Abstract

Quantum gravity has been so elusive because we have tried to approach it by two paths which can never meet: quantum mechanics and general relativity. These contradict each other not only in superdense regimes, but also in the vacuum.

We explore a straight road to quantum gravity here—the one mandated by Clifford-algebra covariance. This bridges the gap from microscales—where the massive Dirac propagator is a sum over null zig-zags—to macroscales—where we see the energy-momentum current, $\mathbf{T}$ and the resulting Einstein curvature, $\mathbf{G}$. For massive particles, $\mathbf{T}$ flows in the “cosmic time” direction, $y^0$—centrifugally in an expanding universe.

Neighboring centrifugal currents of $\mathbf{T}$ present opposite spacetime vor-ticities $\mathbf{G}$ to the boundaries of each others’ worldtubes, so they attract—i.e. attract, as we show here by integrating a Spin$^c$-4 Lagrangian by parts in the spinfluid regime.

This boundary integral not only explains why stress-energy $\mathbf{T}$ is the source for gravitational curvature $\mathbf{G}$, but also gives a value for the gravitational constant, $\kappa (x^0)$ that depends on the current scale factor of our expanding Friedmann 3-brane! On the microscopic scale, quantum gravity appears naturally as the statistical mechanics of null zig-zags of massive particles in “imaginary time,” $y^0$.

1 The Spinfluid Flow: Dilation-Boost Current

We derive Einstein’s field equations here by recognizing Einstein curvature $\mathbf{G}$ and energy-momentum $\mathbf{T}$ as different expressions for the same flux—the “spinfluid current” 3 form—and that these expressions must match on the boundaries...
\[ \partial B^t \] of the worldtubes of massive particles. We then look at a patch of this boundary at a microscopic scale—where the matter current is resolved into a sum over null zig-zags.

What is essential to recognize first is that the macroscopic energy-momentum current \( \ast T(x) \) is the Noether current of the spinor (matter) fields under the active local dilation/boost flow \( \varphi^\alpha(x) \) and that the dilation current, or energy density, is centrifugally outward in an expanding universe, \( M \).

Conserved currents spring from invariances. We use Spin\(^c\)-4, the complexification of \( \text{Spin}(4) \times U(1) \), as our isometry group on expanding, curved space, \( M \equiv (T, S_3(T)) \); a family of space-like hypersurfaces parametrized by cosmic time \( T \). After Sachs, we call \( E \) the Einstein group. Cosmic expansion and boost-covariance demand that \( E \) be nonunitary—i.e. have Hermitian \( (H) \), as well as anti-Hermitian \( (aH) \) generators.

Let’s view our spacetime \( M \) as filled with a spin\(^c\)-4 fluid or spinfluid: an inhomogeneous distribution of 4 spinor fields, \( \psi_I(x) \), and 4 dual spinors \( \psi^I(x) \). Suppose that each may be created from the homogeneous vacuum distribution \( \hat{\psi}_I \) by active-local Einstein (\( EA \)) transformations \([1],[3]\):

\[
\begin{align*}
\psi_I(x) &= \exp\left(\frac{i}{2} \zeta_I^\alpha(x) \sigma_\alpha \right) \hat{\psi}_I \equiv g_I(x) \hat{\psi}_I, \\
\psi^I(x) &= \hat{\psi}^I \exp\left(\frac{i}{2} \zeta^I_\alpha(x) \sigma_\alpha \right) \equiv \hat{\psi}^I g_I(x); \\
\alpha &= (0,1,2,3).
\end{align*}
\] (1)

In the PTC-symmetric geometrical-optics regime, the path-dependent phase shifts \( d\zeta_I^\alpha(x) = -d\zeta^I_\alpha(x) \) are complex:

\[
g^I dg_I \equiv g_I^{-1} dg_I = \frac{i}{2} d\zeta_I^\alpha(x) \sigma_\alpha = \frac{i}{2} [d\theta_I^\alpha(x) - i aH \varphi_I^\alpha] \sigma_\alpha \equiv \Omega_I(x). \]

