MODIFICATION OF THE STRONG NUCLEAR FORCE BY THE ZERO-POINT FIELD

by

ARDESHIR MEHTA, N.D.
Email: ardeshirmehta@myself.com

(Final Draft)

Paper Started on March 7, 1999

This Draft: April 7, 1999

ABSTRACT

The present paper, aiming at a paradigm shift in our current view of the laws of physics, intends to show how, assuming that Quantum mechanics is correct, there is a pressing need to modify the presently-accepted magnitude of the "strong nuclear force". To show this, it is demonstrated that the equations of Quantum Electrodynamics (QED), which force the existence of a Zero-Point Field (ZPF) of virtual radiation even in an "absolute" vacuum, are complementary to the action of the presently widely-postulated "strong nuclear force". Indeed calculations indicate that it may be possible to do away with the "strong nuclear force" altogether, which may ultimately lead to a "Grand Unification of Forces". (Others, notably Puthoff, Rueda and Haisch, have already shown that the ZPF can account for inertia, which in turn, if General Relativity (GR) is assumed to be correct, and owing to the Principle of equivalence of inertia and gravity which is assumed for formulating GR, forces the conclusion that the ZPF must account for gravity as well.)

Keywords: Zero-Point Field, Quantum Electrodynamics, Stochastic Electrodynamics, Unified Field, Grand Unification of forces, Casimir effect, strong nuclear force, paradigm shift.

INTRODUCTION

The present paper attempts to present an argument for a downward modification of the magnitude of the strong nuclear force, based upon quantum mechanics and in particular its prediction of the Zero-Point Field. As such, it aims at introducing a paradigm shift in the current view of the laws of physics. The present paper also indicates that it may be possible to do away with the "strong nuclear force" altogether, which may ultimately lead to a "Grand Unification of Forces".

OVERVIEW

As Puthoff, Rueda and Haisch [1] have mentioned (among many others), Quantum Theory demands that even the most complete vacuum—devoid not only of matter but also of (conventional) energy such as light—must contain vast quantities of "virtual" energy. This energy arises even in a complete and absolutely dark vacuum at a temperature of absolute zero, as a result of Heisenberg's *Uncertainty Principle*, which states that

$$\Delta E \Delta t = 1/2(h/2\pi)$$

eqn. 1a

…and

$$\Delta x \Delta p = 1/2(h/2\pi)$$

eqn. 1b

…where $\boldsymbol{E}$ is energy, $\boldsymbol{t}$ is time, $\boldsymbol{x}$ is position, $\boldsymbol{p}$ is momentum and $\boldsymbol{h}$ is Planck's constant.

Thus the Heisenberg *Uncertainty Principle* sets a fundamental limit on the precision with which these conjugate quantities are allowed to be determined.

Now if we work out the quantum version of a simple mechanical harmonic oscillator—*e.g.,* a mass on a spring—in the above respect, then due to the requirement of Quantum Mechanics that all things must exist in discrete quanta, the energy levels must be discrete, not continuous. (This effect is of course much more pronounced for extremely small objects, though in theory it applies for *all* objects.) Thus by adding energy one can increase the amplitude of the oscillation, but only in units of $\boldsymbol{h}\nu$, where ν is the frequency in cycles per second. In other words, one can only add or subtract $\boldsymbol{E}=\boldsymbol{nh}\nu$ of energy, where $\boldsymbol{n} \geq 0$.

A further quantum effect is due to the fact that if it be postulated that an oscillator is able to come completely to rest, $\Delta\boldsymbol{x}$ would be zero, and this would violate the $\Delta\boldsymbol{x}\Delta\boldsymbol{p}=1/2(\boldsymbol{h}/2\pi)$ limitation of ***eqn. 1b*** above.

The result of both the above considerations is that at all times there must be a minimum energy of $\boldsymbol{E}=\boldsymbol{h}\nu/2$, *i.e.* the oscillator energy can only take on the values $\boldsymbol{E}=(\boldsymbol{n}+1/2)\boldsymbol{h}\nu$. And since $\boldsymbol{n}$ cannot be negative, $\boldsymbol{E}$ can never become zero. (Essentially, this is the Quantum counterpart to the Relativistic requirement that the speed of an object cannot rise to infinity, no matter what the frame of reference; the above implies that its speed also cannot fall to zero, again regardless of the plane of reference.)

Now an electromagnetic field can be regarded as being analogous to a mechanical harmonic oscillator, since the electric and magnetic fields are modes of oscillating plane waves. Each mode of oscillation of the electromagnetic field thus has a minimum energy of $\boldsymbol{h}\nu/2$. As a consequence, the laws of quantum mechanics as applied to electromagnetic radiation necessitate a background "sea" of radiation.

Because this radiation must exist even at a temperature of absolute zero, it has been referred to as "Zero-Point Field" radiation, or ZPF radiation. The vast majority of the energy of the ZPF is, therefore, thought to consist largely (though not entirely) of electro-magnetic radiation, or loosely speaking, light (which word in the present context refers to light of all possible wavelengths, visible as well as invisible). This ZPF "light" however is not observable even with instruments, since according to Heisenberg's *Uncertainty Principle* it is not real but virtual, due to photons being converted into matter-antimatter particles and back again into photons so rapidly that they cannot be detected (in general, in time periods shorter than about 10^{-23} second.)

(The above is derived using the equations of Quantum Electrodynamics, or QED. A different approach, called Stochastic Electrodynamics or SED, which has been adopted by Puthoff *et al* [1], assumes *a priori* the existence of the ZPF and then explains many quantum phenomena using only the equations of classical physics—*i.e.*, eschewing all formulae used in QED—and is rather successful in so doing, and this approach may have benefits too; but strictly for the purposes of this paper, it is not necessary to bring into the picture the differences between QED and SED, even though SED may offer more promising avenues for further inquiry into the ZPF in general.)

