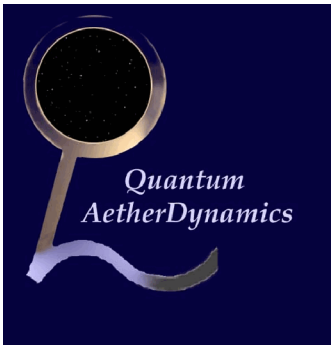

Quantum AetherDynamics Institute (QADI)

QMU Gravitational Field Theory IV: Post-Newtonian Closure Geometry and the Eddington Parameters

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Abstract

The previous papers established the scalar closure sector of QMU gravitation through propagation-density curvature, closure-flow conservation, closure coupling constants, and closure saturation. The resulting theory reproduces the Newtonian inverse-square field while expressing gravitational structure through Ledger One and the propagation-force ledger.

The present paper investigates the weak-field propagation geometry implied by the scalar closure potential

$$\Psi_c = -\frac{GM}{c^2 r}. \tag{1}$$

Using the closure potential as the natural dimensionless expansion parameter, the effective metric projection is developed to post-Newtonian order.

The analysis derives the Eddington parameters associated with the closure geometry and examines the resulting predictions for gravitational redshift, light deflection, Shapiro time delay, and perihelion precession.

The purpose of the paper is not to introduce additional free parameters, but to determine whether the closure geometry already contained within the scalar sector reproduces the experimentally tested weak-field structure of gravitation.

1 Introduction

The first paper in the QMU Gravitational Field Theory series introduced a closure-based description of gravitation in terms of propagation density, closure-flow conservation, and scalar propagation curvature Thomson III [2026a].

The second paper Thomson III [2026b] completed the scalar gravitational ledger through derivation of the closure constants

$$\Gamma_c = c^2, \qquad \eta_m = \frac{G}{c^2}, \qquad \kappa_c = 4\pi. \tag{2}$$

These constants yielded the gravitational ledger identity

$$G = \frac{c^4}{\text{Gforce}} = \frac{(A_u\,\text{curl})^2}{\text{Gforce}}. \tag{3}$$

The third paper examined the strong-field interpretation of the closure potential and introduced the Closure Saturation Principle Thomson III [2026c],

$$2|\Psi_c| = 1, \tag{4}$$

as the operational boundary of geometric distinguishability.

Together these results completed the scalar closure description of gravitation.

A remaining question concerns the relationship between closure geometry and the weak-field tests traditionally expressed through the Parameterized Post-Newtonian (PPN) formalism.

The PPN framework characterizes weak gravitational fields through dimensionless coefficients appearing in the metric expansion Will [2014, 1993].

Among these, the most important are the Eddington parameters

$$\gamma \tag{5}$$

and

$$\beta. \tag{6}$$

The parameter γ characterizes spatial curvature generated by a unit mass, while β measures nonlinear self-coupling of the gravitational field.

Observational constraints obtained from spacecraft tracking, gravitational lensing, planetary ephemerides, and radio timing require both parameters to be extremely close to unity Will [2014], Bertotti et al. [2003].

The objective of the present paper is therefore straightforward.

Beginning from the closure potential derived previously,

$$\Psi_c = -\frac{GM}{c^2 r}, \tag{7}$$

the weak-field geometry implied by closure propagation will be constructed and expanded to post-Newtonian order.

The resulting coefficients may then be compared directly with the PPN parameters.

This approach differs conceptually from conventional metric theories.

Rather than treating spacetime geometry as primitive, the geometry is interpreted as a projection of the underlying closure field.

The closure potential serves as the fundamental quantity, while metric structure emerges as its geometric representation.

2 The Closure Potential as a Post-Newtonian Parameter

The scalar closure potential derived previously is

$$\Psi_c(r) = -\frac{GM}{c^2 r}. \tag{8}$$

Unlike the ordinary Newtonian potential,

$$\Phi(r) = -\frac{GM}{r}, \tag{9}$$

the closure potential is dimensionless.

Consequently it provides a natural perturbation parameter for weak gravitational fields.

