The Fifth Force

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Abstract

Starting from dark energy considerations, we touch upon the Kerr-Newman formulation, and this leads us to the hypothetical fifth force for which hopeful confirmation is coming in.

1 Introduction

For decades people have been thinking that there were only four fundamental forces in nature, but from over
20 years ago the author had been working with the idea there could be a possible fifth short range force too. The author had published this in [1, 2] and also presented it in invited talks in Europe (for example in University of Udine) and USA (Vanderbilt University). He was motivated by the concept an all-pervading zero point energy, which was later christened “Dark Energy” and its presence confirmed by Adam Reiss, Saul Permutter [3] and others through observation of Type 1 supernovae. Many prominent scientists noted this fact of Dark Energy. In the words of Tony Leggett “It is of course clear that your equation predicts an exponential (inflation-type) expansion of the current universe, hence acceleration. And it
would have been nice if the Nobel committee had men-
tioned this · · ·

Now with theoretical and practical work, it seems that
nature also has a hitherto unknown new and a fifth force.
The first hint that there could be a new strong short
range force came in the author’s formulation of charged
elementary particles as Quantum Mechanical Kerr New-
man black holes in the late 1990s [2]. Off and on there
were unsubstantiated claims of the detection of such a
force, for example from FermiLab. Already from around
2016, a Hungarian team [4] had claimed the discovery
of a new force. This was whetted by the University of
California, Irvine. But most physicists remain skeptical
about this. On the other hand, very recently this has been observed by a multi national team at the LHC b collider in Geneva [5]. They were observing the decay of the beauty quark. This vindicates the work of the author, who, for many years has been publishing work on the subject.

2 Theoretical justification for the existence of a fifth force

1. The Kerr Newmann Quantum Mechanical Black Hole

We consider distances of the order of the Compton wavelength. At this level Quantum Mechanical phe-
nomena like zitterbewegung, [6] negative energy solutions and luminal velocities come in to play. Taking a route through relativistic vortices, monopoles and classical considerations, we will be lead to the model of leptons and quarks as what may be called “Quantum Mechanical Kerr-Newman Black Holes” (QMKNBH), wherein features of Quantum Mechanics and General Relativity are inextricably inter-woven. In natural units the Kerr Neumann metric is given by (cf. ref. [7]).

\[
\begin{align*}
    ds^2 &= -\frac{\Delta}{\rho^2}[dt - a\sin^2 \theta d\phi]^2 \\
          &+ \frac{\sin^2 \theta}{\rho^2}[(r^2 + a^2)d\phi - adt]^2
\end{align*}
\]
\[ + \frac{\rho^2}{\Delta} dr^2 + \rho^2 d\theta^2, \quad (1) \]

where, \( a \) is the Compton wavelength and,

\[ \Delta = r^2 - 2mr + a^2 + m^2 + e^2, \quad \rho^2 \equiv r^2 + a^2 \cos^2 \theta \]

At \( r = a \) and \( \theta = \pi/2 \), \( \Delta = 2a^2 \) as both \( e \) and \( m \ll a \), and \( \rho^2 = a^2 \).

It can be seen from equation (1) that in addition to the usual long-range force, there are other forces of the order of atleast \( 1/r^3 \). These are shorter and stronger as \( r \) becomes small.

2. **Short-lived vector Bosons**

It is well known that the Dirac equation [8, 9] is

\[ (\gamma^\mu p_\mu - m)\psi = 0 \quad (2) \]
Here $\gamma^\mu$ are $4 \times 4$ matrices obeying the Clifford algebra and $\psi$ is a 4 component wave function (spinor).

$\psi$ can be written as,

$$
\psi = \begin{pmatrix}
\phi \\
\chi
\end{pmatrix}
$$

(3)

where $\phi$ and $\chi$ are 2-component spinors, $\phi$ being the “large” or positive energy component of $\psi$ and $\chi$ is the “small” or negative energy component which is such that

$$
\chi \sim \left(\frac{v}{c}\right)^2 \phi
$$

(4)

It is also known that this picture gets reversed at high energies where $v \to c$ (Cf.refs.[8, 9]).
We observe that (2) can be written as: [10, 11]

\[ i\hbar (\partial \phi / \partial t) = c\tau \cdot (p - e/cA)\chi + (mc^2 + e\phi)\phi, \]

\[ i\hbar (\partial \chi / \partial t) = c\tau \cdot (p - e/cA)\phi + (-mc^2 + e\phi)\chi. \] (5)

We can see from (5) that (in the absence of electromagnetic subsection),

\[ t \rightarrow -t, \quad \phi \rightarrow -\chi \] (6)

Let us now consider intervals near the Compton scale, where as we know \( v \rightarrow c, \) and \( \chi \) no longer is the “small” component.

