Energy-Momentum Distortion and Rest-Mass Closure

A Projection Mechanism Linking Special Relativity, Schwarzschild Geometry, Schrödinger-Compton Phase, and Moving-Source Anisotropy

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Abstract

This paper proposes a mechanism-level unification of special relativity, Schwarzschild general relativity, and rest-mass structure through a single energy-momentum distortion principle. General relativity is sourced by the stress-energy tensor, so geometry is determined by rest energy, momentum flow, pressure, stress, and energy orientation. In the static spherical case, rest energy appears through its scalar monopole projection and produces radial Schwarzschild distortion. In the local moving case, directed momentum-energy produces Lorentz distortion.

Radial free fall from rest at infinity supplies the exact projection map between the two: the Schwarzschild gravitational load becomes the local Lorentz kinematic load, with matching temporal and spatial factors. The same logic then reaches the rest-mass question: if directed energy-momentum produces directed distortion, the radial character of rest energy requires a closed internal phase explanation.

Rest energy is modeled as a closed internal Schrödinger-Compton phase mode: the stationary quantum phase associated with rest energy, interpreted as a closed Schrödinger-Compton phase geometry. Its internal momentum circulation remains nonzero, while the closed path cancels net external linear momentum. The confined phase energy appears externally as rest mass; its scalar monopole projection gives the radial gravitational source, while its helical internal orientation gives spinorial four-pi behavior.

Comparing the reduced Compton wavelength with the gravitational radius identifies the Planck mass as the exact closure scale, while ordinary observed masses appear as Compton refresh-rate fractions. Finally, the paper formulates a phenomenological moving-source ansatz for radial-plus-directed anisotropic geometry.

1. Motivation and Scope

1.1. Motivation

The motivation begins with the stress-energy tensor. In general relativity, spacetime geometry is sourced by $T_{\mu\nu}$, which contains energy density, momentum density, energy flow, pressure, and stress. A gravitational source therefore carries both magnitude and orientation information. A static spherical source gives a radial geometry. A moving source carries directed momentum-energy and therefore introduces a directed contribution to the same geometric sourcing structure.

This makes the comparison between Schwarzschild geometry and special relativity natural. Schwarzschild geometry expresses the radial rest-energy case. Special relativity expresses the local directed momentum-energy case. Radial free fall from rest at infinity provides the clean test case in which the radial Schwarzschild load is converted into the local directed Lorentz load. The temporal factors and spatial factors can then be compared directly.

The same reasoning also motivates the rest-mass question. If directed energy-momentum gives directed distortion, the radial character of a static rest mass requires an explanation of how mc^2 carries energy while appearing externally as an all-direction radial scalar field. The rest-energy question naturally connects to stationary quantum phase in Schrödinger form: a stationary energy mode evolves by phase, and the rest-energy phase has the Compton angular frequency. This leads to the closed internal Schrödinger-Compton phase interpretation of rest energy. The internal momentum circulation remains, the net external linear momentum cancels, and the scalar monopole projection appears as rest mass and radial Schwarzschild sourcing.

1.2. Scope

The scope of the paper is a mechanism-level projection framework. The first level is an exact factor identity in the Schwarzschild free-fall setting: the radial gravitational load maps to the local Lorentz load. The second level is a closed-mode interpretation of rest energy: rest mass is represented as the scalar monopole projection of the stationary Schrödinger phase of rest energy, expressed as a closed internal Schrödinger-Compton phase mode, with the Planck scale identified as the exact gravitational-closure scale. The third level is a phenomenological moving-source test ansatz: a moving source is described by the radial rest-energy field together with an added directed momentum-energy contribution.

The mathematical status of each level is kept explicit. The Schwarzschild/free-fall factor identity is an exact relation within the stated setting. The closed internal Schrödinger-Compton phase mode is a proposed physical interpretation of rest energy and spinorial internal orientation. The moving-source expression is a weak-field phenomenological ansatz intended for comparison with standard post-Newtonian, gravitomagnetic, moving-lens, matter-current, compact-binary, and waveform treatments.

2. Central Thesis

The starting point is the Einstein field equation [2],

$$G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}. \tag{1}$$

The source of spacetime geometry is the full stress-energy tensor. Wald's formulation emphasizes the geometric role of $T_{\mu\nu}$ in the Einstein equation [5]. Rest energy, kinetic energy, momentum density, pressure, stress, and energy flow all contribute to geometry. The stress-energy interpretation is standard in relativistic gravitation [4]. Its weak-field and post-Newtonian consequences are treated systematically by Poisson and Will [9].

The central thesis of this paper is that spacetime distortion is determined by energy-momentum, while the orientation of the distortion is determined by the orientation of the energy-momentum.

In the static spherical case, rest energy appears through its scalar monopole projection and produces radial Schwarzschild distortion. In the moving case, the same source acquires directed momentum-energy and produces local Lorentz distortion. Radial free fall from rest at infinity supplies the exact projection map between the two: the radial Schwarzschild load becomes the local directed Lorentz load.

This immediately raises a deeper question. If directed energy-momentum produces directed distortion, how does the rest energy

$$E_0 = mc^2 \tag{2}$$

of a static mass appear externally as an all-direction radial scalar field? The answer proposed here is that rest energy is a closed internal Schrödinger-Compton phase mode. Its internal momentum circulation remains nonzero, while the closed path cancels the net external linear momentum. The confined internal energy therefore appears externally as scalar rest mass, while its scalar monopole projection supplies the radial gravitational source.

The same closed internal structure also explains why ordinary observed masses appear below the full Planck mass. The Planck mass is the exact closure scale at which the reduced Compton wavelength equals the gravitational radius, while ordinary masses appear as Compton refresh-rate fractions of that scale.

In this hierarchy, general relativity supplies the general energy-momentum distortion law. Schwarzschild geometry is the static radial rest-energy expression. Special relativity is the local directed momentum-energy expression. Rest mass is the scalar monopole projection of a closed internal Schrödinger-Compton phase mode, and spinorial orientation is the helical internal orientation of the same closed mode.