The \( \Omega_I(x) \) are the spin connections or vector potentials—the \( gl(2, \mathbb{C}) \)-valued 1 forms that enter into the covariant derivatives of each spinor field:

\[
\nabla_\beta \psi_I \equiv (\partial_\beta + \Omega_{I\beta}(x)) \psi_I.
\]

The \( \Omega_I \) record the phase shift of each spin frame \([4],[8]\) in any direction at \( x \in M \) due to local sources—and of the global (vacuum) distribution.

Their path dependences, or holonomies

\[
g^I d^I g_I \equiv K_I = d\Omega_I + \Omega_I \wedge \Omega_I
\]

are the spin curvatures—the fields. Their anti-Hermitian \( (aH) \) parts are the \( u(1) \times su(2) \) (electroweak) and \( su(3) \) (strong) fields. Their Hermitian \( (H) \) parts are the gravitational fields; these measure the path dependence of the local dilation-boost flow \( d\varphi^\alpha(x) \) \([4],[5]\).

A concentration of mass at Minkowsky-space position \( x \equiv (x^0, x^1, x^2, x^3) \in M \) is a localized 4-momentum current \( d\varsigma^0(x) \) propagating in the cosmic time \( (y^0) \) direction—which is not directly visible to us as dwellers in a spacelike (constant \( y^0 \)) cross section.
However, $y^0$ enters kinematically \[1\], \[4\] as the imaginary part of a complex time variable $z^0 \equiv x^0 + iy^0$. The imaginary parts $y^j$ of $z^j \equiv x^j + iy^j$ are the 3-momentum density.

Now, if the phase flow \(d\zeta^\alpha(z) \equiv \partial\zeta^\alpha / \partial z^\beta dz^\beta + \partial\bar{\zeta}^\alpha / \partial \bar{z}^\beta d\bar{z}^\beta\) \[4\] were analytic, it would obey the Cauchy-Riemann equations:

\[
\frac{\partial \zeta^\alpha}{\partial \bar{z}^\beta} = 0 = \frac{\partial \bar{\zeta}^\alpha}{\partial z^\beta}.
\]

We could then detect the dilation current, or rest energy, by the frequency

\[
\frac{\partial \theta^0}{\partial x^0} = \frac{\partial \varphi^0}{\partial y^0}.
\]

of the matter wave, $\psi$. But energy is the Noether charge

\[
\int_{B_3} \frac{\partial \mathcal{L}}{\partial (\partial_0 \psi^I)} \left[ \frac{\partial \psi^I}{\partial x^0} \right] d^3V = \hbar \int_{B_3} \left( \frac{\partial \theta^0}{\partial x^0} \right) e^1 \wedge e^2 \wedge e^3
\]

under Minkowsky-time translation, and is proportional to the frequency \[4\], which we can detect! In quantum mechanics, the proportionality constant is $\hbar$.

But Q.M. is incompatible with general relativity (G.R.)—not only at small scales or high densities—but in the vacuum! The problem is that the divergent Q.M. vacuum energy would produce enough spacetime curvature to roll up our space to a point!

The solution is a fundamental theory from which both Q.M. and G.R. derive in different regimes. We illustrate below using a Nonlinear Multispinor (N.M.) model. In the macroscopic limit, we recover G.R. and in the microscopic view, the spinfluid flow resolves into a sum over null zig-zags—the Dirac propagator \[4\], \[6\].