The weak-field regime corresponds to

$$|\Psi_c| \ll 1. \tag{10}$$

Near Earth's surface,

$$|\Psi_c| \sim 10^{-9}, \tag{11}$$

while within the Solar System the quantity remains extremely small.

The closure potential therefore provides a well-defined expansion parameter throughout all presently tested weak-field gravitational environments.

The observational significance of the closure potential follows from the relation

$$\Phi = c^2 \Psi_c. \tag{12}$$

Since gravitational frequency shifts are governed by

$$\frac{\Delta\nu}{\nu} = \frac{\Delta\Phi}{c^2}, \tag{13}$$

the closure potential is directly measurable through clock-rate comparisons. This weak-field clock-rate relation is the standard gravitational redshift result tested in spaceborne clock experiments Vessot et al. [1980], Delva et al. [2018].

To first order,

$$\Psi_c = \frac{\Delta\nu}{\nu}. \tag{14}$$

The closure potential therefore possesses operational meaning independent of coordinate distance.

Its value may be determined through propagation-rate measurements alone.

This property becomes particularly important near the closure saturation boundary discussed previously, where coordinate descriptions become increasingly ambiguous while propagation rates remain observable.

For this reason the closure potential will be adopted as the fundamental perturbation parameter throughout the remainder of the paper.

3 Temporal Propagation Geometry

The first geometric correction arises from the propagation-rate modification associated with the closure potential.

The observed proper interval is assumed to depend upon local closure density through the dimensionless scalar field Ψ_c.

To first order,

$$d\tau^2 = (1 + 2\Psi_c)\, dt^2. \tag{15}$$

This expression reproduces the standard weak-field gravitational redshift relation.

Substituting

$$\Psi_c = -\frac{GM}{c^2 r} \tag{16}$$

gives

$$d\tau^2 = \left(1 - \frac{2GM}{c^2 r}\right) dt^2. \tag{17}$$

Consequently the temporal metric coefficient becomes

$$g_{tt} = -\,(1 + 2\Psi_c) + \mathcal{O}(\Psi_c^2). \tag{18}$$

The first-order temporal geometry is therefore fixed entirely by the closure potential.

No additional coupling coefficients are required.

The remaining task is determination of the spatial propagation geometry and its post-Newtonian expansion.

4 Spatial Propagation Geometry

The propagation geometry developed in the first gravitational paper showed that weak gravitational deflection requires not only a temporal propagation-rate correction but also a spatial geometry correction.

The temporal term alone reproduces only one-half of the observed light-deflection angle.

Recovery of the full Schwarzschild result therefore requires the spatial geometry to contribute an equal first-order correction.

Accordingly the radial closure geometry is written in the general form

$$g_{rr} = 1 - 2\alpha\Psi_c + \mathcal{O}(\Psi_c^2), \tag{19}$$

where α is a dimensionless closure-geometry coefficient.

The value of α is not assumed a priori.

Instead it will be determined from the closure requirement that the combined propagation-rate and propagation-geometry corrections recover the observed weak-field light-deflection structure.

5 Determination of the Spatial Curvature Parameter

The coefficient α introduced above determines the amount of spatial curvature associated with the closure field.

The temporal propagation correction alone produces only one-half of the observed first-order gravitational light deflection. This result was already noted in the historical development of relativistic gravitation.

Within the closure framework the total first-order light-deflection angle may be written schematically as

$$\Delta\theta = \Delta\theta_t + \Delta\theta_r, \tag{20}$$

where

$$\Delta\theta_t = \frac{2GM}{c^2 b} \tag{21}$$

arises from the propagation-rate correction and

$$\Delta\theta_r = 2\alpha \frac{GM}{c^2 b} \tag{22}$$

arises from the spatial geometry correction Eddington [1920], Will [2014].

