CONSEQUENCES OF A QUANTIZED SPACETIME MODEL∗

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Abstract
A recent extended particle model is discussed, which lead to some interesting consequences in cosmology, neutrino astrophysics and low dimensional and low temperature statistics, some of which have since been verified.

1 The Model
Recent studies go beyond the spacetime points and point particle description of usual Quantum Mechanics and Quantum Field Theory. These include String Theory[1, 2, 3], El Naschie’s theory of Cantorian spacetime and transfinite heterotic String Theory [4, 5] and the author’s theory of stochastic quantized spacetime [6, 7].
The starting point of this model was the fact that the purely classical Kerr-Newman Black Hole describes the electron’s field including the purely Quantum Mechanical $g = 2$ factor. However there are two inexplicable features. The first is the naked singularity of the Kerr-Newman Black Hole, if it is to represent an electron. The second is the complex coordinate shift used by Newman in deducing the Kerr-Newman metric, which Newman himself

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could not explain. It was pointed out [3, 4, 5] that there is a spacetime cut off, at the Compton scale \((l, \tau)\) exactly as in the case of Dirac’s non Hermitian position operator for the electron. From the Uncertainty Principle itself it follows that spacetime points are meaningless as they imply infinite momenta and energy. Rather spacetime intervals are meaningful. In fact the zitterbewegung is symptomatic of the breakdown of physics within this scale. It is this spacetime cut off that fudges the naked singularity and in fact averts what Wheeler has described as the greatest crisis of physics.

Indeed Newman’s complex coordinate shift can be seen to represent the spacetime cut off: For if

\[ x \rightarrow x + il \]

then the plane wave goes over to

\[ e^{i\frac{px}{\hbar}} \rightarrow e^{i\frac{h}{\hbar}p_x} \cdot e^{- \frac{il}{\hbar}} \]  

We can see from (1) that as a result of the complex shift the plane wave is truncated, by the constraint

\[ pl \sim \hbar \]  

the relation (2) can be seen to be the momentum distance Uncertainty relation, as noted above.

We will now review some of the consequences of this formulation, and point out that many of these have since been experimentally or observationally confirmed.

2 Consequences

1. Cosmological Considerations

If we use the fact that there would be a fluctuational creation of \(\sqrt{N}\) particles within the minimum Compton cut off time \(\tau\), where \(N\) is the total number of particles, typically pions, in the universe at a given epoch, we deduce the following relations [11, 12, 13]

\[ m = \left( \frac{h^2 H G c}{3} \right)^{\frac{3}{2}} \]  

\[ \frac{dR}{dt} = HR \]
where $H$ is the Hubble constant,

$$\Lambda \leq 0(H^2) \quad (5)$$

$\Lambda$ being the cosmological constant,

$$G \propto \frac{1}{T} \quad (6)$$

where $T$ is the age of the universe. Equation (3) is known empirically, and has been described by Weinberg to be mysterious. Here it follows as a consequence. Equations (4) and (5) show that the universe would continue to expand for ever (in fact in this case, with decreasing density) and possibly also accelerate. This was subsequently confirmed by the observations of distant supernova [14].

It must be mentioned that till these recent observations were made, it was believed that the expansion of the universe would be subsequently reversed. It may also be mentioned that the above model does not need to invoke dark matter which in any case has not been detected. The relation (3) shows that the universal constant of gravitation varies with time, as in a few other cosmological models. This is as yet an undecided matter.

2. Anomalous Statistics

Following these arguments it was shown that the divide between Fermi-Dirac statistics and Bose-Einstein statistics is not so water tight [15, 16, 17, 18, 19, 20, 21].

This fact has lead to some interesting results. One was that the Neutrino would have a mass given by [22, 23].

$$m_\nu \sim 10^{-8}m_e \quad (7)$$

and in fact there would be a "weak" electric charge given by

$$g_\nu^2/e^2 \sim 10^{-13} \quad (8)$$

Subsequently the superkamiokande experiments showed exactly such a neutrino mass as given in (7) [24].