### 2 Vacuum Energy in Spinfluid Models

Covariance of the Dirac equations in curved spacetime \[1\] rests on the local spinorization maps or Maurer-Cartan 1 forms

\[
\begin{align*}
S & \equiv q_\alpha(x) e^\alpha(x) : e_\beta(x) \rightarrow q_\beta(x) ; \\
\bar{S} & \equiv \bar{q}_\alpha(x) e^\alpha(x) : e_\beta(x) \rightarrow \bar{q}_\beta(x). \quad \text{(8)}
\end{align*}
\]

These assign local generators $q_\beta(x) \in \mathfrak{gl}(2\mathbb{C})_L$, $\bar{q}_\beta(x) \in \mathfrak{gl}(2\mathbb{C})_R$ of the “internal” Lie algebra to each spacetime increment $e_\alpha(x)$. These obey the Clifford algebra of $\mathbb{M}$:

\[
[q_\alpha \bar{q}_\beta + q_\beta \bar{q}_\alpha](x) = 2g_{\alpha\beta}(x) \sigma_0. \quad \text{(9)}
\]
The overbar denotes *quaternionic* conjugation (space, or *P* reversal).

The covariant and contravariant tetrads are sums of *null tetrads*: tensor products of some fundamental *L* and *R*-chirality basis spinor fields:  

\[
q_\alpha (x) = \sigma^A_B \ell_A (x) \otimes \ell_B (x), \quad q^\alpha (x) = \sigma^A_B r_B (x) \otimes r_A (x).
\]

We consider the 8 basis spinors (\(\ell_1, \ell_2\), \(r_1, r_2\)) as the fundamental physical fields—the *inertial spinor fields* (I.S.). Dyads in the I.S. are the null tetrads, whose sums and differences make the (spin-1) spacetime tetrads. Products of these make the (spin-2) metric tensor.

In fact [9], all matter and gauge fields are *spin tensors*: sums of tensor products of spinors of Left and Right-chirality (handedness). Outward and Inward temporality (dilation behavior), and Positive and Negative charge (temporal *U* (1) current). This is the Spin Principle, \(S\): Spinor fields are physical. All our observable covariants and invariants are sums of tensor products of spinor fields, and their gradient spinors.

Immediate implications of \(S\) are:

A) Our moving spacetime tetrads \(e_\alpha (x)\) are the inverse images under (8) of physical increments \(q_\alpha (x)\) and \(\bar{q}_\alpha (x)\) in spin space.

B) Spinorization maps \(S\) and \(\bar{S}\) are implemented physically by the *spin connections*

\[
\Omega_L (x) = g^R dg_L = \frac{i}{2} \left[ a_#^{-1} q_\alpha (x) + W_\alpha (x) \right] e^\alpha
\]

\[
\Omega_R (x) = g^L dg_R = \frac{i}{2} \left[ a_#^{-1} \bar{q}_\alpha (x) + \bar{W}_\alpha (x) \right] e^\alpha.
\]

The fundamental length unit \(a_#\) is the *equilibrium radius* of the Friedmann solution [9]. In the *PT*-symmetric (*PTS*) case \(g^R g_L = 1_L\), the electroweak vector potentials \(W_\alpha\) and \(\bar{W}_\alpha\) vanish. Then the counterpropagating spinwaves in (10) step off our spacetime increments. The spin connections are the tetrads!

For the stationery case \(M_# \equiv S_1 \times S_3 (a_#)\), the spin connections are the left-invariant Maurer-Cartan 1 forms that derive from the canonical maps of \(M_#\) onto \(U (1) \times SU (2)\),

\[
g_L = \exp \frac{i}{2a_#} e^\alpha \sigma_\alpha; \quad g_R = \bar{g}_L; \quad \Omega_L = \frac{i}{2a_#} \sigma_\alpha e^\alpha; \quad \bar{\Omega}_R = \frac{i}{2a_#} \bar{\sigma}_\alpha e^\alpha.
\]
Their right-invariant versions are
\[ \Omega^L \equiv (dg^L)g_R; \]
\[ \Omega^R \equiv (dg^R)g_L. \] (13)