The observed first-order result is

$$\Delta\theta = \frac{4GM}{c^2 b}. \tag{23}$$

Consistency therefore requires

$$2 + 2\alpha = 4, \tag{24}$$

giving

$$\boxed{\alpha = 1.} \tag{25}$$

The spatial metric coefficient therefore becomes

$$g_{rr} = 1 - 2\Psi_c + \mathcal{O}(\Psi_c^2). \tag{26}$$

Comparison with the standard PPN expansion

$$g_{rr} = 1 - 2\gamma\Psi + \cdots \tag{27}$$

immediately yields

$$\boxed{\gamma = 1.} \tag{28}$$

The first Eddington parameter therefore emerges directly from the closure requirement that temporal and spatial propagation corrections contribute equally to first-order light deflection.

No additional adjustable parameter is introduced.

6 Second-Order Temporal Geometry

The second Eddington parameter β characterizes nonlinear self-coupling of the gravitational field.

To determine this coefficient within the closure framework it is necessary to extend the temporal propagation geometry to second order.

The closure potential itself is already dimensionless,

$$\Psi_c = -\frac{GM}{c^2 r}, \tag{29}$$

so higher-order corrections naturally appear as powers of Ψ_c.

The most general second-order temporal expansion may therefore be written

$$g_{tt} = -\left(1 + 2\Psi_c + 2B\Psi_c^2\right) + \mathcal{O}(\Psi_c^3), \tag{30}$$

where B is an unknown nonlinear closure coefficient.

A natural closure-preserving representation is exponential propagation scaling,

$$g_{tt} = -\exp(2\Psi_c). \tag{31}$$

Expanding this expression gives

$$g_{tt} = -\left(1 + 2\Psi_c + 2\Psi_c^2\right) + \mathcal{O}(\Psi_c^3). \tag{32}$$

Thus the second-order coefficient is fixed by smooth repeated closure scaling rather than by a new independent coupling:

$$B = 1. \tag{33}$$

The temporal metric expansion becomes

$$g_{tt} = -\left(1 + 2\Psi_c + 2\Psi_c^2\right) + \mathcal{O}(\Psi_c^3). \tag{34}$$

Substituting

$$\Psi_c = -\frac{GM}{c^2 r} \tag{35}$$

gives

$$g_{tt} = -\left(1 - \frac{2GM}{c^2 r} + 2\frac{G^2 M^2}{c^4 r^2}\right) + \mathcal{O}(c^{-6}). \tag{36}$$

Comparison with the standard PPN form

$$g_{tt} = -\left(1 - \frac{2GM}{c^2 r} + 2\beta\frac{G^2 M^2}{c^4 r^2}\right) + \cdots \tag{37}$$

yields

$$\boxed{\beta = 1.} \tag{38}$$

Thus both Eddington parameters emerge naturally from the closure geometry:

$$\boxed{\gamma = 1, \qquad \beta = 1.} \tag{39}$$

The scalar closure sector therefore reproduces the same first-order post-Newtonian structure associated with the experimentally verified weak-field metric.

7 Post-Newtonian Closure Metric

Using the mostly-plus signature $(-,+,+,+)$, the weak-field closure metric may be written in isotropic post-Newtonian form as

$$ds^2 = -\left(1 + 2\Psi_c + 2\Psi_c^2\right) c^2 dt^2 + (1 - 2\Psi_c)\left(dr^2 + r^2 d\Omega^2\right) + \mathcal{O}(\Psi_c^3). \tag{40}$$

Using

$$\Psi_c = -\frac{GM}{c^2 r}, \tag{41}$$

this becomes

$$ds^2 = -\left(1 - \frac{2GM}{c^2 r} + 2\frac{G^2 M^2}{c^4 r^2}\right) c^2 dt^2 + \left(1 + \frac{2GM}{c^2 r}\right)\left(dr^2 + r^2 d\Omega^2\right) + \mathcal{O}(c^{-6}). \tag{42}$$

This metric is entirely determined by the closure potential and the ledger constants derived previously.

No additional post-Newtonian parameters remain free.

The resulting geometry therefore provides a direct observational bridge between the scalar closure theory and the precision weak-field tests of gravitation.

8 Recovery of Gravitational Redshift

The first observational consequence of the temporal closure geometry is gravitational redshift.