Related work has connected special- and general-relativistic time dilation in orbital settings; Peerally discusses a proportionality between Lorentz and Schwarzschild time-dilation effects in Keplerian free-fall motion [20]. Radosz, Augousti, and Ostasiewicz analyze how kinematical time dilation and gravitational redshift may decouple or factorize in particular geometries, including Schwarzschild free-fall settings [23]. Vossos, Vossos, and Massouros relate GR metrics to SR generalized scalar gravitational potentials derived from GR time-dilation structure [24]. A different dynamical reconstruction of general relativity from proper time and free-fall principles was recently proposed by de Haro [21]. Hilbert's velocity-dependent free-fall result has also been revisited in the context of the equivalence principle by Berkahn, Chappell, and Abbott [22]. These ingredients are organized here into a single projection mechanism: rest energy, Lorentz distortion, Schwarzschild distortion, spinorial internal orientation, and moving-source anisotropy are treated as connected projections of one energy-momentum distortion structure.

Free fall shows the exact mathematical bridge between the radial and directed expressions.

3. The Static Radial Schwarzschild Case

For a spherical mass M at rest, the exterior Schwarzschild metric is [3]

$$ds^2 = -\left(1 - \frac{r_s}{r}\right) c^2 dt^2 + \left(1 - \frac{r_s}{r}\right)^{-1} dr^2 + r^2 d\Omega^2, \tag{3}$$

with

$$r_s = \frac{2GM}{c^2}. \tag{4}$$

For a static clock at radius r,

$$dr = 0, \qquad d\Omega = 0. \tag{5}$$

The metric gives

$$ds^2 = -\left(1 - \frac{r_s}{r}\right) c^2 dt^2. \tag{6}$$

For a timelike clock,

$$ds^2 = -c^2 d\tau^2. \tag{7}$$

Therefore,

$$d\tau = dt\sqrt{1 - \frac{r_s}{r}}. \tag{8}$$

Define the Schwarzschild gravitational clock-rate factor:

$$\chi_{\mathrm{GR}}(r) = \frac{d\tau}{dt} = \sqrt{1 - \frac{r_s}{r}}. \tag{9}$$

The radial spatial factor follows from the radial metric component:

$$d\ell_r^2 = \left(1 - \frac{r_s}{r}\right)^{-1} dr^2. \tag{10}$$

Thus,

$$d\ell_r = \frac{dr}{\sqrt{1 - \frac{r_s}{r}}}, \tag{11}$$

so

$$\frac{d\ell_r}{dr} = \frac{1}{\sqrt{1 - \frac{r_s}{r}}} = \frac{1}{\chi_{\mathrm{GR}}(r)}. \tag{12}$$

The static Schwarzschild sector therefore has a paired structure: the temporal factor is $\chi_{\mathrm{GR}}(r)$, and the radial spatial factor is $1/\chi_{\mathrm{GR}}(r)$. This is the radial expression of rest-energy distortion.

4. The Local Directed Lorentz Case

In special relativity, for a body moving with local velocity v, Einstein's Lorentz-kinematic structure gives the standard boost factor [1]. A modern treatment of the same proper-time relation is given by Rindler [8]:

$$\gamma(v) = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}. \tag{13}$$

Define the inverse Lorentz factor:

$$\chi_{\mathrm{SR}}(v) = \frac{1}{\gamma(v)} = \sqrt{1 - \frac{v^2}{c^2}}. \tag{14}$$

The proper time of the moving body satisfies

$$d\tau = dt\sqrt{1 - \frac{v^2}{c^2}}, \tag{15}$$

so

$$\frac{d\tau}{dt} = \chi_{\mathrm{SR}}(v). \tag{16}$$

The spatial Lorentz factor along the direction of motion is

$$\gamma(v) = \frac{1}{\chi_{\mathrm{SR}}(v)}. \tag{17}$$

The local Lorentz sector therefore has a paired structure: the temporal factor is $\chi_{\mathrm{SR}}(v)$, and the directional spatial factor is $1/\chi_{\mathrm{SR}}(v)$. This is the directed expression of momentum-energy distortion.

The contrast is geometric. Schwarzschild distortion is radial because the source is static rest energy. Lorentz distortion is directed because the source carries oriented momentum-energy.

5. Free Fall Gives the Exact Map

Consider radial free fall from rest at infinity in Schwarzschild geometry. The geodesic calculation follows the standard Schwarzschild treatment in MTW [4]. Carroll gives the same conserved-energy structure in modern notation [6]. For such a radial geodesic, the conserved energy per unit rest mass is

$$e = c^2. \tag{18}$$

In Schwarzschild coordinates this gives

$$\left(1 - \frac{r_s}{r}\right) c^2 \frac{dt}{d\tau} = c^2. \tag{19}$$

Therefore,

$$\frac{dt}{d\tau} = \frac{1}{1 - \frac{r_s}{r}}. \tag{20}$$

The radial timelike normalization is

$$-c^2 = -\left(1 - \frac{r_s}{r}\right) c^2 \left(\frac{dt}{d\tau}\right)^2 + \left(1 - \frac{r_s}{r}\right)^{-1} \left(\frac{dr}{d\tau}\right)^2. \tag{21}$$

Substituting the conserved-energy relation gives

$$\left(\frac{dr}{d\tau}\right)^2 = \frac{r_s c^2}{r}. \tag{22}$$

The local velocity measured by a static observer at the same radius is the ratio of local proper radial distance to local static proper time, as in the standard local-observer reading of Schwarzschild motion [7]:

$$v(r) = \frac{d\ell_r}{d\tau_{\text{static}}}. \tag{23}$$

Using

$$d\ell_r = \frac{dr}{\sqrt{1 - \frac{r_s}{r}}}, \tag{24}$$

and

$$d\tau_{\text{static}} = dt\sqrt{1 - \frac{r_s}{r}}, \tag{25}$$

one obtains

$$v(r) = \frac{dr/dt}{1 - \frac{r_s}{r}}. \tag{26}$$

Combining this with the radial geodesic relation gives

$$v(r)^2 = \frac{r_s c^2}{r}. \tag{27}$$

Therefore,

$$\frac{v(r)^2}{c^2} = \frac{r_s}{r}. \tag{28}$$

This is the exact bridge: the radial Schwarzschild load and the local directed Lorentz load have the same value in the free-fall projection,

$$\frac{r_s}{r} = \frac{v(r)^2}{c^2}. \tag{29}$$

Free fall is the physical map that converts the radial gravitational load into the local directed kinematic load.

