Tempus Edax Rerum

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(Dated: February 16, 2013)

A non-unitary quantum theory describing the evolution of quantum state tensors is presented. Einstein's equations and the fine structure constant are derived. The problem of precession in classical mechanics gives an example.

Quantum mechanical state vectors evolve in time according to the Schrödinger equation. Here we propose a non-unitary process by which quantum state tensors evolve in time. For clarity in this article, the canonical theory of vector states $|\psi\rangle$ is called chronos and the theory of tensor states $|\psi\rangle\,\hat{\pi}$ is called chiros. By combining these ideas we will show something that is beautiful about Nature.

To test any theory two measurements must be made. Call these measurements A and B corresponding to events a and b. The boundary condition set by A will be used to predict the state at b. To make this prediction the observer applies physical theory to trace a trajectory from A to the future event b. Before the observer can verify the theory, sufficient time must pass that the future event occurs. Once this happens a retarded signal from b reaches the observer in the present and a second measurement B becomes possible.

From the present the observer traces a path into the future. Once that future becomes part of the observer's past, a signal reaches the observer in the present and the theory can be tested. A three-fold process.

$$Present \rightarrow Future \rightarrow Past \rightarrow Present \tag{1}$$

If the observer's proper time is t_0 we may begin to quantify the process with a Gel'fand triple $\{\aleph, \mathcal{H}, \Omega\}$ wherein each object holds a Minkowski picture S.

$$\begin{aligned} Past &\propto [t_{min}, t_0) \\ Present &\propto [t_0] \\ Future &\propto (t_0, t_{max}] \end{aligned} \tag{2}$$

$$\begin{aligned} \aleph &= \{x^\mu_- \in S \,|\, t_{min} \leq t < t_0\} \\ \mathcal{H} &= \{x^\mu \in S \,|\, t = t_0\} \\ \Omega &= \{x^\mu_+ \in S \,|\, t_0 < t \leq t_{max}\} \end{aligned} \tag{3}$$

The past and future light cones define the spaces $\aleph$ and Ω and the hypersurface of the present is a 3D delta function $\delta(t - t_0)$ in a 12D bulk. The present is defined according to the observer so it is an axiom of this interpretation that the observer is isomorphic to the delta function. With foresight, we point out that the Dirac delta does not have the properties which will be required of the observer function. We will require that this function returns an undefined value where the argument is null. More on this below.

Unification of the theories requires that quantum mechanics in $\mathcal{H}$ be connected with smooth relativistic dynamics in $\aleph$ and Ω. To this end, define a tensor evolution operator $\hat{M}^3$ that is non-unitary and complimentary to the (vector) unitary evolution operator $\hat{U}$.

$$\text{Chronos} \Rightarrow \quad \begin{aligned} \hat{U} \;&:\; \mathcal{H} \rightarrow \mathcal{H} \\ \hat{U} \;&:= \partial_x \end{aligned} \tag{4}$$

$$\text{Chiros} \Rightarrow \quad \begin{aligned} \hat{M}^3 \;&:\; \mathcal{H} \rightarrow \Omega \rightarrow \aleph \rightarrow \mathcal{H} \\ \hat{M}^3 \;&:= i\pi\varphi\,\partial^3_t \end{aligned} \tag{5}$$

The unfamiliar number φ appearing in equation (5) is the inverse golden mean.

$$\varphi^{-1} = \frac{1+\sqrt{5}}{2} \tag{6}$$

With sufficient conditions on the observer function, it may be possible to motivate state normalization mathematically. If the observer function maintains the values in the range of the Dirac delta, 0 and ∞ (which are both invariant under multiplication by a constant), then non-unitary factors of π and φ associated with $\hat{M}^3$ may be absorbed into the observer at the steps between measurements in Ω and $\aleph$. This process may be interpreted as an effective unitarity preserving boundary condition in $\mathcal{H}$.