At the Compton scale we have the phenomenon of Zitterbewegung or rapid unphysical oscillation. It has been pointed out that in this case, [1] that time
can be modelled by a double Weiner process and can
be described as follows

\[ \frac{d_+}{dt} x(t) = b_+ , \frac{d_-}{dt} x(t) = b_- \] (7)

where for simplicity we consider in the one dimen-
sional case. This equation (7) expresses the fact that
the right derivative with respect to time is not nec-
essarily equal to the left derivative. It is well known
that (7) leads to the Fokker Planck equations [12, 13]

\[ \frac{\partial \rho}{\partial t} + \text{div}(\rho b_+) = V \Delta \rho, \]

\[ \frac{\partial \rho}{\partial t} + \text{div}(\rho b_-) = -U \Delta \rho \] (8)

defining

\[ V = \frac{b_+ + b_-}{2} ; U = \frac{b_+ - b_-}{2} \] (9)
We get on addition and subtraction of the equations in (8) the equations

\[ \frac{\partial \rho}{\partial t} + \text{div}(\rho V) = 0 \quad (10) \]

\[ U = \nu \nabla \ln \rho \quad (11) \]

It must be mentioned that \( V \) and \( U \) are the statistical averages of the respective velocities and their differences. We can then introduce the definitions

\[ V = 2\nu \nabla S \quad (12) \]

\[ V - iU = -2\nu \nabla (\ln \psi) \quad (13) \]

We refer the reader to Smolin [14] for further details.

We now observe that the complex velocity in (13) can be described in terms of a positive or uni directional
time $t$ only, but with a complex coordinate

$$x \rightarrow x + ix'$$  \hspace{1cm} (14)

To see this let us rewrite (9) as

$$\frac{dX_r}{dt} = V, \hspace{0.5cm} \frac{dX_i}{dt} = U,$$  \hspace{1cm} (15)

where we have introduced a complex coordinate $X$ with real and imaginary parts $X_r$ and $X_i$, while at the same time using derivatives with respect to time as in conventional theory.

From (9) and (15) it follows that

$$W = \frac{d}{dt}(X_r - ix_i)$$  \hspace{1cm} (16)

This shows that we can use derivatives with respect to the usual time derivative with the complex space
coordinates (14) (Cf.ref.[15]).

Generalizing (14), to three dimensions, we end up with not three but four dimensions,

\[(1, \nu) \rightarrow (I, \tau),\]

where \(I\) is the unit \(2 \times 2\) matrix and \(\tau\)s are the Pauli matrices. We get the special relativistic Lorentz invariant metric at the same time.

That is,

\[x + \nu y \rightarrow Ix_1 + \nu x_2 + jx_3 + kx_4, \quad (17)\]

where \((\nu, j, k)\) momentarily represent the Pauli ma-
trices; and, further,

$$x_1^2 + x_2^2 + x_3^2 - x_4^2$$  \hspace{1cm} (18)

is invariant, thus establishing a one to one correspondence between (17) and Minkowski 4 vectors as shown by (18).

In this description we would have from (17), returning to the usual notation,

$$[x^i \tau^i, x^j \tau^j] \propto \epsilon_{ijk} \tau^k \neq 0 \hspace{1cm} (19)$$

(No summation over \(i\) or \(j\)) Alternatively, absorbing the \(x^i\) and \(\tau^i\) into each other, (19) can be written as

$$[x^i, x^j] = \beta \epsilon_{ijk} \tau^k \hspace{1cm} (20)$$

Equation (19) and (20) show that the coordinates no
longer follow a commutative geometry. It is quite remarkable that the noncommutative geometry (19) has been studied by the author in some detail (Cf.[12]), though from the point of view of Snyder’s minimum fundamental length, which he introduced to overcome divergence difficulties in Quantum Field Theory. Indeed we are essentially in the same situation, because for our positive energy description of the universe, there is the minimum Compton wavelength cut off for a meaningful description as is well known [16, 17, 18]. Following Feshbach and Villars (loc.cit) we consider (3) to describe a particle anti-particle pair.
Proceeding further we could invoke the $SU(2)$ and consider the gauge transformation [19]

$$\psi(x) \rightarrow exp\left[\frac{1}{2}ig\tau \cdot \omega(x)\right]\psi(x).$$

(21)

This is known to lead to a gauge covariant derivative

$$D_\lambda \equiv \partial_\lambda - \frac{1}{2}ig\tau \cdot \bar{W}_\lambda,$$

(22)

We are thus led to vector Bosons $\bar{W}_\lambda$ and an interaction like the weak interaction, described by

$$\bar{W}_\lambda \rightarrow \bar{W}_\lambda + \partial_\lambda \omega - g\omega A \bar{W}_\lambda.$$  

(23)

However, we are this time dealing, not with iso spin, but between positive and negative energy states as in (5) that is particles and antiparticles. Also we must bear in mind that this new non-electroweak force be-
tween particles and anti particles would be short lived as we are at the Compton scale \[20\].

