BORN:

A

universe

II

Hans Gennow

In our earlier book we showed how the fundamental particles protons, electrons and neutrinos could be created out of vacuum through a fundamental quantum mechanical process without violating the conservation laws of energy and momentum. This leads to a universe where we specially noted that galaxies were formed with a massive core. The predicted mass range fits well with present observations

However, we could not explain why there should be three forces except the gravitational one although we did put forward a hypothesis that the forces are determined through the gravitational force. We can now show how this can come about through yet another fundamental quantum mechanical process. This means that we can determine the magnitude of their couplings. We note that the agreement is quite good.

If we let the value of the gravitational constant vary, we find that the strong force exhibits a minimum right at the present value of the gravitational constant. We have carefully checked our procedure to be sure that we do not generate such an effect in some way. This is a quite remarkable finding which we discuss in the text since it is a bit lengthy. However, we can mention a strange outcome, namely that if the value of the gravitational constant would have been different from its present value, life as we know of most likely would not exist.

If the mentioned minimum is right, then we can deduce the magnitude of the couplings of all the four forces. A truly unexpected result. At present we have no explanation for this result.

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Part I.

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Part I

The creation of the fundamental particles.

0. Introduction.

In our earlier book (Born: A universe, available as a PDF on our site, www.gennowdata.se) we presented a method to produce the standard fundamental particles protons, electrons and neutrinos out of vacuum without violating any laws of physics.

Based on this we showed how a universe could be build. It leads to a universe with galaxies having a massive core in the centre. The expected range of masses of the cores seem to fit well with present observations. Furthermore, we found that phenomena like dark matter and dark energy have quite natural explanations. We called are model “the Freezening” because it resembles the process where water freezes to ice.

However, we could not explain why there should be exactly three forces except the gravitational force. We made the hypothetical suggestion that it is the gravitational force that is the creator. We argued that the gravitational force is the most fundamental one since it is needed to conserve energy. The problem is how such a feeble force can give rise to the tremendous span of the strengths of the forces.

Just think that a bubble creates a pair of electron-positrons that immediately annihilates into a pair of photons. What would prevent them to just disappear into infinity thereby breaking the conservation of energy? The gravitational force must be erected before anything else happens. The question then is what effect it might have on what follows thereafter. It is this process we want to investigate.

In this book we will show how this may come about. This means that we can predict the magnitude of the other forces starting off from the gravitational force.

The question we asked is what kind of mechanism can cause exactly three forces other than the gravitational one. There must be some mechanism because otherwise there could be millions of different types of forces.

There may be various ways of achieving this but the way me just mentioned felt more natural.

We will begin with a short résumé of the relevant parts of our last book concerning the creation of the fundamental particles. This is needed since the procedure we use is in principle the same as before. It is also needed for the understanding of what comes next. Please check out our earlier book for a more detailed description. In part I we will give you the fundamentals of how the different species of particles can be produced. In part II we will connect them together under the umbrella of the gravitational force.

Before we start we would like to mention that we use the rationalized SI system for units. We also would like to note that all calculations are made on a 64-bit platform, but precision is limited to a 32-bit one by software. We will notify you when we get into problems.

1. Global energy conservation and the gravitational force.

We all knew that things might hide under the surface of a lake. We will now discuss what actually can hide under another surface, namely that of vacuum.

There are always things going on in a vacuum bubble. Lumps of energy can be created as long as they return to their original vacuum state in a reasonable time. How do we know there are bubbles at all? The answer is the speed of light. If there were no bubbles, the speed of light would in fact be infinite. What happens is that the bubbles can absorb and reemit the light, but with a delay. An example. It takes light about 3ns (nanoseconds) to move 1 meter. If each bubble delays the signal by 10^{-15} seconds we would expect about three million bubbles per meter.

Now suppose that something is created and flies away. What will make them return? If they don't they will in fact violate energy conservation. We cannot prove that energy conservation must hold but it is plausible.

Axiom 1.

> **Global energy conservation.**
>
> The total energy of a system that is not under influence of external forces is constant. There can be no net flow of energy in any direction.

Note that we have extended the normal definition of energy conservation. We need some kind of a universal force, the gravitational, that assures that whatever is produced will eventually return back. The question is how such a force could look like. One could think of several possible ways but nature will just do what is needed. Nothing more.

In fact, such a force could have a simple $1/R^{\alpha}$ dependence. Well, we already know this but there is no way to tell what it actually should look like. We can only make it plausible.

We could argue that this force, if having just that R dependence, should have $\alpha=2$, nothing else. If α is smaller the force will not be strong enough, if it is larger it would be over kill.

2. Local energy conservation.

In a world with only global energy conservation, strange things will happen. E.g. two cars in a straight head on collision could end up besides the row in the same ditch, while we intuitively would expect them to end up in different ones at least. Well, this is in fact the conservation of momentum we have in mind.

If they end up in the same ditch, it would mean that something else has to compensate the missing momentum. The earth itself, presumably. However, if there instead were two space ships somewhere in empty space, what would then cause the compensation? We would in fact need a speed of interaction that is infinite. If not, we would break global energy conservation.

We therefore need local energy conservation as well.

Axiom 2.

Local energy conservation.

Axiom 2 holds at any point of interaction.

.

A direct consequence of Axiom2 is the Newton laws of mechanics.

3. The characteristics of matter.

A question we cannot answer is that of the existence of something we call the nature. This may lead to the discussion of something divined, which is not part of our profession. We must assume that something, whatever it is, can be created. This something we call energy or lumps of energy. In short energy lumps.

When lumps of energy are released in a vacuum bubble, there must be a local force that prevents them from just flying away. Local energy conservation must be fulfilled. To achieve this, we introduced the characteristics of the energy lumps.

Axiom.

The characteristics of energy lumps.

Every lump of energy has a property we call its characteristic Ç. Ç is always produced together with its anti-characteristic Ç* and fulfils the relation

$$Ç + Ç^* = 0.$$

This means that they eventually will annihilate completely. Furthermore, we associate with every Ç a quantum number of unity.

.

The reason for a number of unity is that a measurement of Ç should result in one unit of this property. The characteristic is a quantum mechanical property and when quantization takes place its z-component (the normal choice) can show up in three different states, +1, -1 and 0.

It is the characteristic that gives rise to the force that prevents the lumps from flying apart.

4. The mechanism.

What can be produced? Let's call it Q (Quo Vadis), whatever it is. Now, say a couple of Q's are produced. As we went through earlier, a force is erected between them and they will eventually come together and annihilate. Nothing left. No success.

Let's try again. A pair is again produced but just before they smash into each other upon return another pair is produced at the same spot. Off course we could expect that these guys might collide, and we assume it is done in such a way that one couple gets extra energy and flies away. The other pair loses energy and gets trapped into a bound state. We picture this process in Fig 4.1

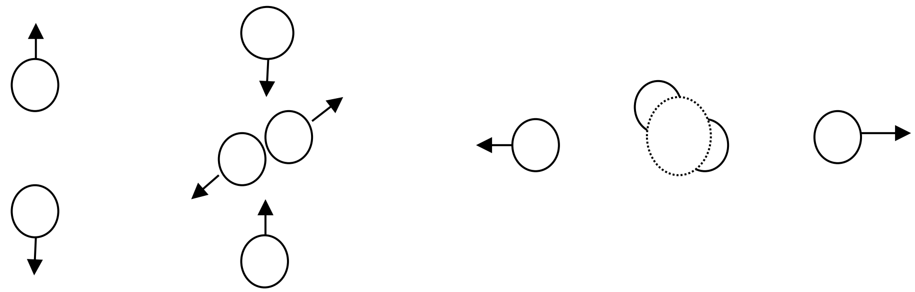

Fig. 4.1. The formation of a bound pair.

The bound pair cannot annihilate because if they did, we will be left with negative binding energy floating around and no force present. This is impossible.

The process must be a bit more complicated because the bound pair gives rise to an angular momentum that was not present from the beginning. We could compensate for this if the two objects acquire a spin upon the collision. If the spins are aligned, the rotational angular momentum could be compensated. The question is whether the spins can match the orbital momentum. In an atom they do not.

Another way would be to add another couple, created in parallel with the first one and which ends up in a bound state rotating the other way so that the net angular momentum will be zero. We now in fact have three couples, one of which escapes and two is left. What prevents the remaining couples from colliding and annihilating?

If the force that attracts a pair of Q's is a plain central force the two pairs that are left could be expected to start to attract each other with a catastrophic outcome. If the force on the other hand has a magnetic type of component that can be used to keep them apart. The nature of such a force is in fact just like the electromagnetic force.

Unfortunately, in the electromagnetic world the magnetic field can never exactly compensate for the electrical force. Only if the objects move with the velocity of light this can happen. However, if the objects have a spin, acquired through the collision, with an associated magnetic field that can be used to get full balance. An electron would thus do the job, and this will be our working hypothesis. We call this the balance act.

What says that we can have a pair in such a bound state? If the Q really is representing the electromagnetic force we already know that an electron-positron pair cannot be in a stable state (positronium). Another problem is that the energy is far from enough in such a system to be useful. The objects must be very close to have enough energy, in fact they could even overlap.

To investigate whether they can form a bound state we used the Dirac equation since it is a relativistic wave equation also considering the spin of the electron. The problem with such equations is that they only hold for point like particles. In our case the particles produced are really close to each other and can in fact overlap. They will not look like points.

To get around this problem we calculated an effective potential due to the overlap and used that when solving the wave equation. Since the force is radial we can always do this. We must account for all effects that are different from those of a point. We repeat the details of the calculations in the Appendix. We will, with a slight modification, also need them for the next step in part II.

In short, we find a correction to the Coulomb potential to mimic points. The correction is determined by calculating the resulting force starting from some assumed distribution of points. If the density of points goes as the inverse of the radial distance, the produced electrical field will be constant with R inside the object. We found that this was an adequate hypothesis. For the details we refer to our earlier book.

We show in Figs 4.2-3 the correctional factors to the coulomb force for the electric and magnetic parts separately. We plot them as functions of the radial distance R/R_0, where R_0 is the radius of the objects. First, we note that if the objects were points, the factors would be identically 1 ($R>2R_0$ always).

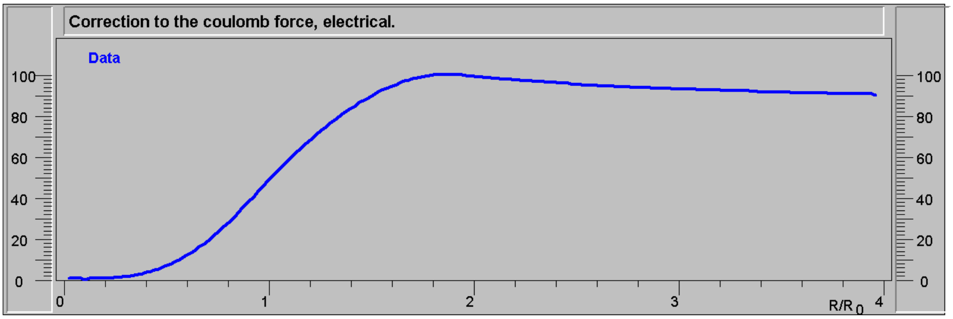

Fig 4.2. The behaviour of the correctional factor for the electrical part.

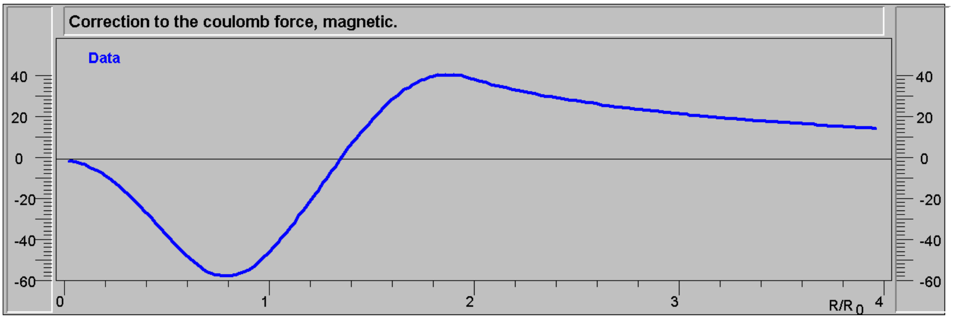

Fig 4.3. The behaviour of the correctional factor for the magnetic part.

We see that the electrical contribution in fact kills the force at small R, quite different from the coulomb force for points. The magnetic factor is a bit more spectacular. At smaller R it gives a force that is repulsive and for larger R attractive. To find the net effect we must add them together in the right proportions and apply them on the coulomb force, which we have done in Fig 4.4.

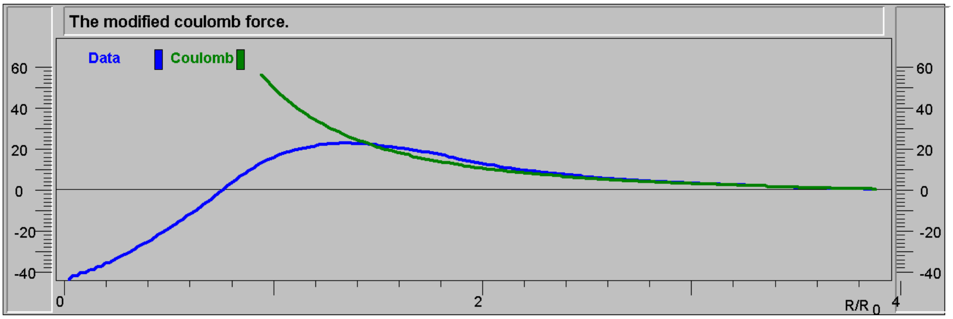

Fig 4.4. The effective force with the correction applied.