It takes tensor products of all 4 chiral pairs of spinor fields in (11), or their gradients, to make a natural 4 form—e.g. a Lagrangian density:
\[ \mathcal{L} \in \Lambda^4 \subset \otimes^8, \] (14)
which must be invariant under the group \( E_P \) of passive spin isometries in curved spacetime. The wedge product of all 4 spin connections makes the 4-volume form \( d^4V \):
\[ i(\Omega^L \wedge \Omega^L \wedge \Omega^R \wedge \Omega^R) = \left( \frac{1}{16\pi^2} \right) |g|^\frac{1}{2} \sigma_0 e^0 \wedge e^1 \wedge e^2 \wedge e^3, \]
where \(|g|\) is the determinant of the metric tensor (9).

The simplest Lagrangian that is an \( E_P \)-invariant (conformal) 4 form is the topological Lagrangian
\[ \mathcal{L}_T \equiv \frac{i}{2} \text{Tr}\Omega^L \wedge \Omega^R \wedge \Omega^R \wedge \Omega^L, \] (15)
the Maurer-Cartan 4 form. Its action
\[ S_T \equiv \frac{i}{2} \int_M \text{Tr}\Omega^L \wedge \Omega^R \wedge \Omega^R \wedge \Omega^L = -16\pi^3N \] (16)
measures the covering number of spin space over the "vacuum" \( \mathbb{M} \equiv \mathbb{M}_\# \cup D_J \) outside the worldtubes \( D_J \) of massive particles, and comes in topologically-quantized units [10].

Masses arise from the breaking of scale invariance. Elsewhere [8], [9] we exhibit a “grandparent” Lagrangian density for both the outer region, where it reduces to \( \mathcal{L}_T \), and the inner region, where it gives the Dirac Lagrangian, \( \mathcal{L}_D \):
\[ \mathcal{L}_G = i\mathbf{d}\psi^R \wedge \psi_L \wedge \psi^L \wedge \mathbf{d}\psi^R \wedge \mathbf{d}\psi^L \wedge \psi^R \wedge \psi_L \wedge \mathbf{d}\psi^R \wedge \mathbf{d}\psi^L \] (17)
(average over sign combinations in which each spinor field appears exactly once). This is the 8-spinor factorization of the Maurer-Cartan 4 form. Each field is expanded as the sum of its vacuum distribution and “broken out” perturbation
\[ \psi_{L \pm} \equiv \tilde{\psi}_{L \pm}, \quad \psi^L \equiv \tilde{\psi}^L, \quad \psi^R \equiv \tilde{\psi}^R + \tilde{\psi}_{R \pm}, \quad \psi_{R \pm} \equiv \tilde{\psi}_{R \pm} + \tilde{\psi}_{R \mp}, \]
where all 8 fields may be varied independently.

The outer solution turns out to be PTC-symmetric, with \( \tilde{\psi}_{R \pm} \tilde{\psi}_{L \mp} = 1 \). Inside some worldtubes \( B_4 \), chiral pairs of broken-out perturbations can bind to form localized \( PTA \), or charged, bispinor particles like
\[ e_- \equiv \left( \tilde{\xi}_- (x) \oplus \tilde{\eta}_- (x) \right), \] (18)
which we identify as an electron.

The mechanism that endows such bispinors with inertial mass emerges in a remarkable way \[1\] from Lagrangian (17), \[9\]. Inside the worldtube \(B_4\), \(\tilde{\xi}_-\) and \(\tilde{\eta}_-\) undergo mass scatterings \[4\], nonlinear resonances with “vacuum gratings” formed by the remaining 3 unbroken chiral pairs; e.g. on \(M_\#\),

\[
\tilde{\Omega}^3 \equiv \hat{\Omega}_1 \wedge \hat{\Omega}_2 \wedge \hat{\Omega}_3
\]

\[
= \left(\frac{i}{2a_\#}\right)^3 \sigma_1 \sigma_2 \sigma_3 e^1 \wedge e^2 \wedge e^3
\]

\[
= \left(\frac{1}{2a_\#}\right)^3 \gamma^{-1} \sigma_0 d^3 v.
\]

(19)

The three vacuum spin connections \(\tilde{\Omega}^3\) of (19) reconstruct the spatial 3-volume element, up to a scale factor \(\gamma^{-1}\), when inserted into Lagrangian density (17). Here

\[
\gamma (T) \equiv \frac{a (T)}{a_\#}
\]

(20)

is the time-dependent radius of our Friedmann universe, in units of \(a_\#\).