Estimates of exactly how much energy the ZPF contains vary greatly, since the above equation must be applied across the board for all frequencies ν (or to be more accurate, all modes—which include frequencies) of light; and it is not yet known where the cut-off point for light frequencies should be applied. (If a cut-off point is not applied at all, the energy of the ZPF would theoretically grow to infinite, and thus would press from all sides on every elementary particle—electron or quark—with infinite force; but since that makes poor sense in the real world (such infinite pressure might "squeeze" the electrons and quarks out of existence!), it makes better sense to assume, at least for now, that a real cut-off point must exist somewhere, even though we don't know where it is right at this stage in our inquiries. Nevertheless, it will become clear from further reading here that the arguments presented herein remain valid regardless of where exactly the cut-off point is, provided there is only one cut-off point.)

Besides, the ZPF does not manifest *only* as radiation but as other kinds of energy as well, though radiation does seem to predominate. But most of those who study the field agree that the ZPF radiation must be enormous. As *NASA*'s Marc G. Millis writes [2], even the most conservative estimates put the energy of the ZPF at anything ranging from 10^{36} to 10^{70} *joules/m*^{3}. "In simplistic terms", says Millis, "it has been said that there is enough energy in the volume the size of a coffee cup to boil away Earth's oceans."

EVIDENCE FOR THE ZPF

One of the most convincing demonstrations of the existence of the ZPF is the Casimir Effect, so-called after its predictor, Dutch physicist Hendrick Casimir, who made the prediction in 1948. If two very highly polished uncharged flat plates—made, say, of quartz—are brought very close to one another in a dark vacuum, they will be pushed together with a force given by the formula

$$F = \frac{\pi^2 (h/2\pi) c}{240 d^4} A$$

eqn. 2

…where ***F*** is the force, ***d*** the distance between the plates, ***A*** the area of the plates, ***c*** is the speed of light, and ***h*** is Planck's constant. (Note that this is *not* an experimentally-derived or empirical formula but one predicted by calculation from the equations of QED. In fact Casimir himself never measured the force that now bears his name.)

The Casimir Effect was quite accurately measured in 1997 by Steven K. Lamoreaux [4] using gold-plated quartz plates made as near to absolutely flat as can be manufactured these days using some of the best modern technology; and obtained a very precise and unambiguous confirmation of the existence of the Casimir force. The force ***F*** was found by Lamoreaux to be accurate to within 5% of the prediction, which is a reasonably allowable amount of experimental error. Thus there is no question that the effect exists.

The Casimir Effect has been explained [3] by the fact that in the cavity between the plates—which is sometimes referred to as a "Casimir cavity"—the ZPF radiation present is diminished in comparison to the ZPF radiation outside the plates, by an amount equal to the energy of those wavelengths of ZPF radiation which are too large to fit between the plates. (In a small space a large wave cannot form, and that is why one can't successfully use one's surfboard in one's back yard swimming pool!) Thus one may say that the Casimir Effect is essentially due to the pressure of light outside the plates being greater than the pressure of light between the plates. So the light outside the plates pushes the plates inward, towards one another, because there is a greater degree of "darkness" between the plates—from a ZPF radiation viewpoint—than there is outside the plates. (Again, the words "light" and "darkness" are used rather loosely here, as denoting the presence and absence, respectively, of all possible wavelengths of electro-magnetic radiation, and as including both real as well as "virtual" radiation.)

Now it should be clear that the above formula is valid only for absolutely flat and parallel plates. If the plates depart significantly from the absolutely flat and parallel to one another in two dimensions, in light of the above explanation for the Casimir Effect, common sense dictates that the force ***F*** diminishes. In other words, and to put it mathematically, if the plates depart from the absolutely flat and parallel, the factor "240" in the denominator of ***eqn. 2*** can rise to any arbitrary number, depending on the extent of the departure of the plates from the absolutely flat and parallel to one another in two dimensions (if ***d*** represents the *shortest* distance between such "plates").

To express it mathematically, if we introduce a factor ***x*** into ***eqn. 2*** such that for absolutely flat and parallel plates ***x*** =1, while for plates which depart from the absolutely flat and parallel, ***x*** >1 by an amount depending on the extent to which and just how the "plates" depart from the absolutely flat and parallel, then we obtain the following modification of ***eqn. 2***:

$$F = \frac{\pi^2 (h/2\pi) c}{240 x d^4} A$$

eqn. 3

The same thing would apply to "plates" that allow a part of the ZPF radiation to pass through them. (Obviously if the plates are *completely* transparent to *all* wavelengths, there would be no Casimir Effect at all, and thus the factor "240" would have to be increased to infinity!)

Now it will be observed that even in the best-case scenario—*i.e.*, if the "plates" are perfectly flat and parallel to one another, completely opaque to all wavelengths of ZPF radiation, and if ***A*** is much larger than ***d***—the force ***F***, which draws the plates together, is inversely proportional to the *fourth* power of the distance ***d*** between the plates. Thus as the distance ***d*** tends towards zero, the force ***F*** tends towards infinity. Of course in practical terms the distance ***d*** cannot be zero, nor can the force ***F*** be infinite; but the above consideration goes to show that if the distance ***d*** diminishes to any arbitrarily small amount within the realms of possibility, the force ***F*** would grow to any arbitrarily large figure: and at very tiny distances the growth in the force ***F*** would be very rapid indeed.