As we see the behaviour at small R is remarkable. The asymptotic behaviour of a point like coulomb force is gone. It could be interesting to see also how the net potential behaves. We obtain it by integrating the force (the electrical and magnetic factors separately). The result you find in Fig 4.5.

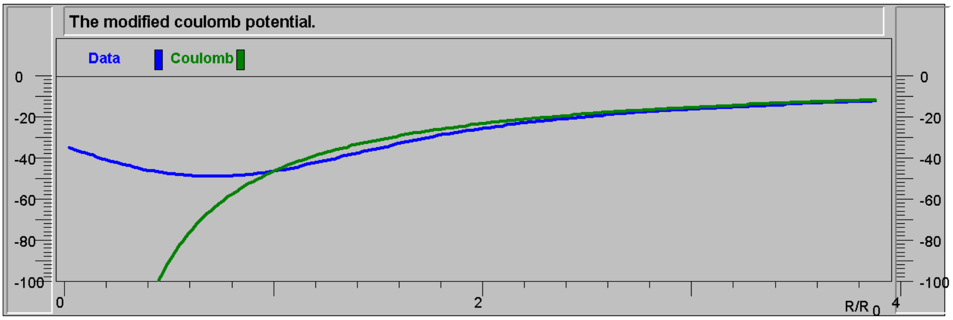

Fig 4.5. The effective potential with the correction applied.

We note that the coulomb potential now has turned into a shallow potential well. In the appendix we give further details on how to apply this factors to the Dirac equation. With these tools we are set to start to investigate solutions to the wave equation.

Since we do not know what kind of states there might be, we do an energy scan. This means that we calculate the behaviour of the wave function as function of the radial distance R and investigate how it varies with energy. More precisely we investigate how the tail behaves by taken a sample of it at large R and plot that quantity. Instead of peaks we are looking for dips.

The wave function should tend to zero with increasing R if there is a good solution.

To find a solution in the present case we must let the radius of the object also to vary. The result is presented in figures 6 and 7.

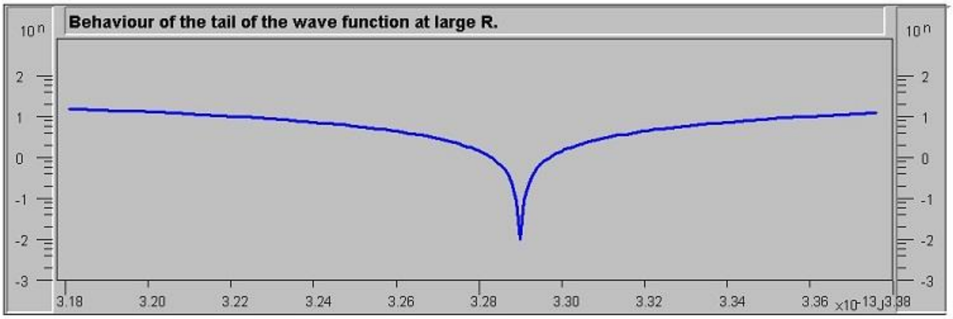

Fig 4.6. The behaviour as a function of the binding energy in units of joule.

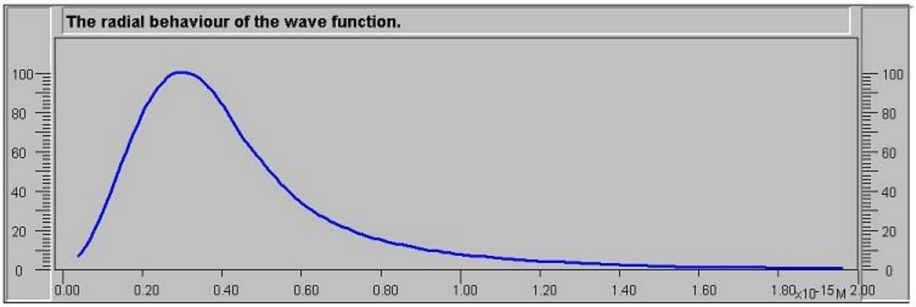

Fig 4.7. The radial probability density $R^2\Psi\ \Psi^*$.

The binding energy corresponds to four masses. This means that there is energy available to create one extra particle that leaves with a kinetic energy worth of one mass.

5. The three forces.

5.1 The electromagnetic force.

In the discussion above we used the electromagnetic force as an example. All forces must have the same construct, i.e. an electric like component as well as a magnetic like one. Otherwise they cannot be produced. This is the basis for our hypothesis of the gravitational force being the creator.

We have thus found a well-defined solution to the wave equation. We should perhaps clarify what we actually mean by the quantization:

Clarification.

> The quantization that takes place is a quantization of space. It is the size of the object that gets quantized. That results in a well-defined particle.

What about the particle mass? We made the following assumption:

Postulate.

> The electron is made up by a constant electric force field that is rotating. The spinning electrical field generates a magnetic field.

Exactly how the field lines are arranged we do not know. In the present case they will be radial. In another arrangement they might be perpendicular to the spin axis. You could perhaps think of it, as the field lines are standing waves fixed on the border. They might also form closed loops, which open up outside the electron. This is perhaps not in line with what you have been taught about the electrical fields, but who knows what rules hold inside of the object. Whatever we do it will not affect the Maxwell equations. What Maxwell concerns, the electron is a black box, just a charge of unknown origin.

The proof of our postulate is that if we calculate the energy content of the electron we find:

The properties of the electron.	Predicted	Measured
Radius [fm] Energy content [J]	.70±.03 .82±.04 10^{-13}	.818 10^{-13}

We had a look into other arrangements of the field than a constant one. We see difficulties in getting consistent solutions. At some point they seem to fail.

The solution to the Dirac equation determines the radius of the particle being investigated. From this we got the following result concerning the electron:

Conclusion.

The mass of the electron and its charge are dual to each other. From the one we can calculate the other, e.g.:

$$e = \sqrt{16\pi\varepsilon_0 mc^2 R_0}\ .$$

5.2 The strong and weak forces.

The important point in the production of particles is that the balance between the pairs works. The strong force must have a similar construct as the electromagnetic force. This means that we have strong charge and strong magnetism. The same holds for the weak force, weak charge and weak magnetism.

Since these forces interact through a massive exchange, the correctional factors will have to be treated slightly differently. The treatment is else the same as in the electron case. The following tables display our findings.

The properties of the proton.	Predicted	Measured
Radius, strong [fm]	.92±.05	-
Radius, electrical [fm]	-“-	.875
Energy content [J]	$1.53\pm.08*10^{-10}$	$1.50*10^{-10}$

The properties of the neutrino.	
Radius [M]	$2.9\pm.2\ 10^{-16}$
Interaction length [M]	$3.2\pm.2\ 10^{-17}$
Mass [J] ([eV])	$2.1\pm.4\ 10^{-20}$ (.13±.03)

The descriptions of the forces are given in the Appendix.

6. The gravitational force revisited.

6.1 The relativistic gravitational force.

The gravitational force is completely different from the other ones just noting that it depends on the masses of the particles interacting. The electromagnetic force does depend on the charge, but that is a fixed value (we are not talking about composite objects) the same for all charged elementary particles.

To be more correct, we have learned that particles consist of bound fields. This means that we expect the gravitational force to act on the strength of the fields, or their energy content. Consequently, we should use the relativistic mass of an object in the Newton gravitational law.

To clarify, we first note that the energy density of the field is proportional to the field squared. Since a moving field scales with the Lorentz factor γ we get a factor γ^2 (see appendix). However, for an object with a given size, its volume will be reduced by a $1/\gamma$ due to the Lorentz contraction, which means a net effect of γ, just as expected. That is, the relativistic mass goes like $m\gamma c^2$.

To find solutions to the Dirac equation we first assume that the gravitational force has an electric as well as magnetic component just as the other forces. We need it for the balance. The second problem is how to incorporate the gravitational force into the formalism of the Dirac equation. We give the details in the Appendix, chapter I.4. In short, we found the following expression for the force:

The general gravitational force.

$$
\begin{aligned}
&F = G'E_1E_2 * (1 - \bar{v}_1 \cdot \bar{v}_2 / c^2)/R^2 \\
&E = Mc^2 \big/ \sqrt{1 - v^2/c^2}\ , M > 0 \\
&E = h\nu, G' \to 2G' \quad , M = 0 \qquad\qquad (1) \\
&G' = G/c^4\ , \\
&G\ \textit{the gravitational const.}
\end{aligned}
$$

This means that the gravitational force acts indirectly on the other fields through their energy contents.

We note that we cannot prove that light can be included in the way given. It is just a plausible assumption. Photons have an energy content and we must expect that they should behave with respect to the gravitational force in a similar way as other objects build by fields. Furthermore, the question is how the gravitational force acts upon fast oscillating fields.

The factor 2 in the case of light comes about for the following reason. The energy density of the field goes like γ^2 as we discussed earlier. For an object without definite size, i.e. no rest mass, we would be left with that factor.

Let us clarify. We first note that if we bring an object from infinity to a distance R from a gravitational source M, its kinetic energy will, according to (1), be

$$E_k = GMm\gamma / R \,. \qquad (2)$$

The total energy E of that object is

$$E = mc^2\gamma = mc^2 + E_k \,. \qquad (3)$$

If we divide (3) by mc^2 we get using (2)

$$\gamma_L - 1 = GM/Rc^2 * \gamma_L \,,$$

or

$$\gamma_L = 1/(1 - GM/Rc^2) \equiv \gamma_G \,. \qquad (4)$$

This defines the quantity γ_G, which depends only on the gravitational field from another object.

If we take the square of (4) we will get to first approximation

$$\gamma_G^2 \cong 1/(1 - 2GM/Rc^2) \,. \qquad (5)$$

This means that the energy density of the confined field in an object scales with a factor that depends only on the given gravitational field. For an object with a definite size the Lorentz contraction reduces this to the factor (4), i.e. the total energy of the object goes like $m\gamma_L c^2$ as expected. For a mass less object, the total energy instead depends on (5).

Comparing the two expressions we see that instead of G for normal objects we should replace it by 2G for mass less objects.

We have compared with two classical experiments. Firstly, we have the bending of light in a gravitational field. Secondly the perihelion shift. It turns out that our predictions agree very well with observations. In fact, we arrive at exactly the same equations as comes out of general relativity. This despite the fact that our approach is completely different.

We note an interesting consequence of our formulation of the gravitational force:

Conclusion.

Light bends light.

This means that two photons can interact through the gravitational force. This result is not contained within the formalism of general relativity.

6.2 Gravitational structures.

Can there be particles formed by the gravitational force? To differentiate it from elementary particles, we would like to call it:

Definition.

A gravitational structure,
or a “Grav” in short.

If we compare the strength of gravitational and electric forces, the former would for an electron be about 10^{39} times weaker.

To get a feeling on how things behave, we first asked ourselves what mass two objects needs to have to produce a force that is the same as that between two elementary charges. The answer is approx. $2*10^{-9}$ kg. Quite heavy stuff compared to other elementary particles. The problem is that the object would have a radius of merely 10^{-36} m. Such objects would be more or less invisible!

If we instead go the other way around, i.e. we assume they have the same radius as the other particles, 1fm, their mass should be about 10^{12} kg. Just the mass of some thousands of super tankers!

The question is whether the gravitational force also has the same structure as the others. As we have discussed we need a magnetic component in order to fulfil the balance act. We are not used to think about this force in such terms, so it will be a challenge.

We describe in the Appendix how this force has been implemented into the Dirac equation.

It turns out that the situation is quite complex. In the example with a mass of $2*10^{-9}$ kg we can in fact find a nice solution but again with a tiny radius of $2*10^{-36}$ m. The problem with such a solution is the small radius. The density of such an object is enormous compared to other particles.

If we increase the mass by a factor ten we again get a similar solution but now with a radius ten times larger. However, the background increases drastically, and the signal does not look as significant. But still a nice solution if you just zoom in on it.

As you see the situation is not quite clear. We need an additional constraint.

We just would like to make another interesting comparison. The density of an electron is of the order of 10^{15} kg/m3. The object with a mass of $2*10^{-9}$ has a density of 10^{99} kg/m3. The question we now asked is to what mass/radius should we scale the latter object to get a similar density as the electron? The answer is an object of mass of about 10^{45} kg and a radius of 10^{20} m! Like a small, heavy galaxy or a giant black hole.

Having all this in mind we come to the following:

Conclusion.

> We cannot tell whether gravitational structures may exist or not. There are indications, but the results do not look reasonable.

This is the conclusion we made in our earlier book. In part II additional findings might give us a clue on the subject.

7. Summary part I.

We have shown how the most fundamental particles can be produced out of vacuum, through a fundamental quantum mechanical process, while fulfilling the conservation laws. As a consequence, the process leads to deeply bound pairs of particle-antiparticles. The binding prevents them from annihilating. Just like atoms, but now on a different scale.