For a static weak field, the temporal metric coefficient is

$$g_{tt} = -\left(1 + 2\Psi_c + 2\Psi_c^2\right) + \mathcal{O}(\Psi_c^3). \tag{43}$$

To first order, the proper clock rate satisfies

$$d\tau \simeq (1 + \Psi_c)\, dt. \tag{44}$$

The fractional frequency shift between two locations is therefore

$$\frac{\Delta\nu}{\nu} = \Delta\Psi_c. \tag{45}$$

Using

$$\Psi_c = -\frac{GM}{c^2 r}, \tag{46}$$

we obtain

$$\frac{\Delta\nu}{\nu} = \frac{\Delta\Phi}{c^2}, \tag{47}$$

where

$$\Phi = c^2\Psi_c = -\frac{GM}{r}. \tag{48}$$

Thus the closure potential reproduces the standard weak-field gravitational redshift relation.

This confirms that Ψ_c possesses direct operational meaning as a fractional propagation-rate or clock-rate deviation in the weak-field limit.

9 Recovery of Light Deflection

The first-order deflection of light by a spherical source depends upon both the temporal propagation-rate correction and the spatial propagation-geometry correction.

In PPN form, the deflection angle is

$$\Delta\theta = (1+\gamma)\frac{2GM}{c^2 b}, \tag{49}$$

where b is the impact parameter.

The closure geometry derived above gives

$$\gamma = 1. \tag{50}$$

Therefore

$$\Delta\theta = (1+1)\frac{2GM}{c^2 b}, \tag{51}$$

or

$$\boxed{\Delta\theta = \frac{4GM}{c^2 b}.} \tag{52}$$

This is the standard first-order light-deflection result.

In closure notation,

$$\Delta\theta = \frac{4\eta_m M}{b} = \frac{4c^2 M}{\text{Gforce}b}. \tag{53}$$

Thus the light-deflection coefficient is fixed entirely by the closure ledger.

No additional optical or phenomenological parameter is required.

10 Recovery of Shapiro Time Delay

The Shapiro time delay provides a second direct test of the spatial curvature coefficient γ.

In the weak-field PPN approximation, the excess radar time delay for a signal passing near a mass is proportional to

$$1+\gamma. \tag{54}$$

For a signal traveling from radius r_1 to radius r_2 with impact parameter b, the leading logarithmic delay is

$$\Delta t_{\text{Shapiro}} = (1+\gamma)\frac{GM}{c^3}\ln\left(\frac{4r_1 r_2}{b^2}\right). \tag{55}$$

Since the closure geometry gives

$$\gamma = 1, \tag{56}$$

the predicted delay becomes

$$\boxed{\Delta t_{\text{Shapiro}} = \frac{2GM}{c^3} \ln\left(\frac{4r_1 r_2}{b^2}\right).} \tag{57}$$

The same spatial closure geometry that supplies the missing half of the light-deflection angle therefore also supplies the standard Shapiro time-delay coefficient Shapiro [1964], Bertotti et al. [2003], Will [2014].

In QMU form, using

$$G = \frac{c^4}{\text{Gforce}}, \tag{58}$$

the delay may be written as

$$\Delta t_{\text{Shapiro}} = \frac{2cM}{\text{Gforce}} \ln\left(\frac{4r_1 r_2}{b^2}\right). \tag{59}$$

This expresses the radar delay directly in terms of the propagation-force ledger.

11 Recovery of Perihelion Precession

The anomalous perihelion precession of a bound orbit depends upon both Eddington parameters γ and β.

In the PPN formalism, the correction to the perihelion advance per orbit is

$$\Delta\varpi = \frac{6\pi GM}{a(1-e^2)c^2}\left(\frac{2-\beta+2\gamma}{3}\right), \tag{60}$$

where a is the semi-major axis and e is the orbital eccentricity.

The closure geometry gives

$$\gamma = 1, \qquad \beta = 1. \tag{61}$$

Therefore

$$\frac{2-\beta+2\gamma}{3} = \frac{2-1+2}{3} = 1. \tag{62}$$

Thus

$$\boxed{\Delta\varpi = \frac{6\pi GM}{a(1-e^2)c^2}.} \tag{63}$$

This is the standard weak-field perihelion precession result Einstein [1915], Will [2014].