A quantum mechanical particle in an infinite square well of length L is represented by a well-known state vector. A particle confined to a temporal square well of duration D should be represented by a similar vector. The state vector of a particle confined in space and time follows from the example of the 2D box.

$$|\psi; x, t\rangle = \psi\left(\frac{n\pi x}{L}, \frac{m\pi t}{D}\right) \tag{7}$$

The values L and D should not affect the theory so let us fix the golden ratio $D = 2\varphi L$ in the spirit of $C = 2\pi R$. Thus we define one quantum of spacetime. Setting

$D = \varphi$ [1] and using the identity $\Phi = \varphi^{-1}$ we simplify the state vector.

$$|\psi\rangle = \psi\,(2n\pi x, \Phi m\pi t) \tag{8}$$

From this function it is possible to derive the fine structure constant and Einstein's equations.

Assume an evolution operator that is the sum of a vector part and a tensor part so that $\hat{\Upsilon} \equiv \hat{U} + \hat{M}^3$. We ignore the difficulties associated with adding a vector to a tensor and for now it will suffice to say that $\hat{\Upsilon}$ is a strange mathematical object. The operator ∂ is a unit vector and $\hat{M}^3$ takes on unitary property in chronos. Using the convention to denote tensor states $|\psi\rangle\,\hat{\pi}$, we outline a new quantum theory.

$$\hat{\Upsilon}\,|\psi\rangle = \partial_x\,|\psi\rangle + \partial_t^3\,|\psi\rangle \tag{9}$$

$$\hat{\Upsilon}\,|\psi\rangle\,\hat{\pi} = \partial_x\,|\psi\rangle\,\hat{\pi} + (i\pi\varphi)\partial_t^3\,|\psi\rangle\,\hat{\pi} \tag{10}$$

$$\langle\psi|\hat{\Upsilon}|\psi\rangle = \langle\psi|\hat{U}|\psi\rangle + \langle\psi|\hat{M}^3|\psi\rangle \tag{11}$$

$$\langle\psi|\hat{M}^3|\psi\rangle := \int \psi^*(x^\mu)\,\delta(x^0)\,\psi(x^\mu)\,dx^\mu \tag{12}$$

Methods for computing $\langle\psi|\hat{U}|\psi\rangle$ are well established. The spatial part x^i of equation (12) can be integrated directly but the temporal part $x^0 = t$ contains new complexity. The observer is fixed in the present (at the origin) with the inclusion of $\delta(t)$ and since this function returns an undefined value at $t = 0$ it is impossible to integrate directly from early times to late times. To use an integrand of the form $f(t)\delta(t)$ we must employ the method from complex analysis $f(t)\delta(t) \mapsto g(r,\theta)$. The integral over all times will trace a path through $\aleph$, $\mathcal{H}$ and Ω.

$$\begin{aligned}\int_{-\infty}^{\infty} f(t)\delta(t) = \int_0^\infty g(r,0)\,dr\; + \\ + \int_0^{\frac{1}{\alpha}} g(\infty,\theta)\,d\theta\; + \int_{-\infty}^{0} g(r,\alpha^{-1})\,dr\end{aligned} \tag{13}$$

The choice of α is not arbitrary but stems from the fact that it is the first eigenvalue of the operator $\hat{\Upsilon}$ in chronos.

$$\begin{aligned}\hat{\Upsilon}|\psi\rangle &= \partial_x|\psi\rangle + \partial_t^3|\psi\rangle \\ \Upsilon_{nm} &= 2n\pi + (\Phi m\pi)^3 \\ \Upsilon_{11} &= 137.6 \approx \alpha^{-1}\end{aligned} \tag{14}$$

The small deviation in the predicted value and the currently accepted value of the fine structure constant can be attributed to many causes. Ralston has notably treated this subject in [2].

The inner product $\langle\psi|\psi\rangle$ takes place in the complex plane so the rotation in equation (13) must be through an unidentified hyper-complex plane. For this reason we replace the canonical rotation through π radians with a new path through α^{-1} hyper-radians. In doing so we create a new geometry in which the π-based geometry is embedded. Let this structure be represented by a non-unitary set of basis vectors in $\mathbb{C}^3$ which will identify Dirac vectors with the state spaces $\{\aleph, \mathcal{H}, \Omega\}$.

$$|\hat{i}| = i \qquad |\hat{\pi}| = \pi \qquad |\hat{\varphi}| = \varphi \tag{15}$$

$$\begin{aligned}|\psi\rangle\hat{i} &= \psi(x^\mu_-) \\ |\psi\rangle\hat{\pi} &= \psi(x^\mu) \\ |\psi\rangle\hat{\varphi} &= \psi(x^\mu_+)\end{aligned} \tag{16}$$