PREDICTIONS FROM THE ABOVE CONSIDERATIONS

It is clear, of course, that at the atomic scale the distance ***d*** cannot diminish to absolute zero—nor, as a consequence, can the force ***F*** rise to infinity—due to the fact that atoms have measurable diameters. The electron clouds around atomic nuclei prevent the nuclei of adjacent atoms from coming together too closely. Without stripping away all the atomic electrons, here cannot arise a situation such that there is no distance whatsoever between atomic nuclei. Thus with plates made of gold-plated quartz—as in the experiment conducted by Lamoreaux—even when the plates are brought together so closely that their surface (gold) atoms actually touch, the wavelengths of electromagnetic radiation that can fit *inside* the atoms of gold would still exert an outward pressure on the plates. That, of course, is the reason why gold-plated quartz plates don't stick together with infinite pressure, or even with such great pressure as would be predicted by ***eqn. 2*** if the distance ***d*** between the plates is assumed to be just a few femtometres (*fm)* or a few attometres (*am*).

However, if we consider the nucleons inside an atomic nucleus to be "plates" in the sense of the Casimir Effect, with the difference that these "plates" are not perfectly flat but on the contrary of a more or less spherical shape, and that in addition they are not perfectly opaque to all wavelengths of light but rather are only partially opaque, then the following reasoning becomes valid. (The notion that nucleons are at all times more or less spherical—even when packed together inside an atomic nucleus—is of course just an assumption, but for now we may make such an assumption just for the sake of the present argument.) Protons and neutrons inside an atomic nucleus are indeed separated by a few *fm* or even less. The current best two values for the proton's radius disagree, but not by much: 0.805 ± 0.011 and 0.862 ± 0.012 *fm* (Stein 1995) [5]. This makes the approximate diameter of a proton around 1.7 *fm*, giving its volume at around 2.7 fm^3. And the diameter of the nucleus of an iron atom, consisting of 26 protons and 30 neutrons, is given as around 8 *fm* [6], which makes its volume around 270 fm^3. These two measurements would seem to indicate that the 56 nucleons inside an iron nucleus are packed quite tightly inside the nucleus, with a spacing of the order of a few tenths of a femtometre. And it stands to reason that the same applies for all nuclei.

(Besides, the above measurements also show that the nucleons cannot be so tightly packed inside a nucleus so as to lose their spherical shape. For that to happen, the sum of the volumes of the nucleons should equal the total volume of the nucleus: and in the case of iron atoms, assuming that neutrons are also more or less of the same diameter as protons, that implies that the total volume of the nucleus should be (56 x 2.7) = 151.2 fm^3, whereas the actual volume is around 270 fm^3, about 80 per cent more.)

In any case, and to put it in simple terms, what the above considerations show is that *inside* a densely-packed atomic nucleus there must exist some amount of ZPF "darkness", or *absence* of ZPF radiation, and certainly a *diminished presence* of all ZPF radiation of wavelength greater than about 1 *fm*, and perhaps even of all radiation of wavelength greater than about 0.5 *fm* or even less.

In other words, the spaces between nucleons inside an atomic nucleus act to some extent like "Casimir cavities". The nucleons act on the waves of ZPF radiation in a manner somewhat analogous to the way breakwaters in a harbour act on ocean waves. Just as the latter inhibit the formation of water waves longer than a certain length, no matter how stormy it may be outside the harbour, so the former would inhibit the formation of waves of ZPF radiation of wavelength longer than a certain dimension, no matter how much ZPF radiation exists outside the nucleus.

Thus, if the Casimir Effect is indeed due to the fact that the excess ZPF radiation outside the plates compared to the ZPF radiation between the plates pushes the plates inward towards one another, then the same sort of effect should exist on the atomic nucleus.

EXAMPLE OF FUSION OF THE HYDROGEN NUCLEUS

To examine the mathematical implications of this line of thinking, one may as a first instance let us consider the fusion of two hydrogen nuclei—*i.e.*, protons—plus two neutrons to form a helium nucleus. This fusion may be looked upon as an instance of the Casimir Effect acting to overcome the repulsive Coulomb force brought about by the protons' positive charge. To examine this viewpoint mathematically, let us assume that the protons, initially far apart, are by some mechanism (as in the interior of a star, say, or in a fusion reaction) brought together to a distance of exactly 1 *fm* apart from one another at their surfaces. (This means that their centres would be 1+1.7 *fm* apart.) Applying the formula for the repulsive Coulomb force between them, namely

$$F = k\frac{e^2}{d^2}$$

eqn. 4

… where $\boldsymbol{k}$ is the Coulomb constant, namely 8.9876 x 10^9 Nm^2C^{-2}, $\boldsymbol{e}$ is the charge of the electron, namely 1.602 x 10^{-19} C, and $\boldsymbol{d}$ is the distance between them, namely 2.7 *fm*, or 10^{-15} m, we get a total repulsive force $\boldsymbol{F}$ equal to

$$\boldsymbol{F}=31.64\ \boldsymbol{N}$$

eqn. 5

Now it is enlightening to compare this figure with the Casimir force acting on the two protons at the same distance from one another, dictated by ***eqn. 3***, where the value $\boldsymbol{x}$ is arbitrarily taken as 5 (to account for the fact that the "plates" in this instance are more or less spherical, and not flat, and that they are only partially opaque to all wavelengths of ZPF radiation.) At that distance between "plates", namely 1 *fm*, and calculating, according to the formula $\boldsymbol{A}=\pi \boldsymbol{r}^2$, the combined cross-sectional area $\boldsymbol{A}$ of both the "plates", and which comes to almost exactly (2 x 2) or 4 *fm*, the Casimir force then is

$$F \quad \frac{\pi^2 (h/2\pi) c}{240 \times 5 \times \left(10^{-15}\right)^4} \, 4\left(10^{-15}\right)^2 N$$

eqn. 6

… and substituting the correct figures and working out the equation gives

$$F \quad 1.04 \times 10^3 \, N$$

eqn. 7

This shows that around the femtometre distance, the Casimir force pushing the protons together, especially when the space between them is additionally shielded by two neutrons (one on each side, of course) is quite strong enough to overcome the repulsive Coulomb force of their electrical charges, being about 33 times as strong.