6. Temporal Identity

The Lorentz clock-rate factor is

$$\chi_{\mathrm{SR}}(v) = \sqrt{1 - \frac{v^2}{c^2}}. \tag{30}$$

For free fall from rest at infinity,

$$\frac{v(r)^2}{c^2} = \frac{r_s}{r}. \tag{31}$$

Substitution gives

$$\chi_{\mathrm{SR}}(v(r)) = \sqrt{1 - \frac{v(r)^2}{c^2}} = \sqrt{1 - \frac{r_s}{r}}. \tag{32}$$

But the Schwarzschild clock-rate factor is

$$\chi_{\mathrm{GR}}(r) = \sqrt{1 - \frac{r_s}{r}}. \tag{33}$$

Therefore,

$$\chi_{\mathrm{SR}}(v(r)) = \chi_{\mathrm{GR}}(r). \tag{34}$$

The radial gravitational time factor becomes the local Lorentz time factor of the freely falling body. The field supplies the velocity; the velocity supplies the local Lorentz factor; the two factors are identical. This temporal identification is adjacent to earlier analyses of kinematical and gravitational time-dilation factorization in Schwarzschild geometry [23], but here it is used as the radial-versus-directed projection identity of one energy-momentum distortion mechanism.

7. Spatial Identity

In special relativity, the spatial factor along the direction of motion is

$$\gamma(v) = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{1}{\chi_{\mathrm{SR}}(v)}. \tag{35}$$

For the free-fall velocity,

$$\gamma(v(r)) = \frac{1}{\sqrt{1 - \frac{v(r)^2}{c^2}}}. \tag{36}$$

Using

$$\frac{v(r)^2}{c^2} = \frac{r_s}{r}, \tag{37}$$

one obtains

$$\gamma(v(r)) = \frac{1}{\sqrt{1 - \frac{r_s}{r}}}. \tag{38}$$

But the Schwarzschild radial spatial factor is

$$\frac{d\ell_r}{dr} = \frac{1}{\sqrt{1 - \frac{r_s}{r}}}. \tag{39}$$

Therefore,

$$\gamma(v(r)) = \frac{d\ell_r}{dr}. \tag{40}$$

The inverse Lorentz contraction factor equals the Schwarzschild radial spatial factor:

$$\frac{1}{\sqrt{1 - \frac{v(r)^2}{c^2}}} = \frac{1}{\sqrt{1 - \frac{r_s}{r}}}. \tag{41}$$

This is the spatial side of the equivalence.

8. The Equivalence Principle in Distortion Form

The equivalence principle states that gravity and acceleration coincide locally [2]. In this formulation, the equivalence principle becomes a factor identity.

A freely falling body in Schwarzschild geometry acquires the local velocity

$$\frac{v(r)^2}{c^2} = \frac{r_s}{r}. \tag{42}$$

That velocity generates the Lorentz clock-rate factor

$$\chi_{\mathrm{SR}}(v(r)) = \sqrt{1 - \frac{v(r)^2}{c^2}}. \tag{43}$$

The Schwarzschild field has the radial gravitational factor

$$\chi_{\mathrm{GR}}(r) = \sqrt{1 - \frac{r_s}{r}}. \tag{44}$$

The equality of the loads gives

$$\chi_{\mathrm{SR}}(v(r)) = \chi_{\mathrm{GR}}(r). \tag{45}$$

The spatial factors match as well:

$$\gamma(v(r)) = \frac{d\ell_r}{dr}. \tag{46}$$

Thus, in the free-fall projection, local directed Lorentz distortion and radial Schwarzschild distortion are the same load expressed in different orientations.

This gives the mechanism in distortion language. Gravity locally becomes acceleration because the radial gravitational load is converted into a directed kinematic load. The same energy-momentum distortion mechanism appears in two orientations.

9. Rest Energy, Moving Energy, and Directional Gravity

The static Schwarzschild field is produced by rest energy. The source has dominant energy

$$E_0 = mc^2. \tag{47}$$

Its field is radial because the source is at rest.

A moving body carries total relativistic energy

$$E = \gamma mc^2, \tag{48}$$

and directed momentum

$$p = \gamma mv. \tag{49}$$

The source is therefore a rest-energy distribution with additional directed energy-momentum content. Its stress-energy tensor includes energy density, momentum density, energy flow, and directional stress, as in the standard stress-energy treatment of relativistic sources [5].

In stress-energy form,

$$T_{\mu\nu}^{\text{moving}} = T_{\mu\nu}^{\text{rest}} + \Delta T_{\mu\nu}^{\text{directed}}. \tag{50}$$

The moving-source tensor contains the rest-energy component, kinetic-energy contribution, momentum flow, and directional stress, as described in post-Newtonian treatments of relativistic sources [9]. In this decomposition, mc^2 gives the baseline radial Schwarzschild distortion, γmc^2 gives the increased gravitational source strength, and γmv gives the oriented gravitational field structure.

Velocity strengthens the gravitational source through total relativistic energy. Momentum orients the field through directed energy-momentum flow. This is the same energy-momentum distortion principle applied to a directed source.

The moving case is the same stress-energy source with additional directed momentum-energy components. In the weak-field projection, the moving-source geometry is read as the radial rest-energy contribution plus the directed momentum-energy contribution.