In our earlier book we showed how a universe can be build based on these processes. We especially noted that galaxies are formed with massive cores build from the bound pairs. The predicted masses of the cores fit well with present observations of black holes.

In part II we will discuss how the three forces can come about.

Part II

The creation of the fundamental forces.

0. Preludes

We have in part I given you the background of the creation of the fundamental particles. As you have seen we have assumed that they have a similar structure, namely that they are composed of electric and magnetic like components. We needed this to create the fundamental particles through a quantum mechanical process (the balance act made this possible, chapter I.4).

If the forces have a similar structure the idea that they were generated by a fourth force came along. That one is the gravitational force. The gravitational force is needed to sustain global energy conservation and thus the most fundamental force.

Just imaging that a pair of electron-positrons are produced that annihilate right away. What would prevent the photons from just escaping thereby violating energy conservation? We need the gravitational force. It must always be erected when objects are created out of vacuum and we will next discuss what the consequences can be.

1. The mechanism.

In part I we presented a scenario of the creation of objects out of vacuum. We called them lumps of energy or energy lumps in short.

This led to the creation of e.g. electrons (/positrons) whose sizes we could determine by using the Dirac equation (the masses were then given by a simple picture of the particles in form of confined fields). Bound pairs of electrons and positrons were formed while another couple acquired enough energy to escape.

This time we are looking into the process that precedes the one where the particles are created. This means that we are investigating the mechanism that could determine which species of particles can be produced, i.e. protons, electrons or neutrinos. Due to the assumption of an associated quantum number of unity (chapter I.3) we expect three forces. More specifically, we would like to calculate the strength of these forces. The elementary particles are created in the step that follows this initial process.

As we discussed in our earlier book the gravitational force must be erected when lumps of energy begin to form. This to fulfil global energy conservation. Thus, we will investigate the gravitational force by making the picture of two virtual gravitational structures (Gravs) that blow apart and investigate the quantum mechanical behaviour of such a system. A Grav is a gravitational object just like an electron is the fundamental object of electromagnetism. We investigated the possibility of gravitational structures in our previous book but could not make any conclusions of their existence. We were lacking a needed constraint. This time we might have found that constraint.

The picture is that a gravitational field is erected and leads to three quantized states. In this field particles are formed accordingly and along the description we gave in our earlier book. The states we find we associate with the different forces. It is not the question of any bound states as in part I.

In part I, Fig 4.1 we showed how particles may be produced. A bubble explodes and a pair of particle-antiparticle flies away. However, the gravitational force will make sure that they return to fulfil global energy conservation. Upon return they might collide by another couple just opening in such a way that one pair acquire energy to escape the scene while the other pair gets trapped into a bound state like an atom.

We are thus investigating a linear problem and the procedure is that in this case we will use the Klein-Gordon equation implemented on a Coulomb like potential. The treatment is quite like the case in part I, namely we take into account the size of the virtual objects. This lead to correctional terms that modify the force. The procedure transforms the force into a nice function, i.e. no singularity at R=0. The details are described in the appendix.

The question is what masses these virtual Gravs must have or more correctly, what strength the gravitational force must have to be able to create the other forces. To cover all known forces the strength of the force must be at least as that of the strong force when the formation starts. This is our first assumption. We will discuss below the consequences if we change that criteria.

2. The procedure.

As we did in our earlier investigation we considered the size of objects. This lead to the calculation of correctional terms to be applied on a coulomb like force. The wave equation is simply modified with these terms so that it is applicable on sizeable objects and not just points. We use the same technic now with the difference that the objects just move longitudinal and not in a circular orbit. We give the details in the appendix. There will be one factor for the force and one for the potential. We have assumed that gravitational structures, Gravs, will have an “electrical” and “magnetic” component like the electron and a spin. Thus, there are four factors in all, but the electrical and magnetic components can be added up in their right proportions.

In fact, in our earlier book we assumed that the strong, the electromagnetic and the weak forces have a similar structure. We need this to have the gravitational force to give rise to the other forces.

We have two unknown parameters, namely the radius of the virtual object and its mass. From the solutions to the Dirac equation of a bound pair of the fundamental particles we found that the binding energy were a factor four times the mass. Due to the Lorentz factor this might change but the exact value is not important in the following. From expression 6.1.1 in part I the potential energy for two alike objects with one fix and the other circulating around is

$$U = GM^2 \Big/ [R * \sqrt{1 - v^2/c^2}\,]$$

This means that, using the binding energy E_b=4Mc^2, we have

$$M^2 / R \propto M \ ,$$

or:

$$M \propto R. \qquad (1)$$

We want to investigate the behaviour of the effective coupling. As seen we expect it to be proportional to R^2 for a given binding energy. We therefore investigate the density $R^2\ \Psi\ \Psi^*$ as function of R. The Lorentz factor is implicitly included through the correctional factors as described in the appendix.

In the case of the strong coupling we would expect an object with mass and radius of order 10^{-8} Kg and 10^{-35} m respectively. More specifically, we require that the construct

$$GM^2 \Big/ \sqrt{1 - v^2/c^2}$$

be equal to the strong coupling at R=0 (one object is at rest). We evaluate it from the calculation of the correctional factors, see Appendix. The parameters must be chosen so that they fit with the strong force. The correctional terms are then calculated according to that prescript and implemented into the wave equation.

To explain the procedure in more detail, we make an analogy with the hydrogen atom. We have a look at the third orbital state and plot the radial density in fig 1.

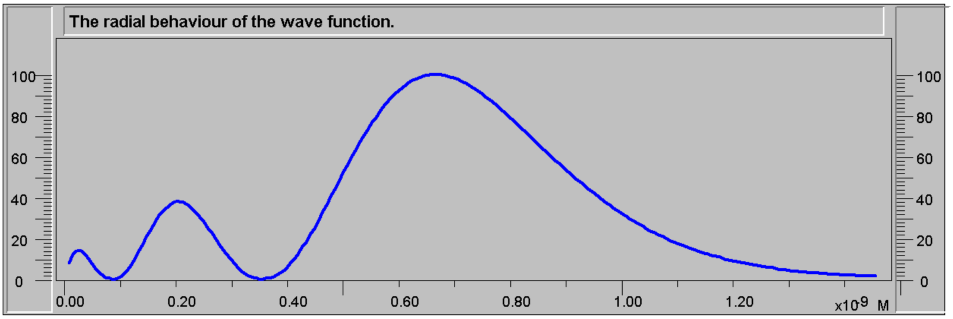

Fig 2.1. The probability density $R^2\ \Psi\ \Psi^*$ for the third orbital state of hydrogen.

As seen there are three signals and not just one. What happens is that the electron in the third level has a probability to be found in the lower levels. An electron could emit a photon spontaneously and drop down to a lower orbit. The probability for these transitions we find by first integrating the peaks and then take the square of these numbers. See any textbook on the subject, e.g. [1].

We show in fig 2a and 2b the radial distribution for the present case, again the third state. We see that we have three peaks corresponding to the three states. We divided them into two regions in R due to the enormous span of magnitudes of the peaks.

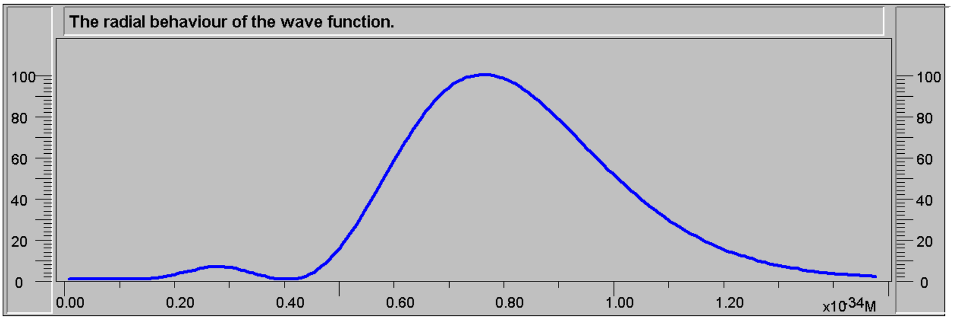

Fig 2.2a. The probability density $R^2\ \Psi\ \Psi^*$.

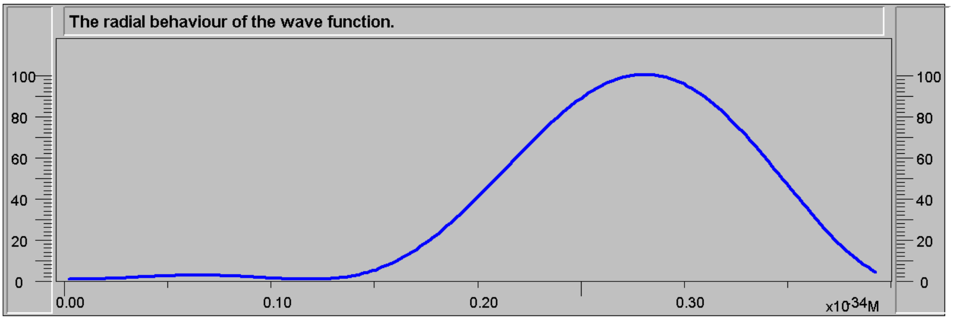

Fig 2.2b. The probability density $R^2\ \Psi\ \Psi^*$, but for lower R.

As you see it looks quite similar to the hydrogen case, except for the magnitude of the peaks. Their relative sizes differ quite substantially.

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However, we cannot directly compare the hydrogen case with the present case since we are not dealing with bound objects circulating around each other. We are instead investigating the behaviour when we drag apart two virtual objects. What we can do is to read off the probability to find the virtual objects in the various states just as in the atomic case.

In doing so we note that the peak at the largest R corresponds to a larger energy and therefore to a stronger force which we take to represent the strong force. We need more energy and a stronger force to drag them further apart. This means that we can investigate transitions to the other states with lower energies. The middle one would then correspond to the electromagnetic force while the one at the smallest R represents the weak force. This is our hypothesis and the outcome of the calculations will show whether this is reasonable.

If you are still in the atomic world one would expect a larger R to correspond to less energy. However, in our case you should rather think of a string or rubber band that is being stretched, the more the more energy needed.

We integrate the peaks and take the square of these numbers. We compare them by dividing the two larger peaks and the two smaller ones. The result are two fractions which we compare to the ratio of the strong over the electromagnetic couplings respectively the electromagnetic over the weak. It turns out that the fractions come close to the expected ratios.

However, the parameters are not completely fixed by this procedure why we need another constraint. We have investigated this in two ways. If the virtual objects become real, we can require that we achieve a good solution to the Dirac equation. This means that the presumed gravitational structures, Gravs, should give a reasonable solution just as is the case for the standard elementary particles. It turns out that our precision is not good enough to make any definite conclusions. The reason for this is that the energy is very large which means we are close to the classical limit with weak, broad signals. In any case we noted in our earlier book that the wave equation is not very selective in this case. We will come back to this later.

Another way would be to simply require that the electromagnetic to weak ratio comes out as expected. We only need a smaller adjustment to achieve this. We would like to find some way to relax this criterion. It turns out this can be achieved but in a very unexpected way.

The spin of the virtual Grav is determined in the same way as we did for the other elementary particles, namely a point on the boarder is set to the velocity as given from a trapped, bound couple. In the case of the other forces the velocity of the boarder corresponds to a Lorentz factor of 3. We now see that we might expect a somewhat larger value as indicated by the solutions to the Dirac equation. But, as noted, we cannot give a definite answer, so have investigated two cases (3 and 4) to be able to see if there is any difference in the result. We will discuss this in chapter 4.1 as well as have a look on what happens if they do not have spin.

The procedure is to choose a combination of R and M that gives rise to a certain value of the strong coupling G_Y (defined in Appendix I.2) and a certain value of the strong to electromagnetic ratio. We choose R and M such that the second ratio, the electromagnetic to weak, comes out as well as possible.

[1] Eugen Merzbacher, quantum mechanics, John Wiley & sons, Inc, 1961

3.Results.

We solve the Klein-Gordon equation for the case of dragging apart two sizeable virtual objects to investigate the effective coupling. We thereby account for the correctional factors as explained in the appendix. As we did in our previous book, we do an energy scan to find signals. This means that we calculate the behaviour of the wave function as function of the radial distance R and investigate how it varies with energy. More precisely we investigate how the tail behaves by taking a sample of it at large R and plot that quantity. Instead of peaks we are looking for dips. The wave function should tend to zero with increasing R if there is a good solution. We show in fig 3.1 how it can look like. As expected the outcome will be a series of signals. The requirement of a quantum number of one will limit it to the three highest ones.

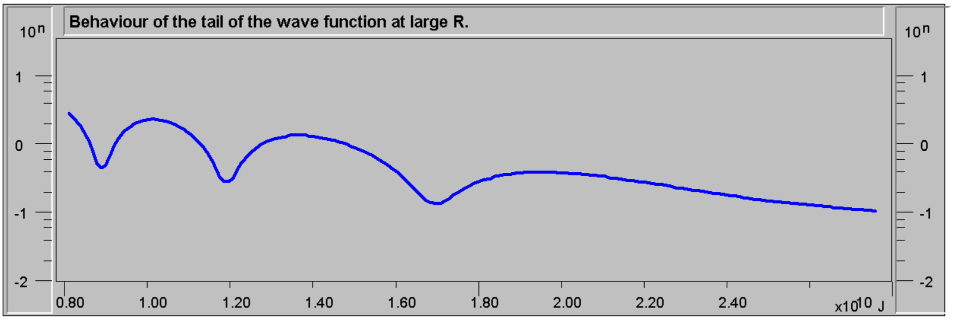

Fig 3.1. The behaviour as a function of the binding energy in units of joule.