The vector $\hat{\pi}$ is associated with the domain of chronos: $\mathcal{H}$. To explore chiros let us suppress one power of π so that $\hat{M}|\psi\rangle = \Phi m|\psi\rangle$. Setting $m = 1$ we develop the tensor character of $\hat{M}^3$.

$$\begin{aligned}\hat{M}^1|\psi\rangle\hat{\pi} &= \Phi|\psi\rangle\,\pi\,\hat{\varphi} \\ \hat{M}^2|\psi\rangle\hat{\pi} &= \Phi^2|\psi\rangle\,\pi\varphi\,\hat{i} \\ \hat{M}^3|\psi\rangle\hat{\pi} &= \Phi^3|\psi\rangle\,\pi\varphi i\,\hat{\pi}\end{aligned} \tag{17}$$

Chiros brings a fractal structure to the algebra as discussed in [1]. The identities $\hat{\pi} = \pi\Phi\hat{\varphi}$, $\hat{\pi} = -i\pi\hat{i}$ and $\Phi^2 = \Phi + 1$ are demonstrative.

$$\begin{aligned}\hat{M}^3|\psi\rangle\hat{\pi} &= i\pi\Phi^2\,|\psi\rangle\hat{\pi} \\ &= i\pi\Phi\,|\psi\rangle\hat{\pi} + i\pi\,|\psi\rangle\hat{\pi} \\ &= i\pi^2\Phi^2\,|\psi\rangle\hat{\varphi} + \pi^2\,|\psi\rangle\hat{i}\end{aligned} \tag{18}$$

Laithwaite's fantastic work *The Multiplication of Umbrellas by Bananas* [3] examines the problem of precession in classical mechanics. He asks if the rate of change of the acceleration might be responsible for the anomalous motion. For the case of a spinning wheel, Laithwaite gives the following simple relationships for the velocity and centripetal force on a spinning element.

$$\frac{dv}{dt} = v\frac{d\theta}{dt} = v\omega = r\omega^2 \tag{19}$$

$$\frac{dF}{dt} = F\frac{d\theta}{dt} = F\omega = mr\omega^3 \tag{20}$$

If the state of a spinning element is $|r,\theta\rangle$ we arrive at a representation $\hat{M}^3=\omega^3$. Using $\omega=2\pi f$ and equation (18) we recover Einstein's equations.

$$\begin{aligned} 8\pi^3 f^3|\psi\rangle\hat{\pi} &= i\pi^2\Phi^2\,|\psi\rangle\hat{\varphi}+\pi^2\,|\psi\rangle\hat{\imath} \\ 8\pi f^3|\psi\rangle\hat{\pi} &= i\Phi^2\,|\psi\rangle\hat{\varphi}+|\psi\rangle\hat{\imath} \\ 8\pi f^3\,\psi(x^\mu) &= i\Phi^2\,\psi(x^\mu_+)+\psi(x^\mu_-) \end{aligned} \tag{21}$$

$$\begin{aligned} f^3\,\psi(x^\mu) &\mapsto T_{\mu\nu} \\ i\Phi^2\,\psi(x^\mu_+) &\mapsto G_{\mu\nu} \\ \psi(x^\mu_-) &\mapsto g_{\mu\nu}\Lambda \end{aligned} \tag{22}$$

$$8\pi T_{\mu\nu}=G_{\mu\nu}+g_{\mu\nu}\Lambda \tag{23}$$

In other work we show that the metric in the past is different than the metric in the future [1]. This indicates that the size of the wheel changes as chiros flows. While this idea is foreign to the realm of everyday physics, the discovery of time reversal symmetry violation by the BaBar collaboration shows that this is possible [4]. The apparent anti-gravity effects witnessed in Laithwaite's gyro demonstration at the Royal Society can be explained if there is a net force on $\mathcal{H}_i$ due contributions from the past and future. Using equation (20) we may write the following.

$$\begin{aligned} F_{net}\hat{\pi}_i &:= \sum_{n=1}^{\infty}\alpha^n\left(\dot{F}\,\hat{\pi}_{i+n}-\dot{F}\,\hat{\pi}_{i-n}\right) \\ &:= m\omega^3\sum_{n=1}^{\infty}\alpha^n\Delta r_n \end{aligned} \tag{24}$$

If this sum is taken to the continuum limit as an integral over time, the inclusion of the differential element dt will give the correct units.