If the arbitrary value $\boldsymbol{x}$=5 in ***eqn. 6*** is decreased, the force $\boldsymbol{F}$ becomes even stronger. It seems however to be against common sense—as pointed out earlier—to assume that the value of $\boldsymbol{x}$ is as low as 1, because protons are not like flat plates.

Now it may be noted, that ~1 *fm* is more or less also the distance the "strong nuclear force" (or "residual strong nuclear force") begins to act noticeably on the protons forcing them together and not allowing the repulsive Coulomb force to push them apart! Thus the above consideration shows that Casimir force complements the action of the "strong nuclear force", and if the above argument is admitted, that it is necessary to reduce the presently-accepted magnitude of the strong nuclear force to account for the action of the Casimir force on the nucleons.

Indeed the above indicates that the Casimir force alone may well be sufficient to explain the protons in a helium nucleus being held together against their mutual Coulomb repulsion; and if so, a hypothesis can be enunciated to the effect that there is in fact no need to postulate a "strong nuclear force" (or a "residual strong nuclear force") in order to explain this phenomenon.

THE PROTON—IS IT HELD TOGETHER BY THE ZPF?

As a second exercise, it is intriguing to find that the proton itself might well be considered as being "held together" against the repulsive Coulomb force of the three quarks inside it, by the radiation forces of the ZPF. If we assume the proton to be an unbroken sphere, and taking it that the Casimir Effect is brought to bear on the proton's entire outer surface—which can be taken as both "plates" $\boldsymbol{A}$ in terms of the Casimir Effect—according to the formula $\boldsymbol{A}=4\pi\boldsymbol{r}^2$ (where $\boldsymbol{r}$ is the radius of the proton) and taking the "distance" $\boldsymbol{d}$ between the "plates" as the proton's diameter ($2\boldsymbol{r}$), we get a total Casimir force F acting inward on the proton equal to

$$F = \frac{\pi^2 (h/2\pi) c}{240 \times (2r)^4} \left(4\pi r^2\right) N$$

eqn. 8

… which calculates to

This draft dated 7 April 1999

$$F \quad 1.6 \times 10^{3} N$$

eqn. 9

Now since the proton is composed of two u-quarks and one d-quark, assuming then that the d-quark (with negative charge ***e***/3) is attracted to one of the two u-quarks (each with positive charge 2***e***/3), and the combined two repel the remaining u-quark according to the Coulomb formula

$$F = k\frac{e^2}{d^2}$$

eqn. 10

…and assuming the distance ***d*** between the quarks to be on the average equal to the proton's radius, namely 0.85 *fm*, we get

$$F \quad 71N$$

eqn. 11

Thus once again the Casimir force is shown to be more than enough (about 22 times more, in fact) to hold the proton together against the repulsive forces generated by its constituent quarks, and as will be shown further on in this paper, the excess may have something to do with the possibility that the proton may not be entirely opaque to ZPF radiation. (If we assume that inside a proton there are just three quarks and nothing else, by Heisenberg's *Uncertainty Principle* it would be impossible at any given time to determine their exact location inside the proton, and thus the three quarks making up the proton could be considered to be a "cloud" of a volume the size of the proton in much the same way as an atom is considered to be a "cloud" of electrons around a nucleus; and thus a large part of the ZPF radiation would therefore pass right through most of this "cloud" which makes up the proton.)

Thus all the above calculations show that it could well be that it could well be the Casimir force, arising out of the omnipresent ZPF radiation, which holds the atomic nucleus together, and perhaps even the proton (and in like fashion, the neutron) together; and not the mathematically unwieldy and entirely empirical "strong nuclear force" which hitherto has been postulated for accomplishing the same result. In any case, it is clear that the presently-assumed magnitude at least, if not the very existence, of the "strong nuclear force" must be reduced to account for the action of the ZPF on the nucleus and nucleons.

THE MOST ELEMENTARY PARTICLES

Now let us consider the most elementary particles of all, the electron and the quark. (For the sake of the present argument we can lump all quarks together in one single category.) The electron and the quark have no *measurable* dimension, and some people have even conjectured that they may actually be points in the same sense as those imagined in geometry, having no dimension at all. As will be shown below, this is highly unlikely, and it is far more likely that the electron and the quark are in some way "held together" by the ZPF, and perhaps even owe their very existence to it.

To arrive at this conclusion it is necessary to ask the question, "What prevents the electron (or the quark) from breaking up further?" The answer to this question, up till now, has only been something along the lines of "The electron *cannot* be broken up further, and that's just the way things are". But this is hardly an *explanation*. Indeed since it is known that the charge of the d-quark is 1/3 that of the electron, it is obvious that the charge of the electron is not the smallest charge there is, and thus cannot be considered to be the "unit of charge". Thus there is ample reason to think that it may be possible to break up the electron (at least) into three parts.

Well then, what if one is not satisfied with such a "pseudo-answer" as "that's just the way things are", but is willing to press for a more satisfying and realistic explanation? After all, with charges, "like repels like". If the electron *could* break up, it could only break up into two (or more) *negatively* charged sub-particles, each repelling the other with tremendous force. And if the electron is actually as small as the "point" of geometry, having no dimensions, these two sub-particles would be so close to each other that they would have to repel each other with *infinite* force, and thus absolutely nothing could stop them from doing so.

In such a hypothetical situation, one would be forced to conclude that even if the electron could not break up, an infinite force might well be sufficient to make even the impossible happen. The proverbial "irresistible force" would finally have met the equally proverbial "immovable object".

