Quantum localization and the sterile neutrino

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Abstract

What if gravity is all about neutrinos? We discuss quantum inertia as a foundation for three time gravity. Mounting evidence for non standard sterile neutrino states begs for an insight into the origin of neutrino mass. Our solution lies at the heart of quantum cosmology. We describe the inverse neutrino see-saw rule for the Higgs mass, in which electroweak symmetry breaking pairs the neutrino mass scale and the Planck scale, in a framework motivated by the neutrino CMB correspondence at 0.00117 eV and the breaking of the equivalence principle by quantum inertia. A sterile mass of 1.29 eV is in good agreement with experiment.

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A rest mass observable has a precise energy, and so by the uncertainty principle, no knowledge of time. When there are three rest masses in a triplet, there are three complementary time coordinates. But motivic quantum logic begins not with smooth time trajectories in a three dimensional space. It infers the importance of the number three from the structure of abstract categories of interest, such as the ribbon categories underlying quantum computation and entanglement renormalizaton.

To a particle physicist, the most meaningful quantitative measure of mass is the rest mass of an electron. We demand that essential degrees of freedom are encoded as quantum information, and the three charged lepton masses occur empirically as the squares of an eigenvalue triplet for the Koide matrix [1][2]

$$\sqrt{M} = \mu_l \begin{pmatrix} \sqrt{2} & e^{i\theta} & e^{-i\theta} \\ e^{-i\theta} & \sqrt{2} & e^{i\theta} \\ e^{i\theta} & e^{-i\theta} & \sqrt{2} \end{pmatrix} \tag{1}$$

where ${\mu_l}^2 \sim m_p/3$ is the dynamical quark scale and θ is very close to the rational $2/9$. An extension [3] to the active neutrinos selects a scale ${\mu_\nu}^2 \sim 0.01$eV with the phase $2/9 + \pi/12$, phenomenologically suggesting an arithmetic meaning for neutrino mass.

Indeed, neutrinos reveal something fundamental about quantum gravity. Neutrino oscillations prove the existence of positive masses, whereas the Standard Model would like neutrinos to be massless. Do right handed neutrinos exist? If neutrinos gain both Dirac and Majorana masses, then, by definition, the four component Dirac spinor has antineutrinos with the same mass as the neutrinos. Typically, a Majorana mass will be associated to a see-saw mechanism, bringing in right handed particles. But the new states need not be heavy, since the novel see-saw that we will describe comes from the quantum information underlying the local theory, where Lagrangians are a derivative concept. Global fits to oscillation experiments currently favour [4][5] a light sterile with a mass close to 1.3 eV, and light steriles are coincident with dark energy in neutrino condensate mechanisms [6] for symmetry breaking.

What are these non standard sterile states? In analogy with right handed charged leptons, let us assume that there is only one local sterile state, in a $3+1$ mixing scheme. Koide parameters are associated to ribbon states [7][8] in a suitable category for quantum computation [9], allowing mirror braids. Our radical suggestion: this single sterile is related by supersymmetry to the photons of the CMB, in agreement with the 2010 discovery that the central mirror Koide mass for $\theta = 2/9 - \pi/12$ exactly matches [10][11] the present day temperature of the CMB at 0.00117 eV (for μ_ν), assuming Wien's law. All six Koide masses are listed in Table 1. We interpret the hotter and colder mirror masses as past and future states, unobservable in our one time physics, with its right handed singlets.

Our local sterile matches the increase in temperature given by the creation redshift $z = 1100$, assuming an empirical ΛCDM, and we happily throw out classical causality in the early universe. This single additional state beyond the

Standard Model, associated now to the cosmic mirror that defines antineutrinos, has a mass of 1.29 eV [12], in good agreement with aforementioned global fits.

Alternative CMB cosmologies without dark matter include the plasma cosmology [13], which notes that electromagnetic structures in astrophysics shape the cosmos more than gravity does. Surely our cosmological arrow of time is associated to measured entropic flows, hot to cold, rather than a CMB that just happens to live in a universe expanding in an a priori time parameter.

To obtain 0.00117 eV for the Koide state, we assume only that Wien's law for black body radiation is universally valid, using a principle of quantized inertia [14][15][16]. Here we break the weak equivalence principle, stating that a gravitational mass m_g is related to the measured inertial mass m_i by

$$m_g = m_i(1 - \frac{\lambda}{4R_H}), \tag{2}$$

where λ is an Unruh wavelength, compared to a Hubble radius R_H for our observable universe. The largest scales define a massless universe, which has an infrared cutoff given by the neutrino condensate scale μ_ν. A dual UV cutoff is the Planck scale m_{Pl}. Since electroweak symmetry breaking should emerge from quantum mass generation, we combine these two cutoffs in an inverse see-saw rule, giving an estimate for the Higgs mass [9]

$$m_H = \sqrt{\mu_\nu{}^2 m_{\mathrm{Pl}}} = \mu_\nu \sqrt{m_{\mathrm{Pl}}}. \tag{3}$$

A geometric mean is natural for a cosmological clock with an origin [17], in contrast to the arithmetic mean of clocks in special relativity. This see-saw is a sign of three time physics, suggesting a combination of rational and irrational phases in the neutrino Koide parameters, as observed.

Quantum inertia laws, with a factor running from 0 to 1, should also be derived from discrete data. But we know how to do cosmic renormalization using Hopf algebras of trees, beginning with only rational numbers, which in turn come from ordinals. In motivic quantum gravity, everything is discrete in the beginning, and all the mathematics of manifolds is secondary to the quantum logic behind universal cohomology. The three times beyond holographic M theory [18] speak of universal cohomology. In quantum logic, the cardinality of a set is replaced by the dimension of a Hilbert space. There are eight subsets of a three point set, defining the correct anyon charges. We are observers. Ask to measure a qutrit of mass, and your space is three dimensional. The gauge group $SU(2)$ is well known to emerge from B_3, the braid group on three strands. In fact, any dimension in extended M theories may be interpreted simply as a number of strands, with no continua in sight.

To get a wormhole in this holographic picture, consider two dimensional pair creation diagrams [19] as categorical axioms. If antimatter has a cosmic horizon, this wormhole diagram links the present to the distant observable past. Seeing the eccliptic in the CMB might not be at all surprising. Our own actions determine our chances of building a future.

Table 1: neutrino masses (eV)

ν	0.0507	0.0089	0.0004
$\overline{\nu}$	0.0582	0.00117	0.0006

Now consider the following. What we usually call antineutrinos, meaning the actual particles, need not be the antineutrinos of an effective Dirac spinor, which may only belong to a derivative local theory. In other words, the right handed mass triplet of Table 1 may belong to physical $\overline{\nu}$ states, and our so called sterile neutrino is a redshifted $\overline{\nu}$. This idea was quantitatively supported by early 2010 results from MINOS [20], which recovered the distinct ν and $\overline{\nu}$ mass differences using the same value for μ_{ν} [10].

More recently, evidence for steriles at the ANITA [21] and MiniBooNE [22] experiments also hint at low mass states, since heavy steriles are unlikely to traverse the whole earth [23]. We can look at neutrino condensate superfluids, and consider the problem of dark matter on different scales [24]. Quantum inertia easily recovers the MOND rule for galactic rotation curves. What is there left to worry about? Quantum gravity as a foundation for quantum computation [25][26] is a unifying basis for science on all scales.

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