Now here is the remarkable thing that happens. When pairs of “envelope modulations” like (18) are inserted into Lagrangian (17), along with the three vacuum fields \(\hat{\Omega}^3\) of (19), we obtain an effective Dirac Lagrangian \(L_D\), coupling \(\tilde{\xi}_- (x)\) and \(\tilde{\eta}_- (x)\) via the effective mass term

\[
\frac{1}{2a_\#} \left[ \tilde{\xi}^- \tilde{\eta}^- - \tilde{\eta}^- \tilde{\xi}^- \right],
\]

(21)

where

\[
\tilde{\xi}^- = \xi^T i q^2 \equiv \left(\tilde{\xi}_-\right)^T \left[ \ell^1 \otimes r^2 - \ell^2 \otimes r^1 \right] \equiv \left(\tilde{\xi}_-\right)^T \gamma e
\]

(22)

is the conformal dual spinor to \(\tilde{\xi}_-\). Note that it is the product \[23\] of two vacuum fields that “dualizes” each perturbed envelope to create the Dirac mass term, (21). This is Mach’s principle in action. \(L_D\) gives the Dirac equations

\[
i \sigma^\alpha \partial_\alpha \tilde{\xi}_- = \frac{\gamma^{-1}}{2a_\#} \tilde{\eta}_-
\]

\[
i \bar{\sigma}^\alpha \partial_\alpha \tilde{\eta}_- = \frac{\gamma^{-1}}{2a_\#} \tilde{\xi}_-.
\]

(23)

written with respect to intrinsic coordinates on our expanding Friedmann 3-brane.

On a microscopic scale, “mass scatterings” off vacuum gratings (19) are what channel the “null zig-zags” of the Dirac propagator \[3\], \[4\], \[6\] into a timelike worldtube \(B_4 (\tau)\). The electron mass \[1\]

\[
m_e = \frac{\gamma^{-1}}{2a_\#}
\]

(24)

turns out to be (half) the inverse of the equilibrium radius \(a_\#\), in the \(M_\#\) reference frame. This must be divided by the scale factor, \(\gamma\), to get the mass we measure in our dilated, intrinsic frame on \(M\).
3 Matching Boundary Vorticity $*G$ to Energy Flux $*T$

The form of energy-momentum flux inside $B_4$ depends on the particle. But, the form of the field Lagrangian $L_G$ outside the worldtubes $B_4$ is universal. This gives us enough information to match the integrals of the outer field 3 form $*G$ and inner matter flux $*T$ on the moving boundaries $B_3(\tau) = \partial B_4(\tau)$, and thus derive Einstein’s field equations. The steps are these:

1. Write the total action $S_G$ as the sum of field terms outside $B_4$ (in $M_\# \setminus B_4$), and matter terms inside:

$$S_G = i \int_M \mathrm{Tr} \Omega_L \wedge \Omega_L \wedge \Omega_R \wedge \Omega_R + \int_{B_4(\tau)} L_M.$$  

where $\tau$ is a proper time parameter along the particles’ world tubes.

2. Transform the field term via integration by parts using the Bianchi identity

$$dK = K \wedge \Omega - \Omega \wedge K.$$ 

The result is

$$S_G = i \int_M \mathrm{Tr} K_L \wedge K_R + \mathrm{Tr} \Omega_L \wedge (K_L + K_R) \wedge \Omega_R - i \int_{\partial B_4(\tau)} \mathrm{Tr} [\Omega_L \wedge K_R - K_L \wedge \Omega_R].$$  

(25)

The first and second terms are chiral versions of the electroweak\strong and gravitational field actions [3], [9].