However, if the ZPF exists everywhere there is a void, it stands to reason that it must act on all things in space, including even the most elementary of elementary particles. Let us, therefore, assume that it acts even on an electron or a quark, holding these particles together and preventing them from breaking apart due to the charge inside them being of only one kind, and thus part of it repelling the remainder. In other words, let us consider each of these particles as "Casimir cavities" too, of a more or less spherical shape (this being assumed to simplify calculations). In that case, we can calculate how large a quark—for example—would have to be.

Let us picture the ZPF radiation acting on all sides of a spherical object the size of a u-quark of charge 2***e***/3, which is trying to break apart into two equal sub-particles of charge ***e***/3. (It makes most sense for a quark, if it does have to break apart, to break apart into *two equal* parts, since that would maximise the Coulomb force of repulsion causing it to do so). Then the Coulomb force on the u-quark of radius ***r*** would be given by the formula

$$F_{Coul.} = \frac{(e/3)^2}{(2r)^2}$$

eqn. 12

… while the Casimir force of the ZPF radiation acting on the same u-quark, and assuming that ZPF radiation of wavelength longer than its diameter (***d***=2***r***) could not form inside the quark, would be given by the formula

$$F_{Cas.} = \frac{\pi^2 (h/2\pi)c}{240 \times (2r)^4} 4\pi r^2$$

eqn. 13

…which is to say

$$F_{Cas.} = \frac{\pi^3 (h/2\pi)c}{960 r^2}$$

eqn 14

As can be seen the denominator in both, ***eqn. 12*** and ***eqn. 14***, contains the factor $\boldsymbol{r^2}$, and this allows us to calculate the ratio between the Casimir force and the Coulomb force for a charged sphere *irresective* of its radius. The ratio when calculated comes out to just a little under 160.

Thus it can be seen that no matter what the size of the quark (or electron), the Casimir force acting on it is much more than sufficient to hold it together against any conceivable Coulomb force that could arise within it due to its possessing a single charge.

The question then must surely arise: is it the Casimir force which prevents the single charge of the electron or the quark from repelling itself, which would cause the particle to disintegrate? For years physicists have been looking for the magnetic "monopole", thinking that if an electron can exist with just one charge, the smallest particle exhibiting magnetic properties should also exhibit a single pole. However, what if we have been "barking up the wrong tree" all along, so to speak? Perhaps what physicists should have been asking is *why* the electron (and quark) exist with only one single charge, and why part of this charge does not repel the rest of it with immense force. (If the radius $\boldsymbol{r}$ of the u-quark is assumed to be 10 *am*, the repulsive force acting on the quark according to the Coulomb formula would be almost 64,000 *N*, by no means inconsiderable for such a tiny particle!)

POSSIBLE GRAND UNIFICATION OF FORCES

Now Steven Weinberg, Sheldon Glashow and Abdus Salam have already shown (1967-1971) that the "weak nuclear force" and the electro-magnetic force can be considered to be aspects of one another, at present called the "electro-weak" force; and indeed this work is so well known that they received the Noble Prize for it. Thus, if we assume, as argued herein, that what used to be called the "strong nuclear force" can be reduced in magnitude to zero, and all phenomena which needed the postulation of the "strong nuclear force" can be explained by the ZPF, we are left with only two separate forces of nature which cannot account for one another: the electro-weak force and gravitation.

As for gravitational and inertial mass, Puthoff *et al.* [7] have shown that inertia can be considered to be a manifestation of the ZPF which puts up a resistance to an object's acceleration precisely equal to that predicted by Newton in his celebrated formula $\boldsymbol{F=ma}$ where $\boldsymbol{F}$ is the force, $\boldsymbol{m}$ is the object's mass and $\boldsymbol{a}$ is the object's acceleration. Thus inertia (at least) can be shown to be a manifestation of the "electro-weak" force. Now according to the equivalence principle enunciated by Einstein for formulating the General Theory of Relativity (GR), inertial "mass" and gravitational "mass" have to be exactly the same. If there is even the slightest difference between the two, it is doubtful that GR can hold up. As a result, if one accepts the notion that inertia is caused by the action of ZPF radiation, it would be next to impossible to assert that gravitation is *not* caused by it, without at the same time dismantling GR. For the sake of the present argument, we may assume for the moment that GR is correct; and if that is assumed, then the ZPF must be assumed to account for gravitation as well. Indeed Puthoff *et al*. [7] have indeed proposed exactly such a thing, basing their ideas partly on a proposal suggested over thirty years ago by Sakharov [8].

If the above is admitted, then the "electro-weak force" (which together with Quantum Theory can account for the ZPF radiation) may be sufficient to account for *all* the fundamental forces of nature, and there may be no need to postulate the existence of either a separate "strong nuclear force" or a separate "gravitational force". In other words, a Grand Unification of Forces, of the kind Einstein unsuccessfully sought towards the end of his life (or what he used to call a "Unified Field Theory") may well become possible.

PHENOMENA ALREADY EXPLAINED BY THE ZPF

It seems abundantly clear, at all events, that the arguments proposed in this paper explain many observed phenomena. For one thing, they would explain why very large atomic nuclei tend to be unstable, and why this instability increases with increasing size of nucleus. If what has been argued in this paper is correct, then once the number of protons—with their repellent charges generating a Coulomb force pushing them apart from each other—becomes too great inside the nucleus, the ZPF radiation outside the nucleus must be insufficient to push nucleons inward. Since the ZPF radiation is strongest outside the nucleus, it acts on the outside of the nucleus only, or at best on places within the nucleus in "line of sight" from the outside, due to the nucleons being more or less spherical, and thus having some gaps between them; but after a certain depth inside the nucleus, the external ZPF radiation cannot reach the inner nucleons and thus cannot act on them. Thus with increasing nuclear size, the ZPF radiation force increases as the square of the nuclear diameter while the repellent force of the protons within the nucleus increases more or less as the cube of the nuclear diameter. (One has to say "more or less", not "exactly", because of course with increasing nuclear size neutrons are also introduced into the picture, which increase the average distances between protons as the nuclear size increases, and thus reduces the repellent Coulomb force to some extent.) Consequently a limit on the size of the nucleus arises, the larger nuclei having too much Coulomb force to be counteracted by the ZPF radiation.