Expressed in closure form,

$$\Delta\varpi = \frac{6\pi\eta_m M}{a(1-e^2)} = \frac{6\pi c^2 M}{\mathrm{Gforce}a(1-e^2)}. \tag{64}$$

The perihelion correction therefore follows from the same closure parameters that determine light deflection and Shapiro delay.

12 Summary of PPN Recoveries

The scalar closure geometry yields

$$\boxed{\gamma = 1, \qquad \beta = 1.} \tag{65}$$

Consequently, the standard first post-Newtonian tests are recovered:

$$\frac{\Delta\nu}{\nu} = \frac{\Delta\Phi}{c^2}, \tag{66}$$

$$\Delta\theta = \frac{4GM}{c^2 b}, \tag{67}$$

$$\Delta t_{\mathrm{Shapiro}} = \frac{2GM}{c^3}\ln\left(\frac{4r_1 r_2}{b^2}\right), \tag{68}$$

$$\Delta\varpi = \frac{6\pi GM}{a(1-e^2)c^2}. \tag{69}$$

Each result follows from the same dimensionless closure potential,

$$\Psi_c = -\frac{GM}{c^2 r}, \tag{70}$$

together with the closure-geometric projections

$$g_{tt} = -\left(1 + 2\Psi_c + 2\Psi_c^2\right), \tag{71}$$

and

$$g_{ij} = (1 - 2\Psi_c)\,\delta_{ij}. \tag{72}$$

The post-Newtonian recoveries therefore do not require any new phenomenological constants beyond those already derived from Ledger One and the propagation-force ledger.

13 Observational Consistency

The principal purpose of the present paper is not to introduce a new gravitational phenomenology but to demonstrate that the scalar closure framework reproduces the observationally verified weak-field structure already established experimentally.

The recovery of

$$\gamma = 1, \qquad \beta = 1, \tag{73}$$

implies agreement with the classical solar-system tests at first post-Newtonian order.

These include

1. gravitational redshift,
2. light deflection,
3. Shapiro radar delay,
4. perihelion precession.

The closure formulation therefore preserves the empirical successes of weak-field gravitation while expressing the dynamics through closure potential and propagation geometry rather than spacetime curvature alone.

The observational role of the scalar sector is consequently limited.

The scalar ledger establishes the weak-field propagation structure, determines the closure constants, and provides the invariant horizon condition.

It does not yet determine rotational effects, binary energy loss, frame dragging, compact-object spin structure, or rotational-wave coupling.

Those phenomena belong to the rotational closure sector developed in subsequent work.

14 Limitations of the Present Theory

The present paper intentionally restricts itself to the scalar closure sector.

Several important components of a complete gravitational theory remain open.

First, the rotational closure field

$$\boldsymbol{\Omega}_c = \nabla \times \mathbf{J}_c \tag{74}$$

has not yet been promoted to a fundamental geometric operator.

At present it serves only as a derived quantity.

A full rotational theory may require torsional, bivector, or defect structure beyond ordinary vector calculus.

Second, the closure ledger presently contains no explicit stress-energy tensor.

The conservation law

$$\frac{\partial \rho_c}{\partial t} + \nabla \cdot \mathbf{J}_c = 0 \tag{75}$$

governs closure transport, but the corresponding transport of gravitational energy and momentum remains to be constructed.

Third, scalar-wave propagation has been established only at the field equation level.

The emission, coupling, polarization structure, and observational constraints of the wave sector remain to be derived quantitatively.

Fourth, the closure saturation principle presently functions as an operational boundary condition.

A deeper derivation from closure dynamics remains desirable.

The present work therefore closes the scalar weak-field ledger while leaving rotational, energetic, and strong-field dynamical questions open.

15 Toward a Closure Stress-Energy Ledger

The natural extension of the scalar theory is the construction of a closure stress-energy analogue.

The closure potential already defines a field energy density through its gradients.