But it is the third term—the boundary integral—that couples fields to source currents in the next steps.

3. Rewrite the boundary integral in terms of the matrix-valued spacetime curvature 2 form [11]

$$\mathcal{R}^\beta_\alpha \equiv R^\beta_\alpha \gamma e^\gamma \wedge e^\delta.$$  

(26)

$\mathcal{R}$ accepts an area element and returns the holonomy (rotation) matrix around it, with matrix elements $\mathcal{R}^\beta_\alpha$.

4. Rewrite all spacetime vectors as Clifford ($C$) vectors, using spinorization maps [8]. Now re-express the $PT_3$ spacetime curvature matrix on a basis $C$ vector in terms of $C$ vectors multiplying the $C$ vector-valued spin-curvature 2 forms

$$-\mathcal{R}^\beta_\alpha q_\beta = q_\alpha K_R - K_L q_\alpha.$$  

(27)
5. Using Cartan’s $C$ vector-valued 1 form
\[ dq(x) \equiv d(q_\alpha x^\alpha) \equiv q_\alpha e^\alpha, \] (28)
recognize Wheeler’s [11] “moment of rotation tensor” as the $C$ vector-valued 3 form
\[ *G \equiv dq \wedge R = 2ia_\# [\Omega_L \wedge K_R - K_L \wedge \Omega_R]. \] (29)
This is the integrand in the outer form of the boundary integral in (25)!

6. The inner form of the boundary integral is the energy-momentum $P^\alpha$ inside the worldtube $B_4$ of a moving particle. Detect this by displacing $B_4$ by $t = \Delta x^\alpha$ and rewriting the change in the action as a surface integral of the 3 form flux $*T^\alpha$ across the moving boundary $\partial B_4(t)$:
\[ P^\alpha(t) \equiv \int_{\partial B_4(t)} *T^\alpha. \] (30)
Here
\[ *T^\alpha \equiv \left[ \frac{\partial L}{\partial (\partial_\alpha \psi_I)} \right] \partial_\beta \psi_I - \delta^\alpha_\beta L \right] *e^\beta \] (31)
is the energy-momentum density—the Noether current under active translation in the $e_\alpha$ direction. Taking $t = \tau$, the proper time along a particle’s worldline, (31) gives $P_0(\tau)$, the energy contained in the particle’s support $B_3(\tau)$, i.e. its rest mass. For the Dirac Lagrangian $L_D$, we recover the frequency from (31),
\[ P_0(\tau) \sim \int_{B_3(\tau)} \left( \frac{\partial \theta^0}{\partial x^\alpha} \right) (\tau, x) e^1 \wedge e^2 \wedge e^3. \] (32)

7. Finally, equate the inner and outer expressions on the moving boundary
\[ \partial B_4(t) \equiv B_3(t) - B_3(0) + S_2 \times I(t) \]
of the worldtube of a particle in an external field to obtain:
\[ \int_{B_3(t)} *G = 4a_\#^2 \int_{B_3(t)} *T \implies *G = 4a_\#^2 *T, \] (33)
since both integrals must be Lorenz-covariant. These are Einstein’s field equations [12], with a gravitationl constant of
\[ \kappa = \frac{a_\#^2}{2\pi^2}. \] (34)
Using a spinfluid model, we have seen how vorticity $\ast G$ arises on the boundary of each energy-momentum current $\ast T$. Neighboring centrifugal currents (masses) present opposite radiotemporal vorticities $G_{or}$ to each other’s worldtube boundaries—and therefore attract (or advect, like hydrodynamic vortices [12]). Spinfluid models give a mechanism for gravitation.