These considerations are also valid for the Klein-Gordon equation because of the two component formulation developed by Feshbach and Villars [10, 11]. There too, we get equations like (5) except that \(\phi\) and \(\chi\) are in this case scalar function. We would like to re-emphasize that our usual description in terms of positive energy solutions is valid above the Compton scale (Cf.refs.[8, 9]). To put it another way, equation (3) describes a new spinor in a ”superspin” space. Thus we are lead to a new short lived interaction (as we are near the Compton scale), mediated by vector
3. Let us start with the equations,

\[ g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu}, h_{\mu\nu} = \int \frac{4T_{\mu\nu}(t - |\vec{x} - \vec{x}'|, \vec{x}')}{|\vec{x} - \vec{x}'|} d^3x' \]

where as usual,

\[ T^{\mu\nu} = \rho u^\mu u^\nu \]

lead, on using (25) in (24), to the mass, spin, gravitational potential and charge of an electron, if we work at the Compton scale (Cf. [2] for details). Let us now apply the macro Gravitoelectric and Gravitomagnetic equations to the above case. Infact these
equations are (Cf.ref.[21]).

\[ \nabla \cdot \vec{E}_g \approx -4\pi \rho, \quad \nabla \times \vec{E}_g \approx -\partial \vec{H}_g / \partial t, \quad etc. \quad (26) \]

\[ \vec{E}_g = -\nabla \phi - \partial \vec{A} / \partial t, \quad \vec{H}_g = \nabla \times \vec{A} \quad (27) \]

\[ \phi \approx -\frac{1}{2}(g_{00} + 1), \quad \vec{A}_i \approx g_{0i}, \quad (28) \]

The subscripts \( g \) in the equations (26) and (27) are to indicate that the fields \( E \) and \( H \) in the macro case do not really represent the electromagnetic field, but rather resemble them. Let us apply equation (27) to equation (24), keeping in mind equation (28). We then get, considering only the order of magnitude, which is what interests us here, after some manipu-
\[ |\vec{H}| \approx \int \frac{\rho V}{r^2} \bar{r} \approx \frac{mV}{r^2} \quad (29) \]

and

\[ |\vec{E}| = \frac{mV^2}{r^2} \quad (30) \]

\( V \) being the speed.

In (29) and (30) the distance \( r \) is much greater than a typical Compton wavelength, to make the approximations considered in deriving the Gravitomagnetic and Gravitoelectric equations meaningful.

Remembering that we have, by the Uncertainty Principle,

\[ mVr \approx h, \]
the electric and magnetic fields in (29) and (30) now become

\[ |\vec{H}| \sim \frac{h}{r^3}, \quad |\vec{E}| \sim \frac{hV}{r^3} \quad (31) \]

We now observe that (31) does not really contain the mass of the elementary particle. Could we get a further insight into this new force?

Indeed in [19] characterization of the electron, it turns out as indicated that the electron can be represented by the Kerr-Newman metric which incidentally also gives the anomalous gyromagnetic ratio \( g = 2 \). (This result has more recently been reconfirmed by Nottale [22] from a totally different point of view, using scaled relativity). It is well known that the Kerr-Newman
field has extra electric and magnetic terms (Cf. [23]),
both of the order $\frac{1}{r^3}$, exactly as indicated in (31).

It may be asked if there is any candidate as yet for the
above mass independent, spin dependent (through $h$)
short range force. Perhaps the speculated inexplic-able $B_{(3)}$ [24] short range force could be a candidate.

It differs from the usual $B_{(1)}$ and $B_{(2)}$ long range
fields of Special Relativity.

Interestingly, if we think of the above force as be-
ing mediated by a “massive” particle, that is, work
with a massive vector field we can recover (30) and
(31) [25]. A final comment: It is quite remarkable
that equations like (26), (27) and (28) which resem-
ble the equations of electromagnetism, have in the usual macro considerations no connection whatsoever with electromagnetism except in appearance. This would seem to be a rather miraculous coincidence. In fact the above considerations of the Kerr-Newman metric formulation, demonstrate that the resemblance to electromagnetism is not an accident, because in this latter formulation, both electromagnetism and gravitation arise from the metric (Cf. also refs. [26, 27, 28, 2]).