Compare this to fig 4.6, part I and please note the difference in the scale of the energy. The signals are now much wider and the background level larger. If we just zoom in on them, the distribution in R looks quite reasonable but still not as nice as in fig 2.2. That one was taken at lower energy where background is smaller. The largest peak is affected by the background which leads to a subtraction method which we describe in the appendix.

For every chosen combination of R and M we get a value for the Yukawa coupling G_Y. We plot the square root of the calculated ratio of the strong to electromagnetic couplings normalized to the expected ratio of the couplings. In doing so we have chosen the parameters so that the electromagnetic to weak ratio comes out more or less correctly, but we are dealing with small adjustments (< 5%). The reason for taking the root is just historical. It gives numbers of the order 50-100 for the values of the ratios which are a bit easier to handle. The visualization also is improved as seen from fig 2 where the result is presented. The region below the line in fig 2 is easier to disentangle.

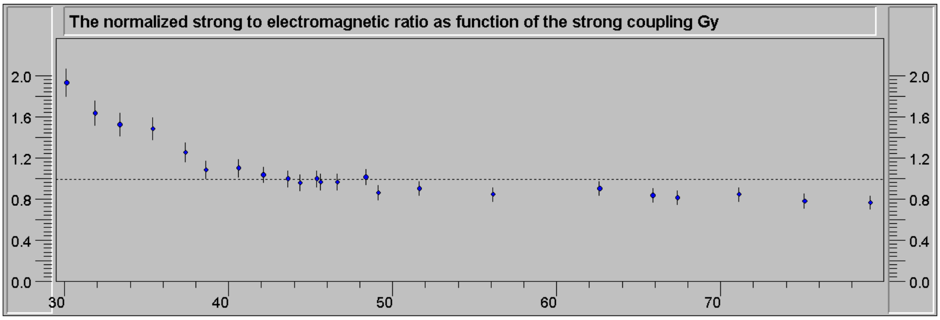

Fig 3.2. The root of the ratio of the strong to electromagnetic coupling divided by the expected ratio.

The ratio shown in fig 2 is expected to be one. This is shown by the dotted line. As seen we have a distribution that first drops off rather quickly but more gently after the cross over. For values of the Yukawa coupling G_Y less than about 30 the curve blows up above 2.

We see that when the strong coupling is about 44 the calculated value agrees with the expected one (by eye, we have not tried any fit since we do not know what the behaviour should be). In the cross over region the electromagnetic to weak ratio comes out to the expected value.

We discuss in the appendix the procedure to extract the values shown. It involves corrections due to background. Such corrections are larger for smaller values of G_Y but drops to essentially zero at the largest values. The electromagnetic to weak ratio cannot be kept quite at its expected value for larger values of G_Y which leads to corrections that works the other way around (< 5%). We give the details in the Appendix, but we show in fig 3.3 how the electromagnetic to weak ratio comes out.

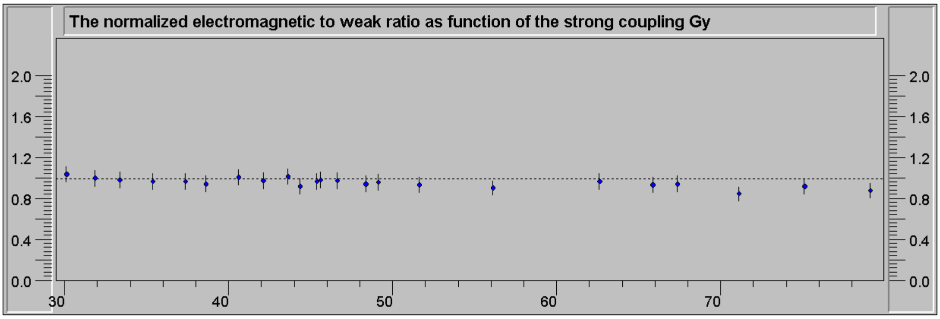

Fig 3.3. The root of the ratio of the electromagnetic to weak coupling divided by the expected ratio.

At the crossover the gravitational object comes out to approximately a mass of $1.9*10^{-8}$ kg and a radius of $1.7*10^{-35}$ m. This is very close to the Planck scale. We see that the signals are becoming quite wide when we come up in energy as expected. We are approaching the regime of classical physics. We could mention that if we use the radius and mass of a Planck object, the Yukawa coupling G_Y would come out to 90.

To confirm are model an experimental finding of such kind of objects would be welcome. We discuss below a possible experimental setup.

It is interesting to note that since we have one unique solution for the value of G_Y we can in principal determine the electromagnetic coupling and hence the weak coupling absolutely. However, the result depends on the ratio of the electromagnetic and weak coupling constants. If that is different the curve will shift a bit to the right or the left. Perhaps a unit or two. We need another piece of information which we will discuss below.

We summarize the result in the following table where we compare to the expected ratios of the known values. The expected value of G_Y we have estimated from [1] at the threshold for nucleon production. The energy dependence is quite strong in this region which makes the expected value a bit difficult to determine.

Relative probabilities	calculated	expected
Yukawa coupling G_Y	44±3	38-43
Ratio of strong to electromagnetic	$5.6\pm.3*10^3$	$5.48*10^3$
Ratio of electromagnetic to weak	$1.09\pm.04*10^4$	$1.117*10^4$

This result is a bit surprising. The values fit quite well with expectations. Nothing says that this should be possible at all. We should clarify that we have two parameters, R and M which we could let vary to adjust the electromagnetic to weak ratio to come out approximately right. We note that the effect of that adjustment is at most 5%, essentially at larger Gy.

The question is whether this is just a coincidence or not. We have three numbers, very different, that fit. What is the likelihood for that? It raises a lot of questions. If we use the distribution in R in the case of the hydrogen atom, the ratios come out about a factor 100 times smaller.

Off course we must be a bit careful before making too strong conclusions. Can this be achieved in another way? What happens if we change things a bit? We will try to sort this out in the following.

[1] The H1 and ZEUS Collaboration, V. Radescu, HERA Precision Measurements and Impact for LHC Predictions, arXiv:1107.4193 [hep-ex].

4. Discussion

We will investigate various questions that will arise concerning our result.

4.1 The dependence of the spin.

As we described in part I the particles created out of vacuum will acquire a spin through the collision they undergo. A point on the boarder of a particle is set to the velocity it has after the collision, i.e. as given from their bound state. The same holds for gravitational objects if produced. In the case of the other forces the velocity of the boarder corresponds to a Lorentz factor of 3. As we have seen, the solutions to the Dirac equation may indicate a larger value. However, the situation is not quite clear cut as we will discuss later. We therefore have considered two factors, 3 and 4.

We have tried out both scenarios, but we cannot detect any difference between the two cases. With a lower spin we need somewhat larger R and M so that the energy of the solution comes out about the same. The distribution in R exhibits a clear dependence on the energy (when we move over the range of values of the Yukawa coupling G_Y).

We also investigated the case with gravitational structures, Gravs, without spin. The behaviour looks much the same as in fig 3.2. The problem is that the electromagnetic to weak ratio is about 30-40% to low over the whole region and we cannot change it. This scenario is in other words of no interest.

4.2 The strong force.

The first question might be what the result would be if we used the strong force directly instead of fixing the gravitational force to the strong coupling.

The result is that the electromagnetic to weak ratio is off by a factor 2 about. The other ratio a bit less. This time everything is fixed why we cannot do anything about it.

We can now make the following:

Conclusion.

Only when we start off from our formulation of the gravitational force with a strength corresponding to the strong force we find good solutions to the wave equation where the relative strength of the forces come out right.

This means that our findings are not just circumstantial.

This also means that the requirement that the force at R=0 should be equal to the strong force is not the explanation for our result.

4.3 The Newton formulation of the gravitational force.

In our calculations we haves used our version of the gravitational force. What would the outcome be if we instead started off from Newton´s formulation?

It turns out that the value of the electromagnetic to weak ratio is too small by a factor 2 about. If we lower M the just mentioned ratio would come up but this would also hold for the strong to electromagnetic ratio which now would come out much too high. This means that if you look on fig. 2 the curve gets shifted to the left, more than a factor 2. In fact, G_Y of the cross over point seems to drop down below the experimental limit.

In all we can make the following

Conclusion.

The newton formulation fails to give the expected result.

Our interpretation is then that this result strengthens our version of the gravitational force.

The question now arises on how these results depend on the gravitational coupling itself.

5. The dependence of the value of gravitational constant.

What would happen if we changed the value of the gravitational constant? If we lower it, we must compensate by larger masses to come back to the original situation (the requirement on the coupling at R=0). If we increase it we must go the opposite way, lower the mass. If we make it four times stronger, we need to decrease M by a factor of 2 but also to increase R by the same factor. If we instead look at G/4, then M is increased by a factor 2 while the radius is decreased by the same factor.

We checked this out for the case of making it two times stronger. In doing so we have to make minor modifications of R and M to make the electromagnetic to weak ratio come out correctly just as before. The requirement that the force at R=0 should be equal to the strong force is always required to be fulfilled. We show in fig 1 and 2 the results for two cases, G*2 respectively G/2.

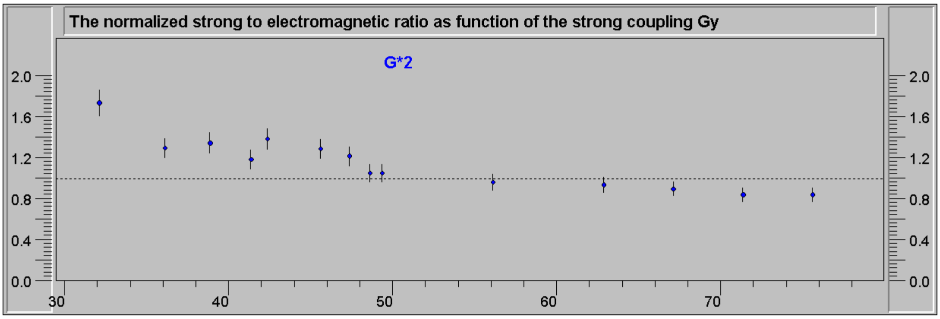

Fig 5.1. The root of the ratio of the strong to electromagnetic coupling divided by the expected ratio with twice the gravitational constant.

This looks much the same as in fig 3.2. However, the cross over point clearly shifts upwards. Exactly how this comes about is not quite clear. However, we noted earlier that we need a somewhat larger mass at smaller values of the Yukawa coupling G_Y than at larger values. This to avoid a too large value of the electromagnetic over weak ratio in the lower region. Since the mass now is smaller by a factor $\sqrt{2}$ this might be the cause. All points would in fact move up a bit, especially at lower G_Y, but perhaps not as much as in fig. 5.1.

If we on the other hand, make the gravitational constant smaller we need a larger mass. By the same argument we would expect the curve to shift down, fig 2.

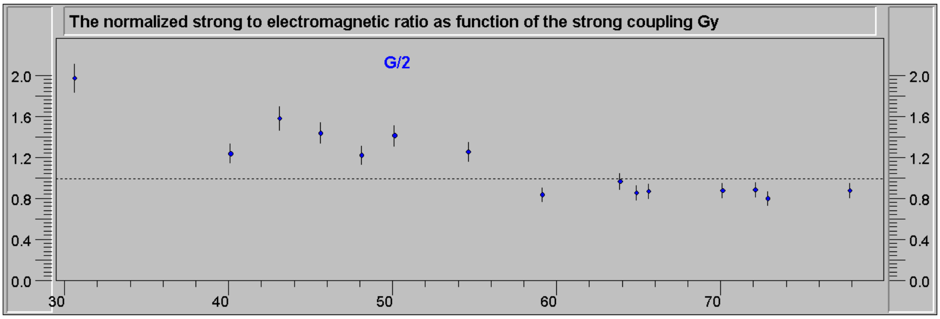

Fig 5.2. The root of the ratio of the strong to electromagnetic coupling divided by the expected ratio with half the gravitational constant.

Instead it again shifts upwards. This means that the explanation we just tried is not the answer. The mass now is larger by a factor √2. We got a bit puzzled when we saw the result. Furthermore, we note that the shift is in fact about the same.

We repeated the calculation making the gravitational constant four times stronger, fig 5.3.

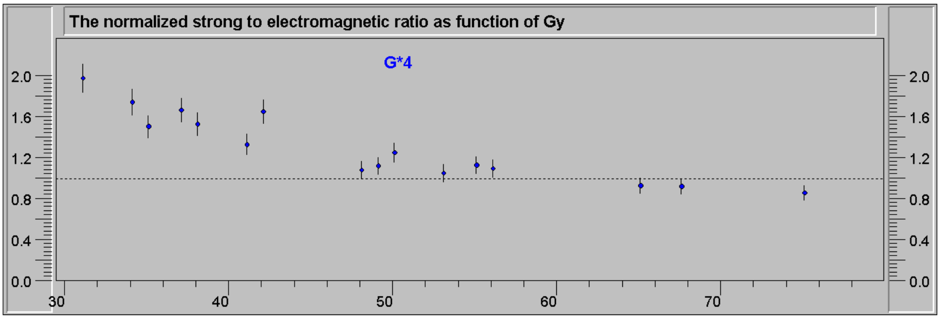

Fig 5.3. The root of the ratio of the strong to electromagnetic coupling divided by the expected ratio with four times the gravitational constant.