The arguments presented herein also explain why it requires *slow moving* neutrons to cause a uranium or plutonium nucleus to undergo fission. To cause the fission to take place, the neutron needs to be *lodged* inside the nucleus, not simply "shatter" it. If a neutron simply *passes through* the nucleus, the ZPF once again acts on the nucleus to hold it together. However, if the neutron gets *lodged* inside a nucleus which is just barely being held together by the ZPF, then it increases the size of the nucleus, which in turn increases the total volume of the nucleus being penetrated by the longer wavelengths of ZPF radiation, thereby decreasing the total Casimir force acting on the nucleus. If the nucleus happens to be on the verge of undergoing fission, and is just barely being held together by the ZPF, this decrease in the total Casimir force is just sufficient to cause the nucleus to break apart.

Moreover, the present arguments also explain why *fusion* of low-mass nuclei takes place spontaneously once these nuclei are brought sufficiently close to each other to overcome the resistance of their electrical charges; and in particular why the fusion of *hydrogen* nuclei is so *very* spontaneous and consequently releases so *much* energy compared with fusion of other low-mass nuclei. It stands to reason that within a nucleus which contains a great many protons and neutrons, there is a greater degree of "darkness"—this word again being used as explained earlier, *i.e.* denoting the absence of ZPF radiation—than within nuclei consisting of far fewer protons and neutrons, and certainly more than "within" the hydrogen nucleus, which is a nucleus consisting of only one proton (and which is perforce bombarded by ZPF radiation from all sides.) Thus the difference between the ZPF radiation in an open vacuum compared with the ZPF "darkness" inside a nucleus consisting of many neutrons and protons must be greater than the difference between the ZPF radiation in an open vacuum compared with the "darkness" inside a nucleus consisting of comparatively few neutrons and protons. In more simplistic terms, from a ZPF radiation viewpoint it is "darker" inside a large or at least a medium-sized nucleus than inside a very small one. Indeed this very consideration explains why the helium nucleus needs two neutrons *in addition to* two protons: namely, to create more of a "breakwater" for enough "darkness" to form inside the nucleus.

And in addition, the arguments presented herein explain why the iron nucleus—which contains 56 nucleons—is the most stable of all nuclei. At around that number of nucleons, packed more or less into a sphere, the ZPF radiation from outside the nucleus can act on every single nucleon, with the greatest degree of pressure being exerted on the exterior nucleons and the least on the most interior nucleons. If the nucleus gets larger, the ZPF radiation cannot act at all on the innermost nucleons (while the repellent Coulomb force of the protons continues to act more and more), thus generating instability tending towards nuclear fission; while if the nucleus is smaller, with fewer nucleons, more of the ZPF can act on all the nucleons, thus generating instability tending towards nuclear fusion.

Thus the energy released by both nuclear fission and nuclear fusion can be explained as a "release" of the "virtual" energy of the ZPF from the void into the "real world". This, in fact, is what Puthoff *et al*. have already said in part [9], although their conclusions are reached differently. To quote from that paper: "The energy released in fusion would be coming from the ZPF".

The present paper also explains why the "strong nuclear force" falls away so rapidly with distance, and not according to an inverse square law as do gravitation or electro-magnetism. As it is the Casimir force ***F*** is inversely proportional to the *fourth* power of the distance ***d*** between the "plates". And if the nucleons are spherical in shape or nearly so, and are separated by distances more or less equal to their diameters, it may even be necessary to introduce an additional factor—call it ***y***—into ***eqn. 3*** by which the power "4" has to be multiplied, so as to allow for the fact that ZPF radiation can penetrate into the Casimir cavity between the nucleons from oblique directions. Thus it is highly likely that under such circumstances the power to which the distance ***d*** must be raised may become rather large—or in other words, with increasing distance ***d*** the force ***F*** may fall away even more rapidly than the fourth power of ***d***.

And lastly, but perhaps most intriguingly, the paradigm shift suggested by the present paper may even go far towards explaining why protons and neutrons exist at all, and have measurable sizes; and even why electrons have no measurable size. Perhaps *all* matter is "held together" by the ZPF radiation, and the sizes of the sub-atomic particles of so-called "matter" are a reflection of how strongly the ZPF radiation "holds them together" and prevents them from flying apart and turning (or *re*-turning?) into pure energy. It may thus be enlightening to examine the possibility that "matter" is merely a name we give to perturbations of the energy of the void, and that in actual fact nothing but the void, bursting with energy at the seams, exists (what we call "matter" being, in fact, those very "seams".)

PARADIGM SHIFT

It may be noted that the vast majority of the above conclusions are based on data that were available to the "fathers" of modern physics, such as Einstein, Bohr, Heisenberg, Dirac, Schrödinger, *etc*. Yet they failed to deduce from these data the conclusions we have managed to derive above. One would be forced to conclude from these facts that their failure was due to their paradigms. Einstein, for instance, was always dissatisfied with Quantum Theory, and in disgruntlement made the now-famous remark "The LORD God does not play dice" ("*Der Herrgott werfühlt nicht.*") But maybe he should have given the LORD God a bit more credit! (After all, if the Almighty can do anything, He can also play dice: right?) By not allowing for the possibility that Quantum Theory could indeed be correct at a very basic level, Einstein apparently did not explore an avenue which was open even in his day for him to travel along.