A minimal scalar form is

$$u_c = \frac{1}{8\pi}\left[(\nabla \Psi_c)^2 + \frac{1}{c^2}\left(\frac{\partial \Psi_c}{\partial t}\right)^2\right]. \tag{76}$$

The corresponding closure flux may be written

$$\mathbf{S}_c = -\frac{1}{4\pi}\frac{\partial \Psi_c}{\partial t}\nabla \Psi_c. \tag{77}$$

For source-free propagation,

$$\Box_c \Psi_c = 0, \tag{78}$$

these quantities satisfy

$$\frac{\partial u_c}{\partial t} + \nabla \cdot \mathbf{S}_c = 0. \tag{79}$$

This relation suggests the existence of a broader closure stress-energy tensor

$$T_c^{\mu\nu}, \tag{80}$$

whose scalar limit reproduces the above conservation law.

The explicit construction of that tensor is deferred to later work.

However, the existence of a conserved closure-energy current provides the natural route toward binary-system energetics and gravitational-wave power calculations.

16 The Rotational Closure Program

The next stage of QMU gravitation concerns rotational closure.

The scalar sector determines the closure potential

$$\Psi_c, \tag{81}$$

but rotating systems require a second independent field structure.

The candidate quantity is

$$\boldsymbol{\Omega}_c = \nabla \times \mathbf{J}_c. \tag{82}$$

Within the present formulation this field remains descriptive rather than fundamental.

Future work will investigate whether rotational closure is represented by

1. a torsional field,
2. a bivector field,
3. a closure defect density,
4. a higher-order QMU operator.

Such a structure would provide the natural source of

- frame dragging,
- rotating compact objects,
- rotational gravitational waves,
- RMFD detector coupling,
- binary-system angular-momentum transport.

The rotational program therefore represents the next major ledger closure objective.

17 Discussion

The principal result of the present paper is that the scalar closure sector reproduces the standard first post-Newtonian structure while remaining entirely expressible through closure quantities.

The dimensionless closure potential

$$\Psi_c = -\frac{GM}{c^2 r} \tag{83}$$

provides a unified description of

- gravitational redshift,
- light deflection,
- Shapiro delay,
- perihelion precession,
- closure saturation.

The closure metric reproduces

$$\gamma = 1, \qquad \beta = 1, \tag{84}$$

without introducing new phenomenological parameters.

Consequently, the scalar theory remains observationally consistent with the standard weak-field tests while preserving the closure ontology developed in the preceding papers.

The resulting interpretation differs conceptually from conventional curvature-based approaches.

The primary physical quantity is not spacetime geometry itself but closure structure.

Geometry becomes a projection of closure relations rather than the fundamental ontology.

The horizon condition

$$2|\Psi_c| = 1 \tag{85}$$

therefore appears as a closure invariant.

The significance of the horizon does not arise from coordinate singularities but from closure saturation.

The present work thus completes the scalar post-Newtonian ledger and establishes a stable foundation for rotational closure theory.

18 Conclusion

This paper developed the post-Newtonian structure of QMU Gravitational Field Theory from the scalar closure potential.

Starting from

$$\Psi_c = -\frac{GM}{c^2 r}, \tag{86}$$

the closure metric was shown to reproduce the standard first post-Newtonian coefficients

$$\gamma = 1, \qquad \beta = 1. \tag{87}$$

As a consequence, the theory recovers the classical weak-field tests of gravitation:

$$\frac{\Delta\nu}{\nu} = \frac{\Delta\Phi}{c^2}, \tag{88}$$

$$\Delta\theta = \frac{4GM}{c^2 b}, \tag{89}$$

$$\Delta t_{\text{Shapiro}} = \frac{2GM}{c^3} \ln\left(\frac{4r_1 r_2}{b^2}\right), \tag{90}$$

and

$$\Delta\varpi = \frac{6\pi GM}{a(1-e^2)c^2}. \tag{91}$$

The scalar closure framework therefore remains compatible with the observationally verified weak-field structure of gravitation.

At the same time, the closure interpretation preserves the invariant horizon condition

$$2|\Psi_c| = 1, \tag{92}$$

and maintains the closure-saturation principle developed previously.

The remaining open problems concern rotational closure, closure stress-energy transport, compact-object rotation, and gravitational-wave energetics.

These subjects define the next stage of the QMU gravitational program.

Acknowledgments

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