The crossover now perhaps shifts to slightly larger values of the Yukawa coupling G_Y. If we again make it weaker, G/4, we get the result in Fig 5.4.

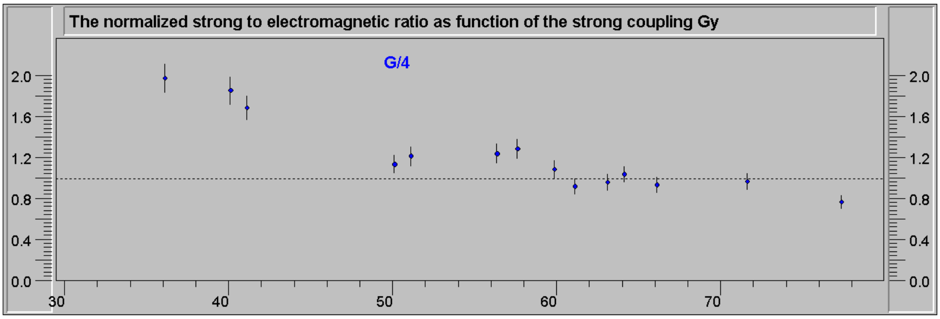

Fig 5.4. The root of the ratio of the strong to electromagnetic coupling divided by the expected ratio with one quarter of the gravitational constant.

The behaviour is the same as for G/2. The cross over seems to stay.

In this case we note that the energy is coming up quite drastically and hence the signals even wider. This makes it somewhat more difficult to get the electromagnetic to weak ratio right. We describe in the Appendix how to handle this situation. We are dealing with masses larger than the Planck mass. We are really at the end of the domain of quantum mechanics.

To confirm these results, we made two more sets, the first one for G*1.5 and G/1.5, figs 5.5 and 5.6.

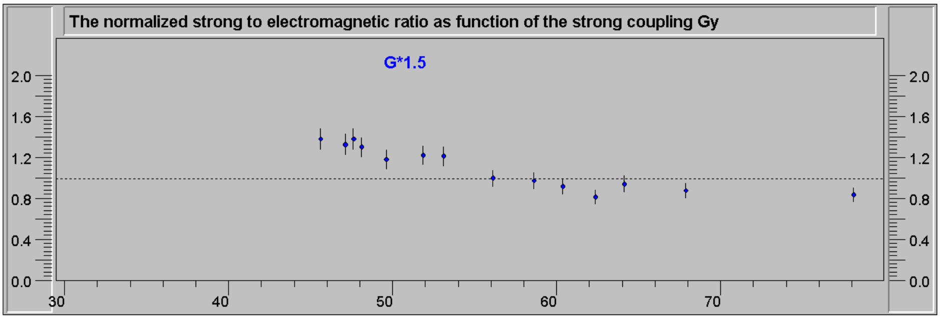

Fig 5.5. The root of the ratio of the strong to electromagnetic coupling divided by the expected ratio with 1.5 times the gravitational constant.

We clearly see a shift down of the cross over point compared to the last cases. The question is whether G/1.5 will follow, fig 6.

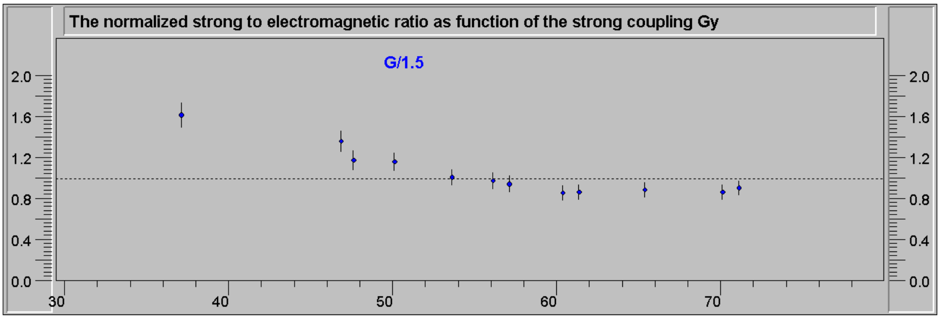

Fig 5.6. The root of the ratio of the strong to electromagnetic coupling divided by the expected ratio with the gravitational constant divided by 1.5.

We see the same behaviour as before, they follow each other. To confirm this behaviour, we made a last one with a factor of 1.2.

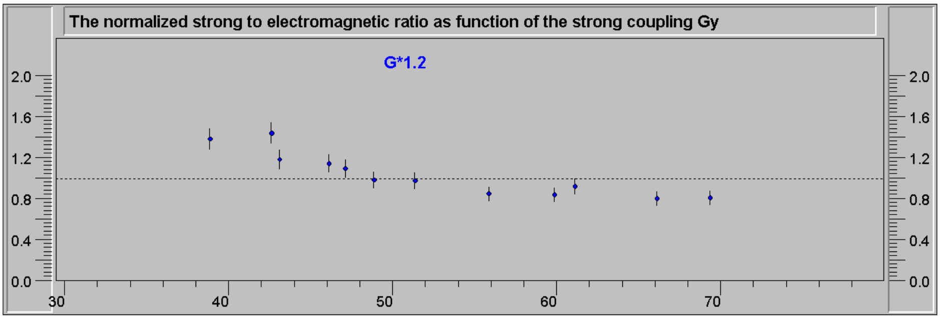

Fig 5.7. The root of the ratio of the strong to electromagnetic coupling divided by the expected ratio with 1.2 times the gravitational constant.

The curve is now shifted down even further. The G/1.2 case is shown in fig 5.8.

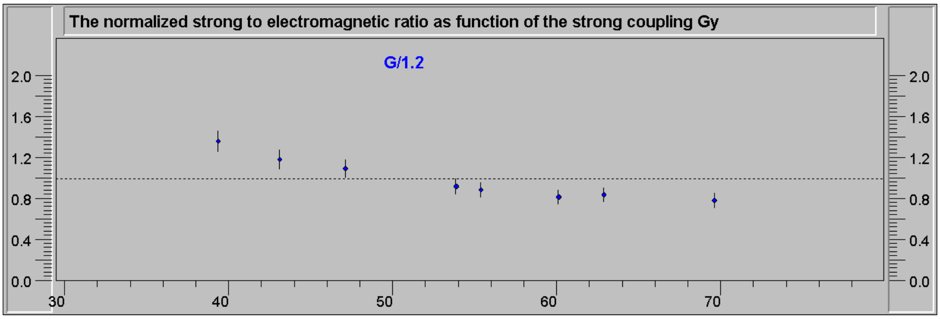

Fig 5.8. The root of the ratio of the strong to electromagnetic coupling divided by the expected ratio with 1.2 times the gravitational constant.

By now not very surprisingly the same behaviour, i.e. the cross over stays.

We can summarize the results in the following plot where we show the Yukawa coupling G_Y at the cross over point for the various values of the gravitational constant G.

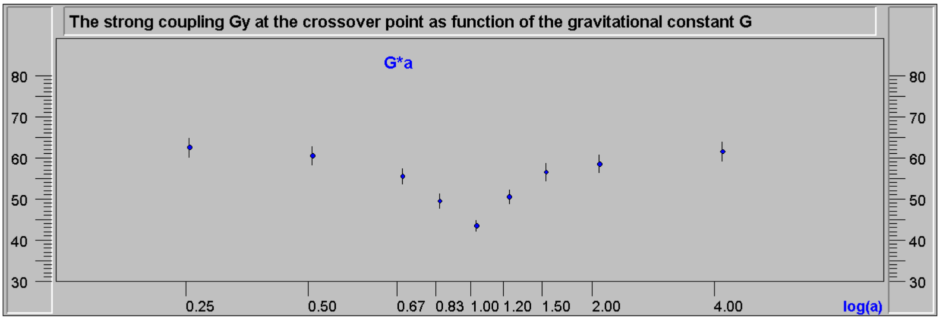

Fig 5.9. Yukawa coupling G_Y at the cross over point for various values of the gravitational constant. The abscissa is the log of the scaling factor.

It looks like we have a minimum at the nominal value of the gravitational constant. The shape of the curve does not look like a normal minimum with a rounded off dip. It rather looks like the behaviour of the solutions to the wave equation with the dips in the energy distributions. The question we asked ourselves if the behaviour in fig 5.9 represents the solution to the wave equation but for a potential representing the combined effect of correlated gravitational and strong forces.

The points entering the plot represent the summary of a lot of solutions to the wave equation as function of G_Y as well as function of the gravitational constant G. This means that we are dealing with a two-dimensional potential. Exactly how to interpret the potential and how to understand the mechanism behind it, is not easily deduced.

We plot the values in the following table as well.

G*a	Yukawa coupling G_Y at crossover
1/4	63
1/2	61
1/1.5	56
1/1.2	50
*1	44
*1.2	51
*1.5	57
*2	59
*4	62

To remind you, the crossover point is the point where the calculated value of the strong to electromagnetic ratio fits with the expected value. Please note the symmetry of the values.

Conclusion.

Our result indicates that the strong force exhibits a minimum at the present value of the gravitational constant.

This is quite a remarkable result. We have checked our procedure very carefully, but we find no obvious reason for this behaviour. Before we found this out we thought that we just would get a curve with some slope as function of G. We have so far, no good explanation for the observed behaviour.

However, if our procedure could be improved and made more automatic, we could use it to determine the gravitational constant in a completely new way. This will check out whether the minimum exactly coincides with its present value.

In the procedure we have required the electromagnetic to weak ratio come out right but remember that we are dealing with quite small adjustments. What would happen if we changed this requirement? Looking at the case with the nominal value of the gravitational constant, points at the largest values of the Yukawa coupling G_Y will change more than values at lower G_Y. The net effect will be that the crossover will shift a bit up or down depending on if we require the electromagnetic to weak ratio be larger respectively smaller. We are talking about shifts of the order 1-3 units in the crossover point. And they will all move in the same way, i.e. the result will look just the same. They will only collectively move a bit up or down.

However, the effect will be about the same irrespective of the value of the gravitational constant. If we for instance look at the cases with G*2 and G/2 it means that the crossover will make a similar shift in both these cases. This means that the points will still be about symmetric around the nominal value of the gravitational constant. Taken together this means that our assumption of the electromagnetic to weak ratio being at is expected value holds.

It is not easy to understand why the outcome is much the same on both sides. We can see what happens due to changes of R and M, but to see how it affects the distribution in R is much more difficult. We also have the Lorentz factor that changes at the same time making things more difficult.

The question then comes on what kind of mechanism that could cause this. First, we note that the value of the gravitational constant determines the magnitude of the strong force. This in turn means that it determines the magnitude of the electromagnetic force as well. This follows from the fact that at the cross over point the calculated value fits with the expected one and we have a simple equation to solve. Knowing the electromagnetic coupling we can then also determine the weak constant.

We could turn the arguments around. If the minimum is the right answer, we can determine not only the gravitational constant but also the others.

Conclusion.

If the minimum is the right answer we can determine the couplings of all the four forces absolutely.

Indeed, a remarkable finding.

6. Consequences.

So, if we can explain the value of the gravitational coupling, we have in practise determined all forces. If the gravitational coupling is slightly different, the strong coupling would differ from its known value and consequently a different value of the electromagnetic one, i.e. the charge of the electron would deviate from its known value.

If the charge of the electron changes so will the chemical bindings do. What would happen to the DNA molecule? Will it still function or just looking different? We could imagine a different kind of life form if it will work at all.

In any case intelligent life may not exist. This means that there can be no one around to observe the value of the gravitational constant. Turning it the other way around, only when the gravitational constant has its present value someone can be there to observe it.

In other words, this is the only value we can observe. However, one question remains. What process sets the value? The answer could simply be by accident! You may not like the idea that we are just a random product. However, think a bit about it.

There may be another explanation. The idea arose that the gravitational constant is floating. In fact, it could depend on the total mass of the universe! Exactly how we cannot tell.

Let us explain. First, we have stated that the gravitational force is needed to conserve energy. Let us look on the case where a bubble creates a pair of electron-positrons. The electromagnetic force would prevent them from escaping, i.e. energy is conserved. Now assume that the pair directly annihilated into two photons at production. We would then need the gravitational force to uphold energy conservation. However, it is quite easy to see that the present value of the gravitational constant would be far from enough. It is in fact a factor 10^{39} to weak.

So, what prevents this scenario? The answer is the creation of the universe. As we have explained in our earlier book it will quite quickly build up to a mass that is enough to prevent the photons to escape.

It is interesting to note that if such a thing would happen today the mass of the universe turns out to be just enough to prevent such a scenario. That is, energy conservation would hold. Off course it is the present size together with its mass that makes the criteria fulfilled. An example: If the mass is $2*10^{52}$ kg and the radius $5.5*10^{9}$ ly (1 ly ~ 10^{16} m), the potential energy would be enough. If the universe would have been larger the force would not have been strong enough. Just the pure fact that it seems to balance is intriguing. However, keep in mind that our predictions are not too accurate (the findings in our earlier book concerning these numbers).