10. Radial and Directed Contributions of a Moving Source

The Lorentz time factor of a moving body is

$$\chi_{\text{SR}} = \frac{1}{\gamma} = \sqrt{1 - \frac{v^2}{c^2}}. \tag{51}$$

The gravitational source strength of the same moving body increases through

$$E = \gamma mc^2. \tag{52}$$

The same Lorentz parameter appears in the local proper-time factor and in the additional directed source contribution.

Along the body's own worldline, the local velocity determines the Lorentz factor and therefore the proper-time relation,

$$\chi_{\text{SR}} = \frac{1}{\gamma}. \tag{53}$$

In the field sourced by the body, the rest-energy part remains radial while the moving part adds the directed energy and momentum contributions

$$E = \gamma mc^2, \qquad p = \gamma mv. \tag{54}$$

These source the combined radial-plus-directed gravitational geometry [10].

The Lorentz factor describes the local proper-time relation of the moving body. The external moving-source geometry contains the radial rest-energy contribution together with the directed momentum-energy contribution; isolated-source boost treatments provide a standard GR context for this external-field reading [11].

The local Lorentz factor gives the directed proper-time face of moving energy. The external moving-source geometry gives the corresponding radial-plus-directed field of the same moving energy.

Special relativity appears when the self-gravitational field of the moving body is negligible. General relativity retains the full statement: the same moving body also carries a gravitational self-field with both radial and directed components.

11. Rest Energy as a Schrödinger-Compton Phase Mode

The previous sections identify a common mechanism: energy-momentum determines spacetime distortion, and the orientation of energy-momentum determines the orientation of distortion. Rest energy produces the radial Schwarzschild contribution, while directed momentum-energy produces the local Lorentz contribution.

This raises a natural question. If energy-momentum produces distortion, and directed energy-momentum produces directed distortion, how does the rest energy of a mass appear externally as an all-direction radial field? The issue is how locally directed internal energy can close into a scalar monopole projection around the source.

The answer proposed here is that rest energy is a closed internal mode. Its internal energy flow is locally directional, while its closed geometry averages the vector projection to zero and leaves the scalar monopole projection.

The rest energy of a massive body satisfies

$$E_0 = mc^2. \tag{55}$$

For a stationary energy mode, the stationary quantum phase in Schrödinger form gives [28]

$$\psi(\tau) = \psi_0 e^{-iE\tau/\hbar}. \tag{56}$$

Setting $E = E_0 = mc^2$ gives the rest-energy Compton phase,

$$\psi_C(\tau) = \psi_0 e^{-imc^2\tau/\hbar} = \psi_0 e^{-i\omega_C \tau}. \tag{57}$$

Thus

$$\omega_C = \frac{mc^2}{\hbar}. \tag{58}$$

Equivalently,

$$E_0 = \hbar\omega_C. \tag{59}$$

This Compton scale is the stationary Schrödinger phase frequency associated with a massive rest-energy mode [25].

Thus the rest energy of mass can be represented as an internal phase rate. The model is therefore formulated in Schrödinger-Compton phase language: the internal orientation is carried by the light-speed scale c, while the closed phase geometry cancels net external linear momentum. The phase may also be written as

$$\phi_C(\tau) = \omega_C \tau, \tag{60}$$

so that

$$\psi_C(\tau) = \psi_0 e^{-i\phi_C(\tau)}. \tag{61}$$

The closed-mode interpretation represents the stationary rest-energy phase as an internal light-speed orientation field. This field gives the local direction of internal momentum flow while preserving the Schrödinger-Compton phase frequency.

To make the directional content explicit, use the internal light-speed direction field

$$\vec{c}(s) = c\,\hat{\mathbf{n}}(s), \tag{62}$$

where c is the invariant speed scale and $\hat{\mathbf{n}}(s)$ is a local direction of internal momentum flow along the closed path. For a closed internal Schrödinger-Compton phase mode, the local internal momentum is

$$\vec{p}_{\text{int}}(s) = \frac{E_{\text{int}}}{c}\,\hat{\mathbf{n}}(s). \tag{63}$$

The local momentum circulation remains nonzero,

$$\vec{p}_{\text{int}}(s) \neq 0, \tag{64}$$

while the internal directions close in the normalized closed-path average:

$$\langle \hat{\mathbf{n}} \rangle_{\text{closed}} = 0. \tag{65}$$

Therefore the closed-path average of the internal momentum cancels externally:

$$\langle \vec{p}_{\text{int}} \rangle_{\text{closed}} = \frac{E_{\text{int}}}{c} \langle \hat{\mathbf{n}} \rangle_{\text{closed}} = 0. \tag{66}$$

The scalar internal energy remains

$$E_{\text{int}} = E_0 = mc^2, \tag{67}$$

and the net external linear momentum is

$$\vec{P}^{\,\text{net}}_{\text{ext}} = 0. \tag{68}$$

The invariant rest mass of the closed system is therefore obtained from the energy-momentum relation,

$$M^2 c^4 = E^2_{\text{int}} - \left| \vec{P}^{\,\text{net}}_{\text{ext}} \right|^2 c^2. \tag{69}$$

Since $\vec{P}^{\,\text{net}}_{\text{ext}} = 0$, the externally observed mass is

$$M_{\text{obs}} = \frac{E_{\text{int}}}{c^2}. \tag{70}$$

For the rest mode considered here,

$$E_{\text{int}} = E_0 = mc^2, \qquad M_{\text{obs}} = m. \tag{71}$$

The closed path also changes the local momentum direction continuously. This produces internal stress in the stress-energy tensor: the energy density is carried by T_{00}, while the momentum flux and internal pressure appear in the spatial stress components T_{ij}.

The radial Schwarzschild contribution should therefore be read as the scalar monopole projection of the closed rest source. The condition

$$\langle \hat{\mathbf{n}} \rangle_{\text{closed}} = 0 \tag{72}$$

removes the net external linear momentum. The internal second-moment structure,

$$\langle \hat{n}_i \hat{n}_j \rangle_{\text{closed}}, \tag{73}$$

belongs to the stress and spin structure of the closed mode. Its scalar projection supplies the radial rest-energy source, while the internal helical orientation remains as the spinorial degree of freedom.