And even those who "fathered" Quantum Theory neglected to explore this avenue. As Puthoff *et al* write [9], "Zero-point radiation is a result of the application of quantum laws. It is traditionally assumed in quantum theory, though, that the ZPF can for most practical purposes be ignored or subtracted away." By trying to "wish away" the ZPF, scientists may have missed exploring an avenue which was more promising than the one they were on.

Thus it may be argued that paradigms are very important in our *approach* to the examination of the Universe—or in other words, our selection of the path we choose to travel along and explore is perhaps even more important than the actual work done travelling along our chosen path.

Now the present hypothesis suggests a paradigm shift in the way we view physics as a whole. Just as Relativity suggested a paradigm shift by doing away with any sense of "absolute rest", thereby opening up vistas which otherwise would never have been explored, perhaps if we approach the study of the material world from the viewpoint of the ZPF, we may be actually be enabled to manipulate matter in ways hitherto undreamed of. For example, as Puthoff *et al*. have noted [9], if inertial mass is actually due to the interaction of the ZPF and the charged particles within the void, then by manipulating the ZPF it may be possible to alter the inertial mass of an object, perhaps even doing away with it altogether: a notion that would open up enormous vistas in space travel and perhaps even earthly travel. Similarly, if the ZPF radiation is sufficient to explain those phenomena which hitherto needed the "strong nuclear force" to explain them, then perhaps by manipulating the void, fusion of individual nuclei, one at a time, taking place at something akin to room temperature, or at worst not-unmanageably high temperatures, and releasing manageable amounts of energy—or what is more popularly known as "cold fusion"—would indeed become possible.

PHILOSOPHICAL CONSIDERATIONS

Additionally, and from a philosophical point of view, the present hypothesis *explains*, rather than merely *describing*, the behaviour of matter at the sub-atomic level. Unlike the other forces, the so-called "strong nuclear force" is merely a *description* of how matter seems to behave at the femtometre distance, more or less, down to the attometre distance, also more or less; but it is not by any means an *explanation* of such phenomena. The curve traced when plotting the strength of the strong force over varying distances is a totally empirical one, not a theoretical one. (Of course any smooth curve can be made to approximate another which a not-too-complicated formula may dictate, but that does not detract from the fact that in its origins, the curve traced by the strong nuclear force is an empirical one and not a theoretical one.) One may argue that it agrees beautifully with measurements, but that can hardly be surprising. It agrees because it is *made* to agree: it is itself based on many, many observations of reality, averaged out. It's a bit like saying "Isn't it marvellous that the week contains exactly seven days, and the day exactly twenty-four hours?" That way, once we start measuring, the number of seconds in a week turns out to be precisely 604,800, which beautifully agrees with the predicted value; but then again, should we be surprised at this?

Just as the day and the week—along with the ~30-day month, which is much less exact, but almost equally *ad hoc*—are very useful for regulating our lives, the "strong nuclear force" may well be extremely useful for nuclear *engineering* (as opposed to nuclear *science*). But from the scientific point of view, it may be well to remember that it may be merely book-keeping, and not really an explanation of *why* sub-atomic particles act at tiny distances the way they actually do. All that the "strong force" postulate does is, basically, tell us *how* things are—but it does not explain *why* they are that way.

The arguments presented in this paper, in sharp contrast, attempt actually to *explain* a great number of phenomena which currently require the postulation of the strong nuclear force. As such, they are more like the year of 365.24219878 days, which, although worked out to 8 decimal places, is still not as absolutely exact as the 7.00000000…-day week. Unlike the week, the year is a *relationship* between physical phenomena: *viz.*, the relationship between the earth's revolution around the sun compared with its rotation around its own axis. The present hypothesis—like the year—seems to satisfy the philosophical mind better than does the postulation of a "strong nuclear force", which is more like the week. It seems, in the words of S.W.P. Wyszkowski [10], "more elegant".

FINAL ARGUMENT

And finally, even if the ZPF radiation is ultimately found to be too weak to explain the *entire* observable facts which give rise to the postulate of a "strong nuclear force", it must still be admitted that the ZPF must have *some* effect on the nucleus and the nucleons. Thus the calculation of the *magnitude* of the strong nuclear force, if it is still needed to postulate one, must nevertheless be revised downwards. By how much, we would not be able to tell until we have determined just how strongly the ZPF radiation acts on the nucleus and nucleons. (It is somewhat like having to take into account wind speed in the landing of a sailplane. A sailplane may be travelling at 50 knots airspeed, while travelling against a headwind of 30 knots, making its speed relative to the ground much less, namely 20 knots, and thus requiring much less runway to land.)

If the ZPF does exist, it must act on all things in the void, including nuclei and nucleons. Both of these can be regarded as "Casimir cavities", to a greater or lesser extent, within which radiation waves longer than a certain wavelength cannot form, and which in turn lowers the ZPF radiation pressure inside the nucleus or nucleon (as the case may be) compared to the ZPF radiation outside. Thus unless the neuclei and nucleons are *completely* transparent to *all* wavelengths of radiation, the Casimir force *must* act on these particles.

The present paper demonstrates clearly that if we regard the atomic nuclei and nucleons as “Casimir cavities”, within which the pressure of ZPF radiation is not as high as it is outside—and I think it is abundantly clear that we *must* do so—then the Casimir force which also *must* act inward on these particles would by itself be of an order of magnitude which might suffice to explain why protons in a nucleus, or quarks inside a proton, do not push themselves away from each other, due to their like charges, and thereby cause the nucleus or nucleon (as the case may be) to fly apart due to all the positive charges inside them repelling each other.

If on the other hand one asserts that there is no ZPF, or that it can be subtracted away—as is done by many physicists today [9]—then one must explain the Casimir force in some other way. (The Casimir force does at least *exist*, as Lamoreaux's experiment shows). Indeed one must also explain why its measured value agrees so well with its value calculated from the equations of QED. But this is not done.