A 20 kilogram wheel was spun at 2500 revolutions per minute. Precession lifted the wheel 1.5 meters in 3 seconds. This created a constant linear $\hat{z}$-momentum. Dividing the impulse by the time we see the force of precession was about 3 newtons stronger than the gravitational force. Keeping terms to first order in α we derive a characteristic length scale for chiros.

$$\begin{aligned} \vec{F}_p &= m\omega^3\alpha\,\Delta r\hat{z} \\ 200 &= (20)(1.8\times10^7)\,\alpha\,\Delta r \\ \Delta r &\approx 10^{-4}\,\text{meters} \end{aligned} \tag{25}$$

And that looks about right! Far from the nano-scale of quantum mechanics and far from the macro-scale of ordinary perception. We find an intermediate regime near the scale of the thought-provoking Casimir effect.

Beyond this example from classical mechanics, many modern results support the ideas presented here. The physics of cellular spacetimes have been developed extensively by 't Hooft [5]. We show an isomorphism to string theory noting that our cosmic structure $\{\aleph,\mathcal{H},\Omega\}$ contains a 9+1D subspace $\{x^i,x^i_\pm,t\}$. Rubino et al. have discovered a third mode in quantum optical experiments which is consistent with our three-fold interpretation of time [6]. Palev and Van der Jeugt have developed quantum statistics associated with a three mode quantum structure and they present a resolution to the mystery of quark color confinement [7].

To illustrate the method we employ the Riemann sphere. Such a sphere is formed from $\mathcal{H}$ by mapping infinity to a single null point. In this way the domain of canonical quantum mechanics is mapped to a sphere missing one pole. The null point defines a dual point: the origin, where we have placed the observer with $\delta(t)$. The position of the origin and the null point may be permuted without affecting physics on the sphere.

To clarify our use of Gel'fand's formalism consider the following three objects. A sphere Ω, the Riemann sphere $\mathcal{H}$ and a sphere $\aleph$ with null points at two opposite poles. In this way it is clear that $\aleph$ is a subspace of $\mathcal{H}$ and Ω is a type of dual space to $\aleph$ which contains $\mathcal{H}$ as a subspace.

Map the Riemann sphere to a plane where the null point is at the origin. This can be thought of as turning $\mathcal{H}$ inside out. Arrange the objects $\{\aleph,\mathcal{H},\Omega\}$ so that a point in Ω fills the null point at the center of $\mathcal{H}$ and then position $\aleph$ symmetrically to Ω around $\mathcal{H}$ so that two null points and a point in Ω all lie at the origin.

$\aleph$ has two null points so while one null point is collocated with the present and the future at the origin, $\aleph_i$'s other null point is collocated with infinity at the far pole of the previous space Ω_{i-1}. This defines a periodic lattice: a plane representing the present $\mathcal{H}_i$, a sphere representing the future Ω_i, a sphere representing the past $\aleph_{i+1}$ and then another plane representing the present at a later time $\mathcal{H}_{i+1}$. This is the topology of equation (5). The three spaces are tangent but do not intersect; only the observer connects them.

At first the observer connects $\mathcal{H}_i$ and Ω_i. We use the properties of the Dirac delta to illustrate the method but these properties need to be refined for global consistency. The observer is a delta with two values in its range: 0 and ∞. Per (3), the value $t=0$ lies in $\mathcal{H}$ when we set $t_0=0$. Likewise, the value $t=\infty$ lies in Ω. This is the mechanism by which the observer joins these otherwise disconnected spaces.

The flow of time proceeds as a quantum clockwork. With the application of the evolution operator $\hat{M}$, the observer's connection to $\mathcal{H}_i$ is released and reconnected to $\aleph_{i+1}$. $\hat{M}$ is applied again breaking the connection to Ω_i. That end of the observer function is reconnected to $\mathcal{H}_{i+1}$ then a third application of $\hat{M}$ restores the original arrangement with a connection between $\mathcal{H}_{i+1}$ and Ω_{i+1}.

So time flows.

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