$V_{(r)} = \frac{4a_5}{3r} + k_r = 3.37225664 \times 10^{82}$$

which becomes the vector meson potential

$$V_r = -4/3a_{(5)} = 3.37225664 \times 10^{82}$$

Considering the scattering of two particles in ADM spacetime, we have the process

$$(\frac{27\pi M^2}{Ⓗ^2})^{-1}$$

which becomes

$$\pi + N^{-1} \to N^{-1} + \rho_1 \to 2\pi = 6.283585307179 \times 3.37225664 = 2.1188514800766690241856 \times 10^{83} kg$$

Here, the characteristic scattering parameter is

$$\lambda = 1.58428227 \times 10^{-33} cm^2$$

9 The Vector Space

In quantum mechanics, the space of states of the universe is canonically a vector space. When we quantize the spacetime structure, the states of spacetime will also comprise a vector space. We can start to understand the behavior of this vector space through a few simple calculations. We have the dot product

$$\vec{\sigma} = \mu \frac{m_o}{4\pi R^2} \cdot \hat{\eta}$$

which gives us the vector magnitude

$$v_s(2) = \frac{-c}{z_0 - z + a} = 244,677,388,085.11479893830135241131$$

which becomes

$$v_{(s)} = \frac{-c}{z_0} = 247,677,337,985.114484238301252441$$

Now we can apply the resonance condition on this dot product, which gives us

$$\lambda = \frac{\lambda u}{2\gamma}(\frac{1-k2}{2}) = -4/918596745 \times 10^{19} Hz$$

which is simply

$$\lambda = \frac{\lambda u}{2\gamma}(\frac{1+k^2}{2}) = 4.049999999999 \times 10^{19} Hz$$

Incorporating the gravitational constant, we have

$$g - \frac{1}{2}(Trn^2 - \frac{1}{2}Trn^2) - g1/2R$$

$$\to T_a B - \frac{1}{2} gaBTu_a uB\gamma 0$$

$$= 3.3706770372 \times 10^{20} \times T_a B - \frac{1}{2} g_a B T_\mu au B$$

$$= 6.091004829 \times 10^{51} N m^2$$

This tells us the scale of the quantum state space.

10 Calculating the Scattering Processes

To test out our understanding of quantum geometrodynamics, we will evaluate a scattering process of particles against a curved spacetime background. Consider the change in momentum

$$\Delta\phi = \frac{2\pi}{1 - 6M/r_0 \frac{1}{2}\pi} = -3.321120767 \times 10^{53}$$

This is equivalent to the scattering parameter

$$\Delta\phi'' = \frac{2\pi}{1 - 6M/r_0} - \frac{1}{2}\pi = -2114291146 \times 10^{53}$$

which gives us

$$-\frac{1}{2} = -0.5...00 \sim 8.1762947 \times 10^{-43-\frac{1}{2}}$$

$$= 0.5... + \infty$$

So that we have the relationship

$$\sim i(-j) = -k$$

$$= \frac{1}{2}\pi$$

Now, if we take a scattering process of two electrons, we obtain the characteristic radius

$$v\Big(\frac{e^p - e^{-p}}{e^p + e^{-p}}\Big) = 1.0317083174 \times 10^{59} km^{-1}$$

Let us now consider the characteristic orbits for these scattering processes. The orbit $r_T p/M = 1.000845369 \times 10^{-73}$. Expressing these parameters in the alternative coordinate system, we simply have

$$b = r_T p(1 - 2M/r_T p)^{-1/2} = 3.132012772 \times 10^{12}$$

which gives us

$$b_{orbit} = 27\frac{!}{2}M = \frac{-42,282,172,422,000}{2}$$

$$= -2.114108621 \times 10^{31} eV$$

Note that this energy level lies above the Planck scale. This agrees with our general intuition, which is that quantum gravitational effects are only accessible above the Planck scale.

