

# COMMENTS ON THE PAPER "ON THE UNIFICATION OF THE FUNDAMENTAL FORCES..."

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## Abstract

In this brief paper we justify observations made in El Naschie's paper "On the Unification of the Fundamental Forces...", on the Planck scale, fractal space time and the unification of interactions, from different standpoints.

In a recent paper El Naschie[1] has emphasized the intimate connection between the Planck length, the Compton wavelength and a unification of the fundamental interactions within the framework of complex time and a fractal Cantorian space. We will now make some observations which justify the contentions made in the above paper, from different standpoints.

1. Complex Time: It has been pointed out[2, 3, 4] that Fermions can be thought of as Kerr-Newman Black Holes, in the context of quantized space time: There are minimum space time intervals, and when we average over these, Physics arises. Within the minimum intervals, we encounter unphysical Zitterbewegung effects, which also show up as a complexification of coordinates[5] - indeed they are the double Wiener process discussed by Abbott and Wise, Nottale and others. It may be mentioned that the transition from the Kerr metric in General Relativity to the Kerr-Newman metric is obtained by precisely such a complex shift of coordinates, a circumstance which has no clear meaning in Classical Physics[6]. On the other hand it is this "Classical" Kerr-Newman metric which describes the field of an electron

including the Quantum Mechanical anomalous gyro magnetic ratio,  $g = 2$ . This has been discussed in detail in references[2, 3].

2. The Unification of Electromagnetism and Gravitation and the Planck Scale: It is in the context of point 1 that we arrive at a unified picture of electromagnetism and gravitation (Cf.ref.[4]). The point is that at the Compton wavelength scale we have purely Quantum Mechanical effects like Zitterbewegung, spin half and electromagnetism, while at the Planck scale, we have a purely classical Schwarzschild Black Hole. However the Planck scale is the extreme limit of the Compton scale, where electromagnetism and gravitation meet (Cf.ref.[4], and [7]). This is because for a Planck mass  $m_P \sim 10^{-5}gms$  we have

$$\frac{Gm_P^2}{e^2} \sim 1 \quad (1)$$

whereas for an elementary particle like an electron we have the well known equation

$$\frac{Gm^2}{e^2} \sim \frac{1}{\sqrt{N}} \equiv 10^{-40} \quad (2)$$

where  $N \sim 10^{80}$  is the number of elementary particles in the universe.

Another way of expressing this result is that the Schwarzschild radius for the Planck mass equals its Compton wavelength. This is where Quantum Mechanics and Classical Physics meet.

This point can be analysed further[7]. From equations (1) and (2) it can be seen that we obtain the Planck mass, when the number of particles in the universe is 1. Indeed as has been pointed out by Rosen[8], the Planck mass can be considered to be a mini universe, in the context of the Schrodinger equation with the gravitational interaction.

3. The above brings us to another interesting aspect discussed by El Naschie in[1]. This is the fact that the Planck mass is intimately related to the Hawking radiation, and infact from the latter consideration we can deduce that a Planck mass "evaporates" within about  $10^{-42}secs$ , which also happens to be its Compton time!

On the other hand, as pointed out in[5, 7], an elementary particle like the pion is intimately related to Hagedorn radiation which leads to a life time of the order of the age of the universe.

The above two conclusions have been obtained on the basis of a background Zero Point Field, the Langevin equation and space time cut offs leading to a

fluctuational creation of particles at the Planck scale and the Compton scale respectively.

4. Resolution and the Unification of Interactions: El Naschie[1] has referred to the fact that there is no apriori fixed length scale (the Biedenharn conjecture). Indeed it has been argued by the author in the above context[9, 10] that depending on our scale of resolution, we encounter electromagnetism well outside the Compton wavelength, strong interactions at the Compton wavelength or slightly below it and only gravitation at the Planck scale. The differences between the various interactions are a manifestation of the resolution.

4. The Universe as a Black Hole: As pointed out in[1] by El Naschie and the author[11, 12], the universe can indeed be considered to be a black hole. Prima Facie this is clear from the fact that the radius of the universe is of the order of the Schwarzschild radius of a black hole with the same mass as the universe. Also as pointed out in[11]) the age of the universe coincides with the time taken by a ray of light to travel from the horizon of a black hole to its centre or vice versa.

5. The "Core" of the Electron: El Naschie refers to the core of the electron  $\sim 10^{-20}cms$ , as indeed has been experimentally noticed by Dehmelt and Co-workers[13]. It is interesting that this can be deduced in the context of the electron as a Quantum Mechanical Kerr-Newman Black Hole.

It was shown that[2] for distances of the order of the Compton wavelength the potential is given in its QCD form

$$V \approx -\frac{\beta M}{r} + 8\beta M\left(\frac{Mc^2}{\hbar}\right)^2.r \quad (3)$$

For small values of  $r$  the potential (3) can be written as

$$V \approx \frac{A}{r}e^{-\mu^2 r^2}, \quad \mu = \frac{Mc^2}{\hbar} \quad (4)$$

It follows from (4) that

$$r \sim \frac{1}{\mu} \sim 10^{-21}cm. \quad (5)$$

Curiously enough in (4),  $r$  appears as a time, which is to be expected because at the horizon of a black hole  $r$  and  $t$  interchange roles.

One could reach the same conclusion, as given in equation (5) from a different

angle. In the Schrodinger equation which is used in QCD, with the potential given by (3), one could verify that the wave function is of the type  $f(r).e^{-\frac{\mu r}{2}}$ , where the same  $\mu$  appears in (4). Thus, once again one has a wave packet which is negligible outside the distance given by (5).

It may be noted that Brodsky and Drell[14] had suggested from a very different viewpoint viz., the anomalous magnetic moment of the electron, that its size would be limited by  $10^{-20}cm$ . The result (5) was experimentally confirmed by Dehmelt and co-workers [13].

Finally, it may be remarked that it is the fractal double Weiner process referred to earlier that leads from the real space coordinate,  $x$  say, to the complex coordinate  $x + \imath ct$  (Cf.ref.[5]), which is the space and time divide: As pointed out by Hawking[15] and others, an imaginary time would lead to a "static" Euclidean four geometry, rather than the Minkowski world, a concept that has been criticised by Prigogine[16]. It is in the above fractal formulation (Cf.ref.[5]), on the contrary, that we see the emergence of the space and time divide, that is, time itself.

Thus in conclusion, it may be said that the recognition of a fractal quantized underpinning of space time ties together several apparently disparate facts.

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