However, if the universe keeps on expanding the gravitational force would eventually become too weak. This means that the gravitational constant would have to become stronger to uphold energy conservation. We could turn the argumentation around and use the present value of the gravitational constant to correlate the mass and the size of the universe. E.g., given its mass we can determine its present size.

You may think whatever you like about that explanation. It might be more exiting if there were some spectacular mechanism behind it. A new particle on your agenda perhaps? As we have said before, we cannot tell nature how to behave.

And again, do not forget about the changing chemical bindings when the gravitational constant changes. Luckily it is a long-term scenario. Even with an accelerated universe, which we in our earlier book on the other hand found to be most likely an illusion.

There is another interesting consequence of this discussion. Intelligent life we could expect to look alike where ever we go in our universe. This because the chemical bindings are the same. The inhabitants would look much like us. No little green men lurking around. In another universe it could be quite different.

There is a more profound question that we hardly can explain. Why should nature bother about energy conservation?

7. Other consequences.

Off course this might not prevent other types of universes to be build. How can we know? These other universes will have another value of the gravitational constant. It is just a random process. Nature will keep on trying and once a seed is formed the evolution gets triggered. The seed gave rise to some value of the gravitational constant. If it happened to be right the process will continue, else not.

This is perhaps not quite satisfactory, i.e. not being able to give a definite procedure. Perhaps easier to believe in something divined? To our mind, randomness seems to fit well with the behaviour of nature.

Is this not just in line with the evolution of Darwin? Nature keeps on trying and if it works the process continues. If not, end of story.

So, please go out into nature and absorb its beautiful randomness.

8. Points vs sizeable particles.

A question that might appear is what would happen if we treated objects like points. All theoretical formulations treat particles as points. The bad thing with that is the occurrence of singularities and the need for renormalisations and so on. As we showed in our earlier book the Coulomb force turned into a nice function when we gave the electron a size (and a content).

If we treat the objects as points, i.e. we set the correctional factors to 1, the outcome is not very encouraging. We just see nothing. Actually, we do see an infinite number of signals and when diving into them the distribution of R shows never ending oscillations. Not very conclusive.

It must be clear that we must consider the sizes of the interacting particles. If we do not, funny things appear. Furthermore, mathematics does not give physics, it is physics that dictates the mathematics we need to describe physical processes.

9. Gravitational structures of the Majorana type.

We have so far treated gravitational objects or Gravs as particle and antiparticle. What happens if the antiparticle is the same as the particle, so called Majorana particles?

For a given pair of R and M both ratios come up a few per cent. If we modify R and M to get the electromagnetic to weak ratio right, we come back to the original situation, i.e. we see no difference.

We should perhaps clarify that the force between Gravs are always attractive irrespective of their type. It has been suggested that there could be a repulsive gravitational variant, this to explain the hypothetical accelerated universe. We say hypothetical because in our earlier book we showed how the acceleration could be explained as being just an illusion.

10. Can there be a fifth force?

Looking at the fourth level we will see four peaks. We still make the same requirement on the gravitational force at R=0. This means we are just investigating whether there can be a fourth super weak force.

A typical outcome is that the square root of the ratio of the two largest peaks now is down by 15%. On the other hand, the ratio of the second to the third drops to $1/10^{th}$ of the expected ratio. The ratio of the 3^{rd} and 4^{th} becomes 30% lower than the ratio of the electromagnetic to weak. This makes no sense.

Summing up, this scenario does not fit at all. The question then comes if there could be a super strong force. But should we not have seen it? We have not investigated this scenario since it is a bit too hypothetical.

11. The exchange mechanism of the forces.

In our earlier analysis we used the known exchange mechanisms in determining the radius and mass of the elementary particles. If we had not, the masses would go wrong. In the proton case the effect (order 1.5%) is too small to be seen, clearly less than the errors. In the neutrino case it would be much larger but on the other hand we do not know what its mass is. It must be obvious that we still need some piece of extra information to pin down everything.

Taken together with our new findings we get a consistent picture of the nature of our fundamental particles and their corresponding forces. Almost, we should add. We are still lacking a small piece of information.

We should stress the fact that it is only through our new formulation of the gravitational force these findings come out. We would like to remember that it gives various predictions in line with observations (e.g. the perihelion shift and the bending of light).

12. Gravitational structures and tidal waves.

As we have explained, we pictured the process by two virtual gravitational structures flying apart. A typical radius of such an object is 1.7 10^{-35} and a mass of 1.9 10^{-8} kg. Such an object is very massive but in practise invisible. You would hardly notice if it passed through you. You would look like empty space. However, if a big lump of them passed through you might feel a bit shaken.

Now say that a big bunch of them would be produced in some violent collision between e.g. black holes. They will spread out like a tidal wave with the speed of light. Presumably it could be detected like a gravitational wave.

We have tried to solve the Dirac equation for a pair of Gravs just like we did for the fundamental particles. It turns out that our precision is not quite good enough. We see signals, but we cannot zoom in on them. The points are jumping around a bit too much. Despite that we occasionally get distributions in R that might be accepted. We show in fig 12.1 how it looks like for the object vid mass 1.9e-8.

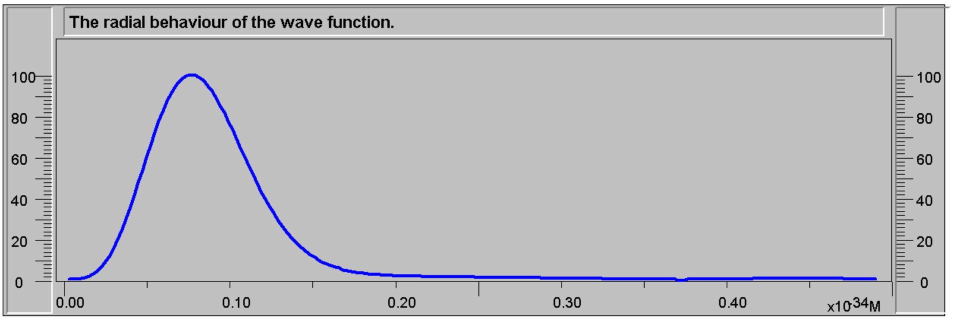

Fig 12.1. The probability density $R^2\ \Psi\ \Psi^*$.

It is interesting to again compare with the electron case, fig 4.7, part I. The scale has been set such that you could compare. As you note the tail is not as pronounced any longer. The same goes for the linear case, with solutions to the Klein-Gordon equation, investigating the gravitational force itself. We show an example in the Appendix.

However, for curiosity we tried out an object with the Planck mass and radius and it turned out to be not too bad. A bit of a surprise we would say. The energy spectrum is shown in fig 12.2.

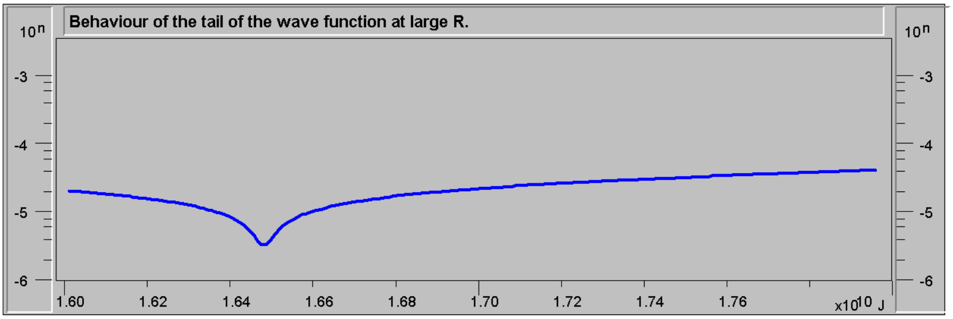

Fig 12.2. The behaviour as a function of the binding energy in units of joule.

It could be interesting to compare with the electron case, fig 4.6, part I. Just look on the energy scale and you will notice the difference. The sharpness of the signal disappeared. We also plotted the radial distribution which comes out very nicely, fig 12.3.

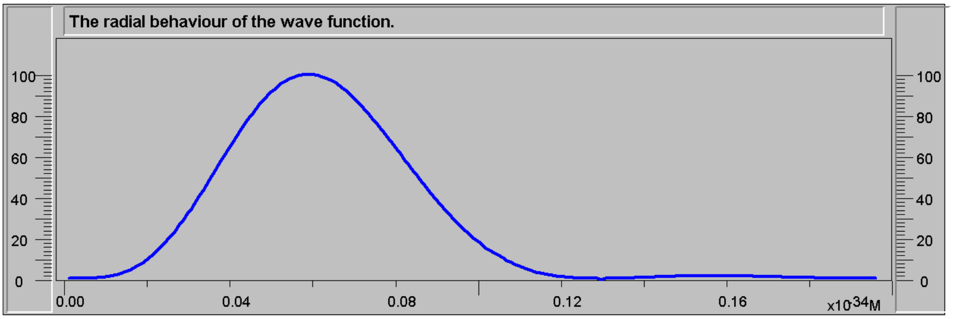

Fig 12.3. The probability density $R^2\ \Psi\ \Psi^*$.

Please note the change in scale from Fig 12.1. The distribution is in fact like the one Fig 12.1. If you are sharp eyed, you may see a tiny indication of background.

In chapter I.6 we found that if we bring an object from infinity to a distance R from a gravitational source M, the Lorentz factor could be written

$\gamma_L = 1/(1 - GM/Rc^2)$. (1)

To avoid a singularity, we must have

$R > GM/c^2$. (2)

If you multiply the right-hand side by 2 you get the Schwarzschild radius, which is the outcome of General relativity. As we noted in our earlier book quantities like the perihelion shift and the bending of light on the other hand come out exactly the same in both treatments.

For a typical object of mass $1.9*10^{-8}$ R becomes $1.4e^{-34}$ according to (2). Earlier we mentioned a typical radius of $1.7*e^{-34}$, i.e. (2) is fulfilled. We just note that the Planck object leads to equality in (2).

What happens if we change the gravitational constant? In the case G*4 we needed to decrease M by a factor of 2 but also to increase R by the same factor. The factors will cancel and (2) is fulfilled. If we instead look at G/4 M is increased by a factor 2 while the radius is decreased by the same factor. Again (2) is fulfilled. In both cases the Yukawa coupling G_Y will come out about the same. As we noted earlier, the two calculated ratios come out approximately the same for a given value of G_Y.

Lastly, would not the gravitational structure fit well with the present proposed requirements on dark matter? In the next chapter we will discuss how to detect them.

13. Detecting gravitational structures.

The problem with a typical Grav is its smallness. A Grav could go right through a proton without problem. Compare with sticking a sharp needle into an apple. If we let a Grav imping on a proton, what would happen?

Since we would like to investigate the effect on the proton we instead look on a proton passing by a Grav at rest. We look on the case where they just touch each other. Since the proton is much lighter than the Grav, we can treat it the same way as we did with the bending of light.

The scattering angle can be written

$$d\beta \approx \frac{dU}{E} = \frac{GM}{c^2} * \frac{dR}{R^2} .$$

Which gives

$$\beta \approx \int d\beta = \int_{R_1}^{R_2} \frac{GM}{c^2} * \frac{dR}{R^2} = \frac{GM}{c^2} \left(\frac{1}{R_1} - \frac{1}{R_2}\right).$$

R_2 we set to infinity. R_1 we set to $.9*10^{-15}$. With $M=1.9*10^{-8}$ we arrive at $\beta=1.6*10^{-20}$. This directly tells us that the energy transfer is indeed small. If we instead take an electron as target we would find $\beta=2.0*10^{-20}$ using a radius of $.70*10^{-15}$ as we found out in our earlier book. If we have a wire chamber filled with hydrogen gas, the energy transfer will not be enough to rip off the electron from the atom. If we look on other gases, we have some difficulty in finding any suitable ones.

Instead we must find substances with suitable excitation energies. The excited electron will drop down more or less directly resulting in a photon. By suitable photon detectors surrounding the chamber we could detect it. Still we have some difficulty in finding good substances. The energy transferred is in fact less than the hyperfine splitting in the hydrogen atom.

If there is some gas that can be used, we still need the wire chamber, not for detection but rejection. There should be no signal in it if a Grav passed by since it cannot ionize the gas. In this way we can get an estimate of the background. The problem is how to reject against neutrino induced excitations. We could look on events with a single electron track originating within the chamber to get some estimate.

The only other way we could think of is that a whole bunch of them are produced in some way and hits earth and is detected like a gravitational wave. They will be spread out over one hemisphere, but we do not know what it would take to trigger such a device.

14. Summary.

We have in our earlier book shown how the elementary particles can be created out of vacuum without breaking the standard conservation laws. The consequence of that process is that two pairs of deeply bound particle-antiparticles are created to match the released energy while energetic particles escape. A second consequence is that due to particles now being built by confined fields, the Newton gravitational law must be reformulated. In this new form various predictions come out quite right.

This is the basis of what we call “the Freezening”, a new model of the creation process of our universe. It leads to galaxies having a massive core in its centre. We note that the predicted masses of cores fit well with present observations of black holes.