11 Spacetime Deflection from the Wordline

Now let us consider how the spacetime worldlines become deflected by quantum interference. We have the lightcone equation in Planck units $x = t$. Let us consider the geodesic equation in a curved spacetime background given by

$$y \equiv b \equiv \frac{dpa}{d\lambda*} + \Gamma^{\alpha}_{\beta\gamma}\rho_{\gamma} = 0$$

We have four momentum components here, which give us a $\Delta\phi = 4M/b = 1.75MeV$ deflection $(\frac{R\odot}{b})$. The rate of change with respect to the characteristic parameter λ is given by

$$\frac{d\rho\gamma}{d\lambda*} = \Big(\frac{-2Mb}{x^2 + b^2}\Big)^{3/2} = -0.75000000000$$

Thus, we have the parameter

$$\rho_{\gamma} = \frac{d\gamma}{d\lambda*} = 1.589091188 \times 10^{-90}$$

whose component in the x direction is given by

$$\rho_x = \rho_0\big[1 + 0(\frac{M}{b})\big] = -0.4999999999...$$

$$= 1.62800767 \times 10^{77} const$$

The component in the y direction is alternatively given by

$$\rho_y(x = +\infty) \equiv \frac{4M}{b}\rho_x = 1.2323808 \times 10^{-69}$$

which is simply

$$(6.283185307179)3.37225665 \times 10^{82}$$

$$= 2.1188514800766690241856 \times 10^{83} kg$$

when we input the appropriate units. This tells us that the characteristic parameter is $\lambda = 1.58428227 \times 10^{-33} cm^2$ which is simply because $\pi + N^{-1} \rightarrow N^{-1}\rho \rightarrow 2\pi$. Now we evaluate the two potentials for the vector mesons:

$$\nu_{(r)} = \frac{4a_5}{2r} + \kappa r = -1.2581941 \times 10^{39}$$

$$\nu_{(r)} = -\frac{4}{3}a_5 = -1.3769061 \times 10^{38}$$

Now we consider a scattering process given schematically by

$$\Big(\frac{27\pi M^2}{Ⓗ^2}\Big) = 3.37225664 \times 10^{82}$$

which is

$$\eta' \to \rho_0 + \gamma$$

$$= 1/2\frac{log^2}{\pi\sqrt{3}}\Big(\frac{1 - 2Mr^2/R^3 1/2 - 1 - M1/2}{3(1 - 2Mr^2/R^{1/2} - 1 - 2MR^{21/2}}\Big)$$

$$= 8.7059503986 \times 10^{64}$$

when appropriate units are applied. Thus we have the pion decay process

$$\Delta^+ \to \rho^+\pi^+$$

$$= 6.317408875280$$

Therefore the following equations hold:

$$\rho, \rho^2, \rho^3 = c^2\rho$$

$$= 1.418058980 \times 10^{-20} cm^2$$

Now we can finally calculate the necessary scattering parameters:

$$2.11 \times 10^{-11} kg$$

$$2.119721044 \times 10^{-14} kg$$

$$2.1188513372 \times 10^{83} kg$$

$$5.4164133 \times 10^{14} kg$$

The corresponding energy scale is

$$3.37225664 \times 10^{164} eV$$

which is clearly well beyond the Planck scale.

12 The Expansion Rate of the Universe

A natural problem we can try to understand, now that we have a full theory of quantum geometrodynamics, is the expansion rate of spacetime. We have the Einstein field equations

$$G_{\mu\nu} + \Lambda_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} = -4.102969819 \times 10^{48} N/m^2$$

When we incorporate the basic symmetry assumptions and the homogeneity of the matter-energy density of spacetime, we obtain the resulting differential equation

$$(\frac{a}{a})^2 + \frac{\kappa c^2}{a^2} - \frac{\Gamma c^2}{3} = \frac{8\pi G}{3}\rho = -5.34973273 \times 10^{158}$$

which describes the expansion rate of spacetime. Note that when we incorporate the appropriate units above, we obtain something slightly above the inflaton scale. Now we instead consider the alternate differential equation

$$\frac{2\ddot{a}}{a} + \big(\frac{\dot{a}}{a}\big)^2 + \frac{\kappa c^2}{a^2} - \Gamma c^2 = \frac{8\pi G}{c^2}\rho = 5.893502189 \times 10^{161}$$

which becomes

$$\to 5.8935021898008600546 \times 10^{161}$$

when perturbative effects are taken into account. This is the first instance we've seen of quantum interference affecting the expansion rate of spacetime. We have the rate of change of the spacetime density satisfying the differential equation

$$\dot{\rho} = -3\frac{\dot{a}}{a}(\rho + \frac{\rho}{c^2}\big) = 2.1440740560 \times 10^{20}$$

which becomes

$$\ddot{a}/a = -\frac{4\pi G}{3}(\rho + \frac{3\rho}{c^2}\Big) = 3.5057352738 \times 10^{19}$$