One way or another, the “strong nuclear force” would seem to be in trouble. Either it must be abandoned as an “explanation”—even though it may be retained for “book-keeping” purposes—or else its presently-accepted value must be revised downwards: and that too, it would appear, by a considerable amount. (Indeed the downward revision of the strong force might have to be so great as to make the strong force actually repulsive inside the nucleus! Somewhat like landing a sailplane with a 50-knot landing speed in a 100-knot headwind. One would then have to land the plane while it was moving *backwards* with respect to the runway!) Logically, therefore, there seems to be no other choice than to recalibrate the “strong force”.

AVENUES FOR FURTHER INQUIRY

It is of course clear that the arguments presented herein depend on several as-yet-untested assumptions, and as a result cannot be dignified yet by the name “Theory”. And for the purposes of a “Grand Unification of Forces”, it also needs to be precisely established just *how* gravity can be said to be a manifestation of the ZPF (which in turn results from the electro-weak force.) Puthoff *et al*. [7] have given a very plausible and decent enough explanation for the mechanism whereby the interaction of the ZPF with charges within it give rise to a gravitational force which is much weaker than the electro-magnetic force; but this explanation has yet to be put to the test thoroughly.

In addition, it needs to be examined if the Casimir Effect is indeed due to the explanation given for it. If there is some other explanation, the arguments given in this paper may not be valid.

Further, it remains to be determined what the cut-off point for the shorter wavelengths of ZPF radiation is in reality. (As mentioned earlier, the cut-off point for longer wavelengths does not seem to be too important, since the longer the wavelength the lower the energy of the corresponding photon.) Indeed, this cut-off frequency may well determine the actual “size” of electrons and quarks. As the quark or electron decreases in size below that of the cut-off frequency, the Casimir force acting on it would decrease with decreasing size, while the maximum possible Coulomb force—*i.e.*, of part of its charge acting on the rest of the charge—would increase. At some stage, then, the two forces would come to a state of equilibrium, and that would, perhaps, determine the “size” of that particular particle.

However, as Puthoff *et al*. have surmised [7], it is possible that there does not so much exist a cut-off *frequency*, but rather a cut-off *resonance*, which differs from particle to particle at the sub-atomic level, and which of course is different for particles combined into a larger whole than it is from the sum of the resonances of the particles when they are separate; and this might explain, for instance, the behaviour of quarks inside the nucleus more accurately than the postulation of a cut-off *frequency*. Perhaps quarks bound to each other inside a nucleon resonate with the ZPF in a way different from the way each would resonate with the ZPF were they capable of existing independently, and that may in some way go towards explaining why quarks cannot exist for any appreciable time outside a nucleon.

And moreover, as said earlier, the ZPF does not consist *only* of radiation but of other kinds of forces as well, although as noted earlier also, radiation certainly predominates. All the same, it still remains to be determined to what extent the other forces in the ZPF also contribute to the Casimir Effect, which in turn might also account for the exact amount of force with which the sub-atomic nuclear particles are held together.

CONCLUSION

It is to be expected that with further examination, the hypothesis presented in this paper will either be disproved conclusively, or else it will become harder and harder to disprove. (It is unlikely that *any* hypothesis can be *proved* conclusively, and indeed it is to be hoped that *no* hypothesis ever will, because if it were, there would be no scope for scientific improvement in that specific field!) It is also to be expected that the present hypothesis will be refined as time goes on. Nevertheless, given the fact that the present hypothesis does explain many phenomena, it seems worth while pursuing its investigation with considerable vigour, particularly in view of the fact that the "Grand Unification of Forces" is the Holy Grail of present-day physics.

Of course even if it turns out that the present hypothesis *cannot* be conclusively disproved, it still will not explain *everything*—for example, it will not explain why Quantum Electrodynamics and General Relativity are so very incompatible with one another—but it may all the same offer us a more satisfactory view of the material aspects of the knowable Universe, which in itself would be a step farther along in our general understanding of the Universe as a whole.

ACKNOWLEDGEMENTS

This paper would never even have been conceived, let alone written, but for the pioneering work of H.E. Puthoff, A. Rueda and B. Haisch in their attempting to derive inertia from the ZPF. Thus it is with grateful acknowledgement to them that I close this paper.

REFERENCES

[1] "Advances in the Proposed Electromagnetic Zero-Point Field Theory of Inertia", Bernhard Haisch, Alfonso Rueda and H. E. Puthoff, Physical Review Letters, Vol. 78, No.1, 1997.
[2] Marc Millis, article entitled "Warp Drive, When?" (http://www.lerc.nasa.gov/WWW/PAO/html/warp/possible.htm#vac)
[3] Milonni, P.W., (1994) The Quantum Vacuum, Academic Press.
[4] S. Lamoreaux, Phys Rev Lett, 78, p5 (1996).
[5] Stein, B. P. Physics Update. Physics Today 48, 9, Oct. 1995.
[6] The Magnitudes of Physics, George Goth, Skyline College, San Bruno, California, http://prisma.foe.calpoly.edu/physmag.html (as of March 11, 1999).
[7] "Physics of the Zero-Point Field: Implications for Inertia, Gravitation and Mass", Bernhard Haisch, Alfonso Rueda and H. E. Puthoff, Speculations in Science and Technology, Vol. 20, pp. 99-114, 1997 (preprint version).
[8] Sakharov, A. "Vacuum Quantum Fluctuations in Curved Space and the Theory of Gravitation", Soviet Physics - Doklady, Vol. 12, No. 11, 1040 (1968).
[9] "Advances in the Proposed Electromagnetic Zero-Point Field Theory of Inertia", Bernhard Haisch, Alfonso Rueda and H. E. Puthoff, Revised version of invited presentation at 34th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Cleveland, Ohio, July 13-15, 1998.
[10] Private correspondence *via* e-mail dated March 22, 1999.