We made the hypothesis that the gravitational force was the generator of the three species of fundamental particles. It is the most fundamental force of them all and must always be erected. We have now shown how this can come about. This means that we can predict the magnitude of the couplings of the forces.

If we let the value of the gravitational constant vary, we find that the strong force exhibits a minimum right at the present value of the gravitational constant. This is a quite remarkable finding. This means that we can deduce the couplings of all the four forces. As a strange consequence, we can mention that if the value of the gravitational constant would have been different from its present value, life as we know of most likely would not exist.

In all we have a consistent picture of how nature can create a universe with the known fundamental particles and their corresponding forces.

15. Short history.

We just would like to mention something about the history behind this work and our earlier.

The original idea came about 45 years ago at the time the author was working for his theses in particle physics. It all started with the question why quarks, the really hot stuff then, were not seen. Later some clever guy stated that they were only asymptotically free. Nice fix.

However, it led to the question whether quantum mechanics could explain it in some way. Consequently, that led to the question how particles can be created and how a universe could be formed. At that time, we were too busy with the daily stuff so that it was forgotten. Until about 14 years ago when it popped up again.

Lastly, we just like to note that the author has a long experience of working with and constructing simulations of e.g. large detector systems (NA4, ARGUS and a proposal for a detector at HERA).

Appendix part I.

1.The electromagnetic force.

1.1 Preparing the wave equation.

Wave equations only holds for point like objects. To set up a wave equation for composite bodies is most likely an endless story. We could divide a body into a million pieces and construct a million equations coupled in some complicated way. However, how to solve them? We will take another approach.

What we do is to find a correction to the Coulomb potential to mimic points. I.e. with a modified potential we can use the Dirac equation to solve the problem for two big balls. The correction is determined by calculating the resulting force starting from some assumed distribution of points. Since we do not know that distribution we have investigated various scenarios. If the density of points goes as the inverse of the radial distance, the produced electrical field will be constant with R inside the object. This is the hypothesis we will begin with.

The normal procedure to solve equations like this is to let one object be at rest and the other circulating around with its reduced mass. This means that the actual calculation we perform starts off by looking at the field produced by the one at the centre. Shortly, we can treat it as build up by current tubes that produce an electric field as well as a magnetic one. We separate these contributions in order get a better understanding of how things work. This also gives us a better chance to check out the procedure.

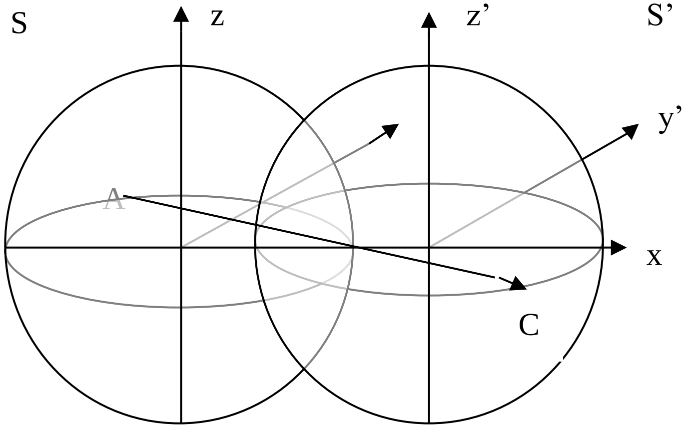

Fig. 1.1 Two objects in close encounter. S' is rotating around S.

To get the effective force we have to integrate over two spheres, for every point C in one sphere S' we calculate the field generated from all points A in S and sum up the resulting force. In doing so we take care of the relativistic effects as described below. We do the integration numerically for varying distances R between the objects and then we just fit a simple expression to parameterise the result. By integration of the resulting distribution we find the potential. Both are needed. We express the result as a correction factor to a point like coulomb interaction.

In these calculations we separate the *original* electrical and magnetic fields. The treatment is a bit different, but we also would like to see the importance of the two components. The magnetic field gives rise to two contributions, namely the force between two magnetic moments and the effect of the magnetic moment of the particle at rest on the moving charge. In solving the wave equation, we work as usual in a system fixed at one of them.

There is in fact a third effect, namely the force on the particle at rest due to the electric field generated by the moving dipole. However, this is automatically included by the relativistic treatment. This treatment is made in two steps. First, every point is transformed from the precessing system S' attached to the moving particle to the system S at rest. Then we apply the field from the object at rest.

The treatment of the precession ω_T (see under kinematics), known as the Thomas effect in atomic physics, gets more complicated in our case. If you try to use it straight off, you will find that the surface of the particle might be moving faster than light! Off course, a point does not care about that. Now we must care for the internal rotational energy that leads to a modified result. In fact, for a given available kinetic energy a point will move faster than a spinning ball in an orbital motion. Part of the linear energy goes into rotational energy.

We all know that a sizable object will look compressed when moving fast. A ball will look like a cigar from the side. If you now let the ball rotate, the cigar will get even more deformed and look like nothing else.

In doing all this it is clear we must have a model for the particle. The result will differ depending on how we look upon it. You may now start to realize that this is getting complicated. It's almost like a never-ending story.

In the model we now used we assume that we have a constant electric field that is rotating. To achieve this, we use a point distribution that goes like 1/r, where r is the radial distance inside an object.

1.2 The electrical field contribution.

There are different ways to treat this field. The first way is to start off from the object at rest and calculate the field at every point in the moving object. We then apply the Lorentz force in usual manor and get the component of the force along the common axis.

The other way is to divide the moving ball into small cells that we treat as moving charged points. In doing so we can use the retarded potentials or better the Effimenko fields directly. However, the retarded point is not so easy to find since the points move in complicated orbits. In the first way we could divide the rotating ball at the centre into static current tubes with a given linear continuous charge density.

Since the charges are rotating they will be describing an accelerated motion. In principle they would radiate. However, the situation is the same as in the atomic world. We are only interested in the case when the two objects are in a quantized state where no radiation takes place. We have simply switched it off.

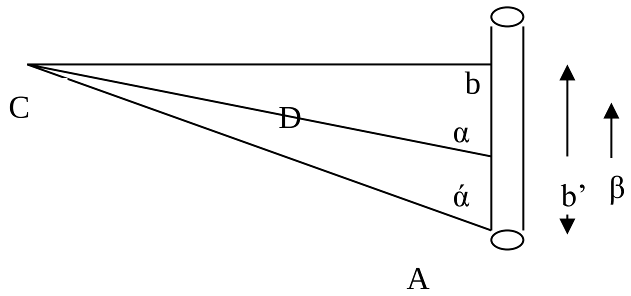

Fig. 1.2. A current element of charges moving with relative speed β.

Since the electrical field E' is perpendicular to the current element the component in C is γE'sinά. However, the observed angle is α. Using $b' = \gamma b$, $\gamma = 1/\sqrt{1-\beta^2}$,
we have

$$tg\alpha' = tg\alpha/\gamma.$$

This gives

$$\sin\alpha' = tg\alpha'/\sqrt{1+tg^2\alpha'} = tg\alpha/\gamma\sqrt{1+(1-\beta^2)tg^2\alpha}$$
$$= \sin\alpha/\gamma\sqrt{1-\beta^2\sin^2\alpha}.$$

Likewise, we find

$$\cos\alpha' = \cos\alpha/\sqrt{1-\beta^2\sin^2\alpha}.$$

The distance becomes

$$D' = b'/\cos\alpha' = \gamma b/\cos\alpha' = \gamma D\cos\alpha/\cos\alpha' = \gamma D\sqrt{1-\beta^2\sin^2\alpha}$$

The gives us the field

$$E = \gamma E' \sin\alpha' = \gamma \frac{\delta q}{4\pi\varepsilon_0} \frac{\sin\alpha'}{D'^2} = \frac{\delta q}{4\pi\varepsilon_0} \frac{\sin\alpha}{\gamma^2 D^2 (1-\beta^2 \sin^2\alpha)^{3/2}} \text{, (1)}$$

where $\delta q = \gamma \rho ds$ due to the Lorentz contraction, ρ is the charge density, ds the line segment.

The force between the two objects caused by a charge δq in A and an element δq in B then is

$$\delta F = \delta F_x = \delta q E_x = \delta q E * \frac{D_x}{D},$$

where E is given by (1). D is the distance vector from A to C. The net force is obtained by integrating over both spheres.

As a check-up we calculate all components of F to make sure that there is no net force in the perpendicular directions.

1.3 The magnetic field contribution.

We are not going to deal with the vector potential. We have to deal with forces and we note that the magnetic fields from two dipoles gives rice to a force that only depends on R. We can therefore calculate a scalar potential, just as in the electrical case. Since we have a static situation we can use the standard Biot-Savare formulation if we just remember to scale the charge density according to its velocity.

The magnetic field in C from a current element A is

$$\overline{B} = \frac{\mu_0}{4\pi} \delta q\, \overline{v}_A x \overline{D} / D^3 .$$

The angle between $\overline{v}_A$ and $\overline{D}$ is just the same as for the electrical field case, i.e. we can use the derivation from above.

The force on a charge δq in C is

$$\overline{F} = \delta q\, \overline{v}_C x \overline{B}$$

Again, we integrate over the two spheres and take the component of F along the x-axis.

1.4 Correctional factors.

The calculation of the force between the two objects is repeated for various distances between them. The result is normalized to the coulomb force between two points in both cases. The correctional factor to the force is given through

$$F = \frac{k}{r^2} V_p \, .$$

The correction V_c to the potential is defined in a similar way.

We fit an expression to resulting distribution that is used in the Dirac equation. This expression must be very smooth because otherwise we will get problems with the wave equation. We will explain this below. A smooth expression could be a short polynomial (2-3 terms normally) divided by a longer one. In this way we can get the right asymptotic behaviour.

In the case of the B field, we have dressed up a sinus function with polynomials.

The whole procedure has to be repeated a few times in order to make it converge. We note that the region of small R is not very well determined due to precision problems.

1.5 Kinematics.

When solving the wave equation, the procedure is to transform to a system where one is at rest and the other is turning around but now replaced by its reduced mass.

For a given R the potential energy and the force depends on the correctional factors. On Vc and Vp respectively. From the kinetic energy we get the speed and can calculate the acceleration from the force:

$$F = \frac{dp}{dt} = \frac{ma}{\sqrt{1 - v^2 / c^2}} . \qquad (2)$$

This holds in the case of a circular orbit where the object moves with constant velocity. On the left side we have:

$$F = \frac{e^2 V_p}{4\pi\varepsilon_0 R^2} . \qquad (3)$$

From this we get the Thomas frequency (see any textbook on the subject)

$$\omega_T = a * (1 - \sqrt{1 - v^2 / c^2}) / v .$$

If we assume the object moves in a circular orbit we have the following relation between the speed and the acceleration:

$$v^2 = R * a . \qquad (4)$$

This is the classical expression, but it holds also in the relativistic case. Now, it turns out that when R is in the region around $2R_0$, the velocity of the boarder becomes larger than the speed of light! R_0 is the radius of the object. If we on the other hand use (4) in (2) we can solve for a or v from the force. This time the velocity is reasonable but quite larger than the velocity as given by the kinetic energy.

Something definitely looks wrong. One would first come to the conclusion that the object is not in an orbital state but has a vertical speed component. That will just make it even worse.

The problem goes back to the behaviour of the correctional factors. The kinetic part will in fact never go to zero with decreasing R, while this is the case for the force. In fact, the force becomes negative when R goes below R_0 approximately.

The real problem is how to understand this. One could say that when R is not equal to that of the bound state we will get such kind of result. Then we are thinking in classical terms, which is hardly applicable here. At the end the wave function will tell us that we are in a less likely situation, but not completely forbidden.

We have investigated the effects of using the different methods to determine the Thomas angular velocity. There are effects, but in short, we are talking about a few percent at most in the energy of the solutions and less in the radius. We also used an average of the two methods. The nice thing with this is that the angular velocity comes out to approximately ½ of the spin for R in the region between R_0 and $2R_0$. This is in fact what happens in case of the hydrogen atom. The meaning of this is not clear to us. When R is outside ω_T will drop.

1.6 The Dirac equation.

We use the Dirac equation since we are at relativistic energies. This equation can be written

$$(\frac{\delta}{\delta x_\mu} - \frac{ie}{hc}A_\mu)\gamma_\mu \psi + \frac{mc}{h}\psi = 0$$

for a potential A_μ. This equation can also be written as two coupled first order equations expressed in the two components f and g of the wave function (see any text book on the subject):

$$\hbar c(\frac{dF}{dr} - \frac{\kappa}{r}F) = -(E - V - mc^2)G,$$

$$\hbar c(\frac{dG}{dr} + \frac{\kappa}{r}G) = (E - V + mc^2)F \ ,$$

where F= r*f and G= r*g.

To solve, we rewrite it as one equation in the second derivative and solve for either component of the wave function. In order to reduce these equations into one we substitute G from the first into the second. After some algebra we get

$$F'' = \frac{1}{r}[-F'(k_1 + k_2) + (k_1(1-k_2) + A_1A_2r^2)\frac{F}{r} + (F' + \frac{k_1F}{r})\frac{rV'}{A_2}]$$

where $k_1 = 1-\kappa$, $k_2 = 1+\kappa$ solving for f,g or $k_1 = -\kappa$, $k_2 = \kappa$ solving for F,G. κ = ±(j+1/2), j =total angular momentum and

$$A_1 = [(E + mc^2)/\hbar c + \frac{\gamma}{r}V_c],$$

$$A_2 = [(-E + mc^2)/\hbar c - \frac{\gamma}{r}V_c].$$

$V' = \frac{\gamma}{r^2}V_p$, $\gamma = \frac{e^2}{4\pi\varepsilon_0\hbar c}$. V_p and V_c are the correctional factors for the force and the potential respectively. The equation is rewritten with a change of variable before implementation.