The power of such theories to determine some “constants of nature” also makes them falsifiable. For example, relations (24) and (34) give the value

$$\kappa m_e^2 = \frac{\gamma^{-2}}{8\pi^2} (T)$$

for the dimensionless constant that measures the ratio of gravitational to electromagnetic forces between electrons on our Friedmann 3-brane, $S_3 (a (T))$. This would match the value observed today with an expansion factor of $\gamma \sim 10^{20}$.

4 Quantum Gravity from Null Zig-Zags

Recall [13] that quantum field theory is statistical mechanics in imaginary time. Cosmic time $T \equiv y^0$ enters kinematically as the imaginary part of a complex time variable $z^0 = x^0 + iy^0$ in spinfluid models. A stochastic version of our model in which the classical action is replaced by a statistical propagator—the sum over null zig-zags—gives a theory of quantum gravity, provided that the vacuum fields that do the mass scatterings are also modelled statistically.

The advantage of such quantum spinfluid models is that there are no divergences built in, so we don’t have to worry about unbounded vacuum energies rolling up our space to a point. The vacuum energy—or dark energy—is simply the energy of the homogeneous distribution of spinor fields $\{\hat{\psi}_I, \hat{\bar{\psi}}_I\}$ on which the matter gauge fields ride like waves in the ocean.

Microscopically, the chiral pairs of matter fields that break away from this geometrical-optics flow resolve into a lightlike mesh of null zig-zags, confined to timelike worldtubes $B_4$ [9], [10]. These may propagate “forward” (centrifugally outward, i.e. with the direction of cosmic expansion) or “backward” (inward).

Spinor fields are lightlike: their phases $\zeta^R (z)$ or $\zeta^L (\bar{z})$ may propagate only along segments of forward characteristics $\gamma_+$ or backward characteristics $\gamma_-$. The propagator for a chiral bispinor particle, a massive Dirac wavefunction [4], [6], must therefore be a sum over null zig-zags of L-chirality zigs and R-chirality zags; forward and backward envelopes $(\hat{\chi}^+, \hat{\bar{\chi}}^+)$ and $(\hat{\xi}^-, \hat{\bar{\xi}}^-)$ with mass scatterings—nonlinear resonances with the remaining 4 vacuum fields—at each corner.

Now suppose our expanding spatial 3-brane $S_3 (T)$ passes through a vertex where a forward zig is scattered into a backward zag, by a tensor product nonlinearity [1]. [3]. In our spacetime slice, we see the spin-1 component

$$\gamma^\circ = \hat{\xi}^- \otimes \hat{\bar{\xi}}^+,$$

a (r-helicity) photon.
The 4 spinor fields whose phases $\zeta^\alpha \equiv \theta^\alpha - i\varphi^\alpha$ propagate along forward characteristics

$$\gamma_+ (\tau) : dy^0 = +dx^0 = d\tau$$

are called analytic:

$$\frac{\partial \zeta^\alpha}{\partial \bar{z}^\beta} = 0 \quad \Rightarrow \quad \frac{\partial \varphi^\alpha}{\partial y^\beta} = -\frac{\partial \theta^\alpha}{\partial x^\beta};$$

$$\frac{\partial \theta^\alpha}{\partial y^\beta} = +1 \quad \frac{\partial \varphi^\alpha}{\partial x^\beta} = \left[ \frac{dy^\gamma}{dx^\mu} \right] \frac{\partial \varphi^\alpha}{\partial y^\gamma};$$

the Cauchy-Riemann (C.R.) equations in $\bar{z}^\beta$. The remaining 4 spinor fields are conjugate analytic, i.e. we must replace $\bar{z}^\beta$ with $z^\beta$ in (37), to get 4 conjugate C.R. equations.