This gives a simple way to understand why rest energy has a scalar external projection. The internal energy flow is locally directional, while the closed internal path averages the vector projection to zero. The internal momentum circulation supplies the stress structure of the closed mode, while the scalar monopole projection of the rest-frame source appears externally as the radial Schwarzschild source.

In this interpretation, $T_{\mu\nu}^{\text{rest}}$ is the stress-energy expression of a closed internal rest-energy mode. When the body moves, the same source acquires an additional directed component:

$$T_{\mu\nu}^{\text{moving}} = T_{\mu\nu}^{\text{rest}} + \Delta T_{\mu\nu}^{\text{directed}}. \tag{74}$$

The rest component gives the radial gravitational field. The directed component gives the local Lorentz distortion and contributes to the radial-plus-directed anisotropic geometry of the moving source.

This resolves the apparent tension in the expression mc^2. The quantity c supplies the light-speed scale of the internal mode. The local direction of that scale is represented by $\hat{\mathbf{n}}$, while the closed path distributes the external projection over all radial directions. Through the Compton relation, the internal light-speed energy scale is expressed as a phase frequency.

12. Planck Closure and Compton Refresh-Rate Mass

A useful scale relation connects this closed internal phase mode to the gravitational radius of the same mass. The reduced Compton wavelength is

$$\bar{\lambda}_C = \frac{\hbar}{mc}, \tag{75}$$

while the gravitational radius is

$$r_g = \frac{Gm}{c^2}. \tag{76}$$

Their ratio is

$$\frac{r_g}{\bar{\lambda}_C} = \frac{Gm^2}{\hbar c}. \tag{77}$$

Using the Planck mass,

$$m_P = \sqrt{\frac{\hbar c}{G}}, \tag{78}$$

this becomes

$$\frac{r_g}{\bar{\lambda}_C} = \left(\frac{m}{m_P}\right)^2. \tag{79}$$

Thus, at exactly the Planck mass,

$$m = m_P, \tag{80}$$

the gravitational radius and the reduced Compton wavelength are equal:

$$r_g = \bar{\lambda}_C. \tag{81}$$

This equality gives the closed-phase interpretation a natural geometric origin. A closed internal phase mode should be understood as a geometric closure of the internal light-speed energy flow. The natural way for a phase mode to close while yielding a radial scalar projection is for the relevant spacetime scale to reach its gravitational-closure threshold. This occurs exactly when the reduced Compton wavelength and the gravitational radius coincide.

The Schwarzschild radius is

$$r_s = 2r_g. \tag{82}$$

If one uses r_s instead of r_g, the equality is shifted by the conventional factor $\sqrt{2}$. The clean Planck equality is exact for r_g and $\bar{\lambda}_C$:

$$m = m_P \quad \Longleftrightarrow \quad r_g = \bar{\lambda}_C. \tag{83}$$

The Planck mass is therefore the natural mass scale at which the internal Compton phase scale and the gravitational closure scale meet. At this scale, rest energy can be interpreted as a closed Schrödinger-Compton phase geometry. The corresponding Planck internal Compton phase momentum scale is

$$p_P = \frac{E_P}{c} = m_P c, \qquad E_P = m_P c^2. \tag{84}$$

For an ordinary observed mass, the expressed internal momentum scale follows the same Compton refresh fraction:

$$p_{\mathrm{int}}(m) = p_P \frac{\omega_C(m)}{\omega_P}. \tag{85}$$

The closure cancels the net external linear momentum, while the internal circulation remains the geometric source of the scalar rest-energy projection.

The Planck mass represents the full gravitational-closure scale, while ordinary observed particle masses are determined by the Compton frequency of the expressed mode.

For a mass m,

$$\omega_C(m) = \frac{mc^2}{\hbar}. \tag{86}$$

For the Planck mass,

$$\omega_P = \omega_C(m_P) = \frac{m_P c^2}{\hbar}. \tag{87}$$

Taking the ratio gives

$$\frac{\omega_C(m)}{\omega_P} = \frac{mc^2/\hbar}{m_P c^2/\hbar} = \frac{m}{m_P}. \tag{88}$$

Therefore,

$$m = m_P \frac{\omega_C(m)}{\omega_P}. \tag{89}$$

This relation is a normalization identity: it expresses the observed mass as the Compton phase-rate fraction of the Planck closure scale. The Planck mass is the full closure scale, while an ordinary particle represents a lower-frequency projection of the same internal phase mechanism.

For the electron, for example,

$$m_e = m_P \frac{\omega_C(m_e)}{\omega_P}. \tag{90}$$

The electron is therefore a Compton-frequency fraction of the Planck closure scale in its external observed mass.

In this sense, the observed mass is the rate at which the internal Compton phase mode is expressed in the external physical description.

This gives a mechanism-level perspective on the hierarchy problem. Observed particle masses appear as expressed Compton phase-rate fractions of the Planck closure scale, while the detailed origin of the Higgs scale and the standard technical problem of radiative stability remain subjects for the usual particle-physics treatment. The externally measured mass is the Compton refresh-rate fraction of the closed internal mode,

$$m = m_P \frac{\omega_C(m)}{\omega_P}. \tag{91}$$

In this reading, the large gap between ordinary particle masses and the Planck mass becomes a hierarchy of expressed Compton phase rates.

For ordinary particles,

$$m \ll m_P, \tag{92}$$

so

$$r_g \ll \bar{\lambda}_C. \tag{93}$$

The external Schwarzschild radius is far below the Compton scale, but the Compton phase may still be read as the low-energy projection of this closed internal mass mode.