There are some difficulties in solving it due to discontinuities caused by the A-terms. The procedure is to first find them and then adjust the stepping in such a way that we encompass them in a symmetrical way. When we come close, the stepping is refined by a factor 1000 typically. There can be several discontinuities over the stepping region. It all depends on the shape of the correctional factors. The stepping is done in quadrature.

If the correctional factors are not smooth enough we can get artefact solutions. A small kink can give a “ghost” signal.

Since we do not know what kind of states there might be, we do an energy scan. This means that we calculate the behaviour of the wave function as function of R for a given binding energy and investigate how it varies with energy. More precisely we check how the tail behaves by taking a sample of it at large R and plot that quantity. Instead of peaks we are looking for dips.

The procedure is to assume some value for the R_0 and look for a solution. The result will be some values of the binding energy and the peak of the distribution in R. We use the new value of R_0 as input and repeat until stable.

If we have found the correct solution the process will converge, otherwise not.

There might be questions whether the result we get simply is what we put in. Solving for the case of the hydrogen atom, we know that the energy levels scale with the mass of the electron. This could be interpreted as if we used another value of the mass as input we will get that as a result. However, in doing so the correctional terms will change leading to a different solution.

1.7 Field energy content.

The energy is given by

$$W = \frac{1}{2}\int(\varepsilon_0 E^2 + \frac{1}{\mu_0}B^2)dV \; . \qquad (2)$$

To calculate it we follow the procedure described earlier, with the difference that the point C is an empty cell in the left ball. For every point A (except C) we sum up the fields for E and B separately in point C. We calculate E^2 and B^2 and then sum up over all points C. We note that the integration is a bit sensitive to the actual binning. The errors given should reflect this.

Assuming the model with a constant field rotating inside the object we have calculated the energy content analytically. The speed v, being perpendicular to E, gives us the fields

$$\bar{E}' = \gamma_r \bar{E}, \quad \gamma_r = 1/\sqrt{1 - v^2/c^2} \; .$$

$$\bar{B} = -\frac{1}{c^2}\bar{v}x\bar{E}' \; .$$

Inserting this into (2) we get

$$W = \frac{\varepsilon_0}{2}E^2\int\frac{1 + v^2/c^2}{1 - v^2/c^2}dV \; . \qquad (3)$$

The energy density of the electrical field is (from the solution to the Dirac equation)

$$\frac{\varepsilon_0}{2}E^2 = \left[\frac{e^2}{4\pi\varepsilon_0}\frac{1}{4R_0}\right]\frac{1}{2\pi R_0^3}. \qquad (4)$$

The expression within brackets is equal to the particle rest energy (mc^2). However, there is a normalisation factor associated with the constant field itself. The field is the result of using a point distribution with weight 1/R. It is the component along any axis that counts as described earlier. This gives us a factor 2/3 for the field squared.

We evaluate the resulting integral by using spherical coordinates:

$$I = \frac{1}{2\pi R_0^3}\frac{2}{3}\int \frac{1+\omega^2 r^2 \sin^2\theta / c^2}{1-\omega^2 r^2 \sin^2\theta / c^2} r^2 dr \sin\theta d\theta d\phi, \qquad (5)$$

where we used $v = \omega r \sin\theta/c$. r runs from 0 to R_0, θ form 0 to π and φ from 0 to 2π.

If everything fits, we should have I=1. Integration over φ gives a factor 2π. The rest becomes, setting $b=\omega/c$

$$I=\frac{1}{R_0^3 b^3}\frac{2}{3}\left[-4\sqrt{1-b^2R_0^2}\,ArcSin(bR_0)+4bR_0-\frac{2}{3}b^3R_0^3\right]. \qquad (6)$$

bR_0 is simply the rotational velocity of the surface, β_0 (β=v/c). We have assumed that the surface will get the same speed as the particle has after collision, which is the speed it has in the bound state. Inserting the limits, we can write

$$I = -\frac{8}{3\beta_0^3\gamma}ArcSin(\beta_0)+\frac{8}{3\beta_0^2}-\frac{4}{9},$$

where γ is the Lorentz factor and β_0 corresponds to an energy of two masses worth, i.e. β_0 =0.9428. This gives

I=1.25.

Not quite unity, but the prescription for the normalisation is maybe not fully consistent with our original procedure. We must stress that we at first did not expect that we at all would get something reasonable out of such a simple assumption. We must remember that this is just a first attempt to find a description of the electron.

2. The strong force.

We will assume that the force can be described by the old Yukawa potential right at the threshold. It is adequate in this region:

$$\frac{G_Y}{R} * e^{-R/L},$$

where

$$G_Y = \frac{1}{4\pi} * \frac{G_{p\pi p}^2}{\hbar c},$$

and where $G_{p\pi p}$ is the pion-proton vertex coupling. L is the order of the pion Compton wave length (h/mc= $.9*10^{-14}$ M).

The correctional terms are now defined through

$$U = \frac{G_Y}{R} V_c * e^{-R/L}.$$

$$F = \frac{G_Y}{r^2} V_p (1 + R/L) e^{-R/L}.$$

The procedure determines F and the potential U is then obtained by integration. To keep the field constant with R the weight factor, being 1/R in the case of the electron, must be slightly modified. This new factor is normalised to the boarder of the particle, i.e. for $R=R_0$. R_0 is the radius of the particle. This gives an overall normalisation of $(1+R_0/L)e^{-R0/L}$.

3. The weak force.

Firstly, we assume that we can use the Yukawa type of potential just like the proton case since we are right at the threshold. It is adequate for the nucleon case in this region. More precisely we use the same Yukawa potential but with an effective coupling of

$$G_W = \frac{1}{4\pi} * \frac{G_F}{\sqrt{2}},$$

where the Fermi coupling G_F is $1.16*10^{-5}$.

4. The gravitational force.

The wave equations.

The implementation of the gravitational force in the wave equation turns out to be less obvious. How to deal with the Lorentz factors? We can hardly put them directly into the equation.

The only solution we find is that they must be implicitly included through the calculation of the correctional terms. A correctional factor just expresses how the force between the objects changes from a pure point like Coulomb type of interaction. And this is exactly what we need.

Dividing the objects into many pieces as before, we calculate the force between all pairs of pieces using the full relativistic formulation of the Newton law. This means that for every point A and C the force is scaled by a factor

$$f = \frac{1}{\sqrt{1-v_A^2/c^2}} * \frac{1}{\sqrt{1-v_C^2/c^2}} * (1-\bar{v}_A\bar{v}_C),$$

as obtained from equation (1), section 6.1 in part I. Due to this extra factor, the 1/r weight must be slightly modified to keep a constant field inside the object.

Summing all up using just the radial component we should get the net force. The final correctional factor is obtained by normalising to the Newton force between the pair of objects that now corresponds to the Coulomb force.

Appendix part 2.

1.The Dirac equation.

It is the same as in Part I. We need it to investigate whether gravitational structures can be formed in the same way as for the fundamental particles. The only difference is that the net correctional factors change a bit why we show them below. The electrical and magnetic contributions have been added together in their right proportions.

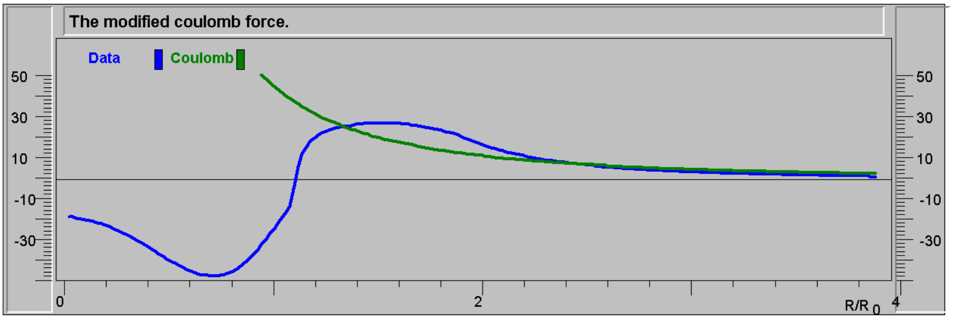

Fig 1.1. The effective force with the correction applied.

This one looks a bit shaky compared to the distribution in Part I. It is caused by limitations in the precision. In the implementation the two contributions are treated separately and parametrized. This will remove kinks that otherwise could cause ghost signals in the solution.

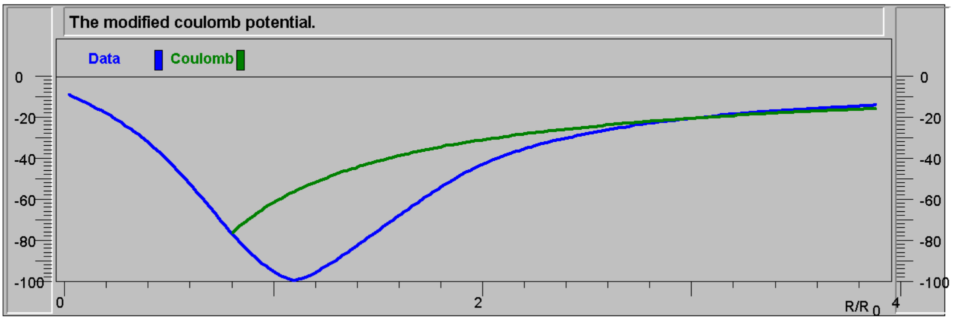

Fig 1.2. The effective potential with the correction applied.

2.The Klein-Gordon equation.

To treat the linear case for the gravitational force we use the Klein-Gordon equation. This equation can, for a free particle, be written

$$(\frac{\delta^2}{\delta x_\mu{}^2} - \frac{1}{c^2}\frac{\delta^2}{\delta t^2} - \frac{m^2c^2}{\hbar^2})\psi = 0\,.$$

We introduce a Coulomb like potential by the normal replacement

$$p_\mu = (\frac{\delta}{\delta x_\mu} - \frac{ie}{\hbar c}A_\mu)\,,$$

with $A_\mu = (0,0,0,iA_0)$, $eA_0=V(x)$. This gives

$$\frac{\delta^2}{\delta x_\mu{}^2}\psi = (\frac{\delta}{\delta x_\mu} - \frac{ie}{\hbar c}A_\mu)(\frac{\delta}{\delta x_\mu} - \frac{ie}{\hbar c}A_\mu)\psi =$$
$$\frac{\delta^2}{\delta x_\mu^2}\psi - \frac{ie}{\hbar c}\psi\frac{\delta A_\mu}{\delta x_\mu} - \frac{ie}{\hbar c}A_\mu\frac{\delta\psi}{\delta x_\mu} - \frac{ie}{\hbar c}A_\mu\frac{\delta\psi}{\delta x_\mu} - \frac{e^2}{\hbar^2c^2}A_\mu^2\psi\,,$$

where δA_μ=Div A=0.

With $\psi = \varphi(x)e^{-\frac{iE}{\hbar}t}$ and $A_\mu\,\delta\psi/\delta x_\mu = iA_0\delta\psi/ic\delta t$ we get

$$(\frac{\delta^2}{\delta x_k{}^2} + \frac{1}{c^2}\frac{E^2}{\hbar^2} - 2\frac{-V}{\hbar c}\frac{1}{ic}\frac{-iE}{\hbar} + \frac{V^2}{\hbar^2c^2} - \frac{m^2c^2}{\hbar^2})\phi = 0\,.$$

Or

$$(\frac{\delta^2}{\delta x_k{}^2} + \frac{(E-V)^2}{\hbar^2c^2} - \frac{m^2c^2}{\hbar^2})\phi = 0\,,$$

where $V = \frac{V_c}{r^2}$.

In this case we only need one type of the correctional terms. We show in figs 3 and 4 the “electrical” and the “magnetic” respectively.

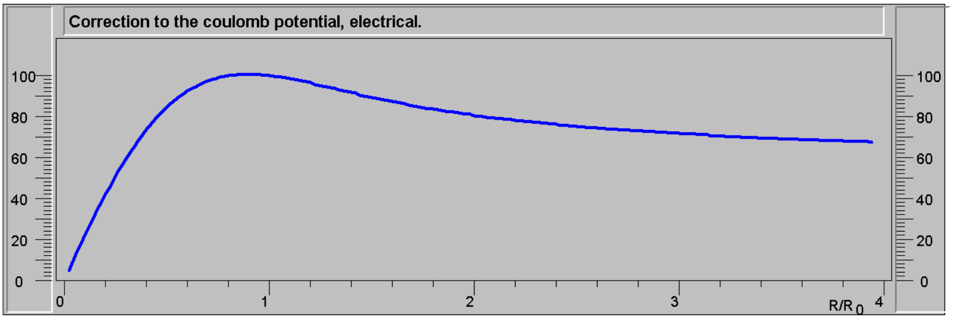

Fig 2.1. The behaviour of the correctional factor for the electrical part.