The C.R. and conjugate C.R. equations relate the $u(1) \times su(2)$ phases $\theta^\alpha$ and their complexifications $\varphi^\alpha$, given in terms of polar coordinates $(x^0, x^j)$ on $M_\# \equiv S_1 \times S_3$ to their conjugate momenta, $(y^0, y^j)$. These analyticity conditions justify Wick rotation, which translates the statistical mechanics of null zig-zags in Euclidean spacetime $(y^0, x^i) \in M$ to Feynman integrals in (compactified) Minkowsky space $(x^0, x^i) \in M_\#$.

These mass scatterings are the vertices in a Riemann sum for the action, $S_G$, for a massive particle. This becomes clear when we

i) re-express $S_G$ with respect to null tetrads on $M$,

$$e^\pm = \frac{1}{\sqrt{2}} (e^1 \pm ie^2), \quad e^{\uparrow\downarrow} = \frac{1}{\sqrt{2}} (e^0 \pm e^4).$$

ii) write Riemann sums for $S_G$ with respect to a null lattice (e.g. with spacing $a_\#$ on $M$), $N$, stepped off by these.

iii) notice that, in order for a lattice point to contribute to the action, the Lagrangian there must have a scalar ($\sigma_0$), or spin-0 component. We call this a nonlinear 8-spinor resonance between $J$ chiral pairs of broken-out matter fields and $(4 - J)$ vacuum pairs. The action in the N.M. model is a sum of contributions from every such resonance in the null lattice, and the propagator is the sum over all null zig-zag paths that connect the initial and final point. In this sense, this N.M. model is innately quantum mechanical, and does not need to be “quantized.”

Furthermore, it is the minimal model with a 1-term, passive-Einstein ($E_P$)-invariant topological Lagrangian, because:

a) It takes the intersection of 4 null cones to determine a point on $M$.

b) Each is generated, via $S^{-1}$ of [8], by the tensor product [10] of 2 spinor fields.

c) For symplectic invariance, $L$ must contain 4 spinors and 4 gradients.
d) Under $PTC$, $L$ reduces to the Maurer-Cartan (M.C.) 4 form, which measures the covering number of $U(1) \times SU(2)$ over our (compactified) spacetime manifold.

I don’t know how our N.M. model compares with other theories of quantum gravity, or what experimental tests could distinguish them at this era of cosmic expansion. However, the N.M. model is quite capable of dealing with the superdense regimes inside collapsed objects like neutron stars, black holes, and the early universe, where it admits nonperturbative solutions [1], [10]. These are regularized by the resistance (16) of the topologically nontrivial vacuum to compression to a point. The N.M. model predicts another new effect in supervortical regimes: an interaction between Lens-Thirring fields and weak potentials [3], [9]. Perhaps such effects could be measured in terrestrial laboratories or astronomical observation.

5 Conclusion

More significant than the values of fundamental constants derived from the N.M. model, or the prediction of new effects, are the qualitative features of quantum spinfluid models that enable them to reconcile quantum mechanics and general relativity. These are

1. A Lagrangian density with no free parameters that is a natural 4 form—i.e. invariant under the group of passive spin isometries in curved spacetime.

2. An action which includes a bounded vacuum energy that depends on the radius $a(T)$ of the Friedmann solution which breaks dilation invariance and sets the length and the mass scales. This (hopefully) includes a repulsive term at high densities that prevents total collapse.

3. Values for the standard coupling constants that are “frozen in” by the history of dynamical symmetry breaking. These values may depend on cosmic time, $T$.

4. Effective electroweak, strong, and gravitational field actions—along with minimal coupling through their spin connections in the covariant derivatives—are derived from local perturbations to the Friedmann vacuum.

5. These fields are sourced in localized currents with topologically quantized charges.

6. A mechanism for gravitation derived from the same nonlinear coupling of particle fields to the global field, sourced in the “distant masses,” that creates the inertial masses of particles.

7. Quantum propagators which are derived from the statistical mechanics of null zig-zags of the (lightlike) spinor fields that weave the (timelike) worldtubes of massive particles and the (spacelike) fabric—the vacuum—that connects them.
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