13. Toroidal Phase Geometry and Spinorial Orientation

Geometrically, such a closed phase mode may be represented as a closed internal Schrödinger-Compton phase mode following a helical path on a toroidal internal geometry. Wheeler's geon concept provides a useful historical reference for self-confined radiation-like field configurations as gravitationally significant structures [27]. Here the relevant object is formulated in Schrödinger-Compton phase language as a closed rest-energy phase mode. In this picture, the c^2 in $E_0 = mc^2$ is the light-speed internal scale of the closed phase mode. The internal momentum circulation remains, while the closed path averages the vector projection to zero and leaves the internal energy as scalar rest energy:

$$E_{\text{internal}} = mc^2, \qquad \vec{p}_{\text{int}}(s) \neq 0, \qquad \vec{P}^{\,\text{net}}_{\text{ext}} = 0. \tag{94}$$

The mass of the external rest state is therefore the invariant mass of the closed energy-momentum system:

$$m = \frac{E_{\text{internal}}}{c^2}. \tag{95}$$

A helical toroidal closure also gives a simple geometric reason why such an internal mode can carry orientation without behaving like an ordinary vector in external space. After one 2π circuit, the helical path returns the internal orientation with the spinorial sign change. A full restoration occurs after a 4π circuit. This is the geometric signature of spinorial behavior: a 2π rotation changes the internal orientation, while a 4π rotation restores the state [26].

The spinorial structure can be represented by assigning the closed internal mode a two-component orientation state,

$$\Psi_s = \begin{pmatrix} \psi_+ \\ \psi_- \end{pmatrix}. \tag{96}$$

A rotation by angle θ acts on this internal orientation through the spinor representation

$$\Psi_s(\theta) = \exp\left(-\frac{i}{2}\theta\, \boldsymbol{\sigma} \cdot \hat{\mathbf{a}}\right) \Psi_s(0), \tag{97}$$

where $\boldsymbol{\sigma}$ are the Pauli matrices and $\hat{\mathbf{a}}$ is the rotation axis. For a full 2π rotation,

$$\Psi_s(2\pi) = -\Psi_s(0), \tag{98}$$

while for a 4π rotation,

$$\Psi_s(4\pi) = \Psi_s(0). \tag{99}$$

In this mechanism, the spinorial transformation is the algebraic expression of the closed helical geometry. The closed internal Schrödinger-Compton phase mode carries a local direction field $\hat{\mathbf{n}}(s)$ and a nonzero internal momentum circulation. The closed-path average cancels only the net external linear momentum,

$$\vec{P}_{\text{ext}}^{\,\text{net}} = 0, \tag{100}$$

while the internal momentum and internal orientation remain as physical degrees of freedom.

The same closed internal structure therefore has two projections. Its scalar monopole projection supplies the external rest-energy source and gives the radial Schwarzschild contribution. Its helical internal orientation supplies the spinorial degree of freedom, with 4π restoration. A closed phase geometry therefore carries both a scalar rest-energy projection and a spinorial internal orientation.

The rest-mass sector is the stationary quantum phase of rest energy, written in Schrödinger form and interpreted as a closed Schrödinger-Compton phase geometry. Rest energy is therefore a closed internal phase mode whose external stress-energy projection gives radial Schwarzschild distortion. Directed momentum-energy is an external directed component whose local projection gives Lorentz distortion. These are two organizations of the same energy-momentum source. The internal pressure or stress associated with the changing direction of the closed internal Compton phase momentum is contained in the spatial stress sector of the same $T_{\mu\nu}$.

14. Stationary Schrödinger Form of the Closed Rest Mode

The closed toroidal rest-energy ansatz recovers the stationary Schrödinger-form phase of the rest mode within the same closed-mode structure. The internal energy of the closed mode is

$$E_{\text{int}} = E_0 = mc^2. \tag{101}$$

The internal light-speed orientation field is

$$\vec{c}(s) = c\,\hat{\mathbf{n}}(s), \tag{102}$$

and the associated internal momentum scale is

$$\vec{p}_{\text{int}}(s) = \frac{E_{\text{int}}}{c}\hat{\mathbf{n}}(s) = mc\,\hat{\mathbf{n}}(s). \tag{103}$$

The closed-path average cancels the net external linear momentum,

$$\langle \vec{p}_{\rm int} \rangle_{\rm closed} = 0, \tag{104}$$

while preserving the local internal momentum circulation.

The reduced Compton wavelength is

$$\bar{\lambda}_C = \frac{\hbar}{mc}. \tag{105}$$

This gives

$$mc = \frac{\hbar}{\bar{\lambda}_C}. \tag{106}$$

Multiplying by c gives

$$E_0 = mc^2 = \frac{\hbar c}{\bar{\lambda}_C}. \tag{107}$$

The corresponding internal angular frequency is

$$\omega_C = \frac{c}{\bar{\lambda}_C}. \tag{108}$$

Therefore

$$E_0 = \hbar\omega_C. \tag{109}$$

Define the stationary internal phase mode by

$$\psi_C(\tau) = \psi_0 e^{-i\omega_C\tau}. \tag{110}$$

Then

$$\frac{\partial \psi_C}{\partial \tau} = -i\omega_C\psi_C, \tag{111}$$

and hence

$$i\hbar\frac{\partial \psi_C}{\partial \tau} = \hbar\omega_C\psi_C = E_0\psi_C. \tag{112}$$

Thus the closed rest mode satisfies the stationary Schrödinger-form equation

$$i\hbar\frac{\partial \psi_C}{\partial \tau} = E_0\psi_C = mc^2\psi_C. \tag{113}$$

This result identifies the Schrödinger-form phase as the phase expression of the closed rest-energy mode. The toroidal closure supplies the internal rest-energy phase and its Compton frequency; the closed-path average removes external linear momentum and leaves the scalar rest-mass projection.

15. Moving-Source Anisotropy as an Empirical Projection

The identities derived above are exact in the stated Schwarzschild free-fall setting. The moving-source extension translates the same principle into an empirical projection for systems in which compactness and velocity both matter. Exact and idealized boost constructions, including Aichelburg-Sexl-type limits, provide the standard relativistic background for gravitational fields of boosted sources [10]. Related boost treatments of isolated sources are given by Barrabes and Hogan [11].