4. We can arrive at the same conclusion from a slightly different point of view.
We recall the equations

\[ g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu}, \]

\[ h_{\mu\nu} = \int \frac{4T_{\mu\nu}(t - |\vec{x} - \vec{x}'|, \vec{x}')}{|\vec{x} - \vec{x}'|} d^3x' \]

(32)

where as usual,

\[ T^{\mu\nu} = \rho u^u u^v \]

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lead, on using (33) in (32), to the mass, spin, gravitational potential and charge of an electron, if we work at the Compton scale. Let us now apply the macro Gravitoelectric and Gravitomagnetic equations to the above case. Infact these equations are (Cf.ref.[21]).

\[ \nabla \cdot \vec{E}_g \approx -4\pi \rho, \quad \nabla \times \vec{E}_g \approx -\partial \vec{H}_g / \partial t, \quad etc. \]

(34)

\[ \vec{E}_g = -\nabla \phi - \partial \vec{A} / \partial t, \quad \vec{H}_g = \nabla \times \vec{A} \]

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\[ \phi \approx -\frac{1}{2}(g_{00} + 1), \quad \vec{A}_i \approx g_{0i}, \] (36)

The subscripts \( g \) in the equations (34) and (35) are to indicate that the fields \( E \) and \( H \) in the macro case do not really represent the electromagnetic field, but rather resemble them. Let us apply equation (35) to equation (32), keeping in mind equation (36). We then get, considering only the order of magnitude, which is what interests us here, after some manipulation

\[ |\vec{H}| \approx \int \frac{\rho V}{r^2} \vec{r} \approx \frac{mV}{r^2} \] (37)

and

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V being the speed.

In (37) and (38) the distance r is much greater than a typical Compton wavelength, to make the approximations considered in deriving the Gravitomagnetic and Gravitoelectric equations meaningful.

Remembering that we have, by the Uncertainty Principle,

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ther insight into this new force?

Indeed in the above linearized General Relativistic characterization of the electron, it turns out as indicated that the electron can be represented by the Kerr-Newman metric which incidentally also gives the anomalous gyromagnetic ratio $g = 2$ of ref. [2]. (This result has recently been reconfirmed by Not-tale [22] from a totally different point of view, using scaled relativity). It is well known that the Kerr-Newman field has extra electric and magnetic terms (Cf.[23]), both of the order $\frac{1}{r^3}$, exactly as indicated in (39).

which we got beforeIncidentally this result can be re-
lated to the care new man metric whatever it is, We are lead Two a short strong force which is at least off the order of \(1/r^3\)

3 Experimental evidence

3.1

In recent years, a group of Hungarian researchers claimed that they discovered a new particle — called X17. Such a particle would require the existence of a fifth force of nature. Some physicists are sceptical that the new particle exists.

Confirmation for such a 17-MeV particle is awaited.
The Jefferson Laboratory in the DarkLight experiment aims to search for dark photons with masses of 10–100 MeV (cf. also [29]). They propose to do this by firing electrons at a hydrogen gas target. They hope that they would be able to either find the proposed particle or find suitable limits on its coupling with normal matter. They have now seen it show up in the same way hundreds of times. That leaves some physicists excited by the prospect of a new force. But even if an unknown force is not responsible for the strange signal, the team may have revealed some novel, hitherto and unknown physics even help explain dark matter. However, so far, most scientists remain skeptical. For years, researchers tied to
the Hungarian group have claimed to discover new particles that later vanished. The group shot protons at a thin sample of Lithium-7, which then radioactively decayed into Beryllium-8. As expected, this created pairs of positrons and electrons. However, the detectors also picked up excess decay signals that suggested the existence of a potential new and extremely weak particle. If it exists, the particle would be about 1/50 the mass of a proton. And because of its properties, it would be a boson. The findings were peer viewed and published in the Physical review letters [30, 4, 31].
[5] The Large Hadron Collider (LHC) physicists, in March 2021, reported signals for new physics - a new force of nature. We come to Beauty quarks, or bottom quarks. A paper put out by the collaboration in March was based on data from the LHCb experiment, that recorded the outcome of the ultra high-energy collisions produced by the LHC and found that beauty quarks were decaying into electrons and muons at different rates, which should not be so. When a beauty quark decays into electrons or muons via the weak force, it ought to do so equally often. Instead, it was found that the muon decay was only hap-
pening about 85% as often as the electron decay. This would imply some new force of nature that pulls on electrons and muons differently is interfering with how beauty quarks decay. The result was a “three σ” one. The study so far examined beauty quarks that were paired up with “up” quarks. Two other decays were also studied: one where the beauty quarks that were paired with “down” quarks and another where they were also paired with “up” quarks. This time, muon decays were only happening around 70% as often as the electron decays. This time the result was a two σ result. We might be on the brink of a major breakthrough, but more data is required. In addition, other experiments at the LHC, as well at the
Belle 2 experiment in Japan, are also looking for these results.
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