Thus, the relationship between the pressure and the density is given by

$$\rho \to \rho - \frac{\Lambda c^4}{8\pi G} = -7.699572508 \times 10^{66}$$

which tells us that

$$\rho - -pc^2 = 3.1507977326 \times 10^{20}$$

Thus, we have that the inequality

$$p < \frac{\rho c^2}{3} = 1.0502659108 \times 10^{20}$$

holds.

13 Negatively Curved Space and the Strain Tensor

A centerpiece of our theory of quantum geometrodynamics is the relationship between mechanical properties, of elastic structures, and the underlying properties of the spacetime fabric. In fact, we've proposed a more-or-less direct correspondence between the two. The strain tensor of a material must correspond to some spacetime variable. Thus we propose an additional ingredient to the Einstein field equation, the spatial strain tensor that breaks Lorentz invariance. In analogy with the mechanical situation we have the relation

$$C = A(T_{rs})^2 + B^2 Tr(s^2) = -1.6197236776$$

Thus, the strain tensor can be computed as

$$S_{mm} = \frac{1}{2}\Big(\frac{\partial \epsilon_m}{\partial x_m} + \frac{\partial \epsilon_\eta}{\partial x_m}\Big)$$

$$= \Big(\frac{dG}{dt}\Big)^2 = \frac{G_0 + G}{G} = 1.1616142740 \times 10^{18} N/m^2$$

The quantum metric G increases with t from $G = 0$ to $G = +\infty$ or from $G = \infty$. Hence $\frac{dG}{dt}$ decreases, from 0 to 1.

So, the super-Hamiltonian, factoring in the spacetime strain, is given by $g - 1/2(Tr(n^2) - \frac{1}{2}Tr(n^2)) - g1/2$.

Thus we have the spacetime curvature

$$R = 46,877,188,603.8$$

14 Planck length

Now that we have a full theory of quantum gravity, a basic domain to look at is the Planck scale. The length at the Planck scale, which is of course the funamental parameter of interest, is given by

$$\ell_p = \frac{\gamma\hbar}{c^3} = -1.32059027 \times 10^{-78} cm^2$$

Thus, we have the Planck time

$$t_p = \frac{\gamma\hbar}{c^5} = -4.9783728 \times 10^{-100} cm^2$$

which tells us that the Planck energy is given by

$$E_p = \frac{\hbar c^5}{\gamma} = -1.04052224 \times 10^{-14} cm^2$$

Converting to gravitational units, we have

$$E_G = \frac{m^2}{r}\gamma(2\gamma^2 - 3\gamma^3/2 + \gamma^5/2)$$
$$= -0.00274846714cm^2$$

Alternatively, we can express this as

$$E_G = \frac{m^2}{r}\gamma(\frac{6}{5} - \frac{1}{2}\lambda) = -0.06122448950cm^2$$

where the parameter

$$\lambda = \frac{q}{2r} = -6.5141500031 \times 10^{-19}cm^2$$

Thus, we have

$$\frac{7}{10} \times \frac{m^2}{r}\gamma = -2.32450506 \times 10^{69}cm^2$$

Now, we know that

$$L = h/mc$$

compton wavelength. If we apply this to the gravitational situation, we have the macroscopic scale

$$= 0.000242878674cm^2$$

$$\rightarrow \mu\omega = -96,222,663.5664$$

where

$$\lambda f$$

is the frequency times λ. In the case of the photon, we have the basic frequency

$$Photons = \frac{c}{4\pi\lambda f} = 4,773,333,242.79$$

so that

$$\mu\omega = 2.6282063440 \times 10^{17}$$

On the other hand, we know that

$$\omega \rightarrow 3\pi = \frac{1}{24}Ml^2\omega^3(3\pi)3.3046776545 \times 10^{20}kg$$

$$= 21216.6667 \times 10^{20}kg$$

which is the Planck mass. Thus, geometrodynamics reproduces the basic scale of Planck parameters.