In the weak-field limit,

$$\frac{GM}{rc^2} \ll 1, \tag{114}$$

the static gravitational clock-rate factor is approximately

$$\chi_g(r) \approx 1 - \frac{GM}{rc^2}. \tag{115}$$

For the moving-source phenomenological ansatz used below, the relevant small parameter is the combined anisotropic load

$$\epsilon_{\text{moving}}(r,\theta) = \frac{GM}{rc^2} F(\gamma,\theta). \tag{116}$$

The ansatz should therefore be used in the regime

$$\epsilon_{\text{moving}}(r,\theta) \ll 1. \tag{117}$$

In stronger compact-binary settings, the same angular scaling should be compared with post-Newtonian or numerical-relativity waveform corrections and treated as a phenomenological scaling expression.

When the source moves, its field receives two effects:

1. relativistic source enhancement through $E = \gamma mc^2$;
2. directional compression and orientation through $p = \gamma mv$ and the moving geometry.

Let

$$\beta = \frac{v}{c}, \qquad \gamma = \frac{1}{\sqrt{1-\beta^2}}. \tag{118}$$

A compact phenomenological expression for the anisotropic moving-source clock-rate factor is

$$\chi_g^{\text{moving}}(r,\theta) \approx 1 - \frac{GM}{rc^2} F(\gamma,\theta), \tag{119}$$

where θ is the angle relative to the source motion, and $F(\gamma,\theta)$ is a dimensionless anisotropic direction factor.

A useful test form is

$$F(\gamma,\theta) = \frac{\gamma^2(1+\beta^2)}{\sqrt{\gamma^2\cos^2\theta + \sin^2\theta}}. \tag{120}$$

This expression encodes the two physical effects in one factor: source-energy enhancement and directional field compression.

Along the direction of motion,

$$\theta = 0, \tag{121}$$

so

$$F_{\parallel} = \gamma(1+\beta^2). \tag{122}$$

Transverse to the direction of motion,

$$\theta = \frac{\pi}{2}, \tag{123}$$

so

$$F_{\perp} = \gamma^2(1+\beta^2). \tag{124}$$

In the relativistic limit,

$$\beta \to 1, \tag{125}$$

one obtains

$$F_{\|} \approx 2\gamma, \qquad F_{\perp} \approx 2\gamma^2. \tag{126}$$

Thus the transverse enhancement dominates:

$$\frac{F_{\perp}}{F_{\|}} = \gamma. \tag{127}$$

The field becomes increasingly concentrated in the transverse plane as the source speed approaches c.

The observable residual can be parameterized as

$$\Delta_{\mathrm{dir}}(r,\theta) \propto \frac{GM}{rc^2}\left[F(\gamma,\theta) - 1\right]. \tag{128}$$

This residual vanishes in the static limit and grows when compactness and velocity are both significant.

This empirical expression is a test ansatz for the moving-source projection of the same energy-momentum distortion mechanism. Its role is to organize and compare moving-source effects in the language of radial distortion, directed Lorentz distortion, and radial-plus-directed gravitational anisotropy.

16. Phenomenological Moving-Source Test Prediction

The empirical prediction is the angular scaling of the residual after the static radial contribution has been removed. The relevant observational background includes gravitomagnetic source motion [12], moving-lens corrections [14], aberration in gravitational lensing [17], matter-current lensing [15], and compact-source post-Newtonian waveform modeling [16]. Light propagation in fields of moving bodies provides an additional relativistic lensing context [18]. In a compact moving-source system, subtract the best-fit static Schwarzschild or standard radial mass contribution from the observed lensing, timing, or waveform observable. The remaining directed moving-source component should scale as

$$\Delta_{\mathrm{dir}}(r,\theta) = A_{\mathrm{sys}}\frac{GM}{rc^2}\left[\frac{\gamma^2(1+\beta^2)}{\sqrt{\gamma^2\cos^2\theta + \sin^2\theta}} - 1\right], \tag{129}$$

where A_{sys} is a system-dependent amplitude and projection factor determined by the observable being fitted.

The most direct signature is the transverse-to-longitudinal anisotropy. From the test factor above,

$$F_{\|} = \gamma(1+\beta^2), \qquad F_{\perp} = \gamma^2(1+\beta^2). \tag{130}$$

The directional factors themselves obey

$$\frac{F_{\perp}}{F_{\|}} = \gamma. \tag{131}$$

For the residual after subtracting the static contribution, the relevant ratio is instead

$$\frac{\Delta_{\perp}}{\Delta_{\|}} \approx \frac{F_{\perp} - 1}{F_{\|} - 1} = \frac{\gamma^2(1+\beta^2) - 1}{\gamma(1+\beta^2) - 1}. \tag{132}$$

In the relativistic regime this residual ratio approaches the same leading transverse enhancement controlled by γ.

The empirical prediction is that after subtracting the static radial field, the moving-source residual is angle-dependent and is stronger transverse to the source motion than along the direction of motion. The direction factors satisfy $F_\perp/F_\parallel = \gamma$, while the directly subtracted residual scales as $(F_\perp - 1)/(F_\parallel - 1)$.

The effect should be negligible for ordinary laboratory sources and most weak galactic systems. It becomes relevant where compactness and velocity are both appreciable:

$$\frac{GM}{rc^2} \not\ll 1, \qquad \frac{v}{c} \not\ll 1. \tag{133}$$

The clean observational target is the isolation of the directed moving-source projection expected from energy-momentum sourcing, organized by the scaling law above.

17. Observational Domains

For ordinary laboratory masses, the factor

$$\frac{GM}{rc^2} \tag{134}$$

is extremely small. For a one-kilogram mass at one meter,

$$\frac{GM}{rc^2} \sim 10^{-27}. \tag{135}$$

Even large Lorentz factors leave the self-field negligible.

In compact astronomical systems, the situation changes. Compact objects can have

$$\frac{GM}{rc^2} \sim 0.05 - 0.3, \tag{136}$$

and velocities in compact binaries can reach significant fractions of c.