Yet another interesting result was the super conductivity type of behaviour of electrons in low dimensions, in particular one and two dimensions. These would be idealizations of thin wires and thin films. It was shown [15] that
in a thin wire which can be approximated as a one dimensional object, the electrons would behave as if they were below the Fermi temperature, whatever be the temperature. It is interesting that recent observations with nano tubes do indeed confirm such features\cite{23, 26, 27}.

Further it was shown that\cite{17, 20, 21}, an approximately mono energetic collection of Fermions would show bosonization effects and vice versa, including a Bose-Einstein type of condensation a little above absolute zero. These need to be examined experimentally.

3. Quarks and Monopoles

It was shown that electromagnetism was the result of the double connectivity of the spin half electron, brought out by the fact that well outside the Compton wavelength it is the positive energy solutions which are invariant under reflection that predominate \cite{8, 9}. From these considerations it was possible to deduce the well known gravitational force - electromagnetism ratio

\[
Gm^2/e^2 \sim 10^{-40}
\]  

(9)

However, it was argued that as we approach the Compton wavelength the double connectivity or three dimensionality of space breaks down as we begin to encounter predominantly the negative energy components of the Dirac bi-spinor (with opposite parity), and this was shown to explain the fractional charges of the quarks, and also provide an order of magnitude estimate for their masses as also their handedness\cite{28, 29}. This would also explain why free quarks are never seen in nature. A similar explanation holds for monopoles \cite{30, 31} (Cf. Appendix).

It is interesting that from the above considerations, using relations like (8) and (9), we get the well known ratio of all interactions\cite{32}

\[
g_{\text{strong}}^2 : g_{\text{em}}^2 : g_{\text{wk}}^2 : g_{\text{grav}}^2 \sim 1 : 10^{-3} : 10^{-15} : 10^{-40}
\]

APPENDIX

In \cite{8, 9} it was argued that one could get a reconciliation between Quantum Mechanics, Electromagnetism and Gravitation, from the following consideration:

We use the well known fact that the Dirac four spinor which describes the electron has the negative energy spinors $\chi$ and the positive energy spinors $\theta$ and that as we approach the Compton wavelength, it is the negative energy
spinors which dominate, and further under reflections, $\chi$ behaves like the pseudo spinor,

$$\chi \rightarrow -\chi$$  \hspace{1cm} (10)

It was pointed out that this leads to a covariant derivative,

$$\frac{\partial \chi}{\partial x^\mu} \rightarrow \frac{i}{\hbar} \left[ \frac{\hbar}{i} \frac{\partial}{\partial x^\mu} + iN A^\mu \right] \chi$$  \hspace{1cm} (11)

where

$$A^\mu = \hbar \Gamma^\mu_\sigma = \hbar \frac{\partial}{\partial x^\mu} \log(\sqrt{|g|})$$

(and $N = 1$ is the weight of $\chi$ which shows up as a density).

We would like to point out that this is exactly the circumstance for the Dirac monopole.

What this means is that it is the region at or within the Compton wavelength where the negative energy spinors predominate that shows up as a monopole.

We can verify the above conclusion from a slightly different point of view. Using the fact that as pointed out by Dirac the Compton wavelength above is a region that is minimal in the sense that within it we have the unphysical Zitterbewegung effects which have to be averaged out, we are lead to a non commutative geometry\[7\]

$$[x, y] \approx 0(l^2)$$  \hspace{1cm} (12)

and similar relations. For a non commutative structure we have a strong magnetic field $B$, which in case of (12) is given by

$$\mu = B l^2 \approx \frac{\hbar c}{e}$$  \hspace{1cm} (13)

It will be immediately observed that (13) defines the Dirac monopole. Interestingly the monopole given by (13) gives an explanation for the discreteness of the charge, as is well known which conclusion also follows from the fact that in equation (11) above the weight $N = 1$.

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