The moving-source correction has the phenomenological form

$$\Delta_{\text{obs}} \sim \frac{GM}{rc^2}\left[F(\gamma,\theta) - 1\right]. \tag{137}$$

It depends on

$$\frac{GM}{rc^2}, \qquad \frac{v}{c}, \qquad \theta. \tag{138}$$

The relevant observational arenas include compact binaries and waveform modeling [16], moving gravitational lenses [14], lensing by spinning or escaping lenses [13], aberrational lensing corrections [17], matter-current lensing [15], and gravitomagnetic systems [12]. Moving and spinning sources also affect electromagnetic-wave propagation through variable gravitational fields [19].

The proposed test is organizational and phenomenological. Standard general relativity contains moving-source effects through $T_{\mu\nu}$ and post-Newtonian dynamics [9]. Gravitomagnetic formulations describe the field role of mass currents [12]. Moving-deflector lensing supplies a direct lensing context [14]. Matter-current lensing makes the momentum-flow contribution explicit [15]. Compact-binary waveform modeling gives the corresponding strong-field dynamical context [16]. The present formulation places these effects inside one projection structure. Static rest energy gives radial Schwarzschild distortion. Directed momentum-energy gives local Lorentz distortion. A moving gravitational source gives radial-plus-directed anisotropic geometry.

18. Final Result

The complete relation can be stated directly: energy-momentum determines spacetime distortion.

In the static spherical case, rest energy gives the Schwarzschild clock-rate factor,

$$\chi_{\mathrm{GR}}(r) = \sqrt{1 - \frac{r_s}{r}}. \tag{139}$$

In the local moving case, directed momentum-energy gives the special-relativistic clock-rate factor,

$$\chi_{\mathrm{SR}}(v) = \sqrt{1 - \frac{v^2}{c^2}}. \tag{140}$$

Free fall from rest at infinity gives the exact bridge:

$$\frac{v(r)^2}{c^2} = \frac{r_s}{r}. \tag{141}$$

Therefore,

$$\chi_{\mathrm{SR}}(v(r)) = \chi_{\mathrm{GR}}(r). \tag{142}$$

The corresponding spatial identity is

$$\gamma(v(r)) = \frac{d\ell_r}{dr}. \tag{143}$$

The moving-source extension gives the empirical radial-plus-directed anisotropic projection:

$$\chi_g^{\mathrm{moving}}(r,\theta) \approx 1 - \frac{GM}{rc^2} F(\gamma,\theta), \tag{144}$$

with

$$F(\gamma,\theta) = \frac{\gamma^2(1+\beta^2)}{\sqrt{\gamma^2\cos^2\theta + \sin^2\theta}}, \tag{145}$$

used in the weak combined-load regime

$$\frac{GM}{rc^2} F(\gamma,\theta) \ll 1. \tag{146}$$

Thus the three expressions are one mechanism in three orientations. Schwarzschild general relativity is the radial rest-energy distortion. Special relativity is the local directed momentum-energy distortion. Moving-source gravity is the radial rest-energy distortion together with the directed momentum-energy contribution.

The equivalence principle appears because free fall maps the radial gravitational load into the local directed Lorentz load. The field supplies the velocity; the velocity supplies the Lorentz factor; the factors coincide.

The rest-mass sector completes the same chain. Rest energy is the stationary quantum phase of $E_0 = mc^2$, written in Schrödinger form as a Compton phase,

$$\psi_C(\tau) = \psi_0 e^{-imc^2\tau/\hbar} = \psi_0 e^{-i\omega_C\tau}. \tag{147}$$

The closed-mode interpretation treats this phase as a closed internal Schrödinger-Compton phase geometry. Its internal momentum circulation remains nonzero, while its closed-path average cancels the net external linear momentum:

$$\vec{p}_{\rm int}(s) \neq 0, \qquad \vec{P}^{\rm net}_{\rm ext} = 0. \tag{148}$$

The externally observed rest mass is therefore the invariant mass of the closed energy-momentum system,

$$M_{\rm obs} = \frac{E_{\rm int}}{c^2}. \tag{149}$$

The Planck scale gives the closure threshold. The gravitational radius and the reduced Compton wavelength satisfy

$$\frac{r_g}{\bar{\lambda}_C} = \left(\frac{m}{m_P}\right)^2, \tag{150}$$

so $m = m_P$ gives $r_g = \bar{\lambda}_C$. Ordinary observed masses appear as Compton refresh-rate fractions of the Planck closure scale:

$$m = m_P \frac{\omega_C(m)}{\omega_P}. \tag{151}$$

The toroidal/helical reading gives the internal orientation of the same closed phase geometry. The scalar monopole projection gives the radial rest-energy source, while the helical internal orientation gives the spinorial 4π restoration behavior:

$$\Psi_s(2\pi) = -\Psi_s(0), \qquad \Psi_s(4\pi) = \Psi_s(0). \tag{152}$$

The same closed rest mode also recovers the stationary Schrödinger-form phase. Since

$$\omega_C = \frac{c}{\bar{\lambda}_C}, \tag{153}$$

one obtains $E_0 = \hbar\omega_C$, and the internal rest mode obeys

$$i\hbar \frac{\partial \psi_C}{\partial \tau} = E_0 \psi_C. \tag{154}$$

Special relativity, Schwarzschild general relativity, rest mass, stationary Schrödinger-form phase, spinorial internal orientation, and moving-source anisotropy are therefore organized as connected projections of one energy-momentum distortion mechanism. The formulation keeps the stress-energy source explicit and separates radial rest-energy distortion from directed momentum-energy distortion. Rest energy gives the radial gravitational field. Moving energy gives directed Lorentz distortion. A moving gravitational source carries both: the radial field of rest energy and the additional oriented field structure of momentum-energy. Moving astronomical systems provide the natural observational domain for the resulting radial-plus-directed moving-source anisotropy.

Keywords

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Ethics Statement

This work contains no studies involving human participants, human data, animal subjects, or clinical intervention. The research is theoretical and was conducted in accordance with standard scholarly and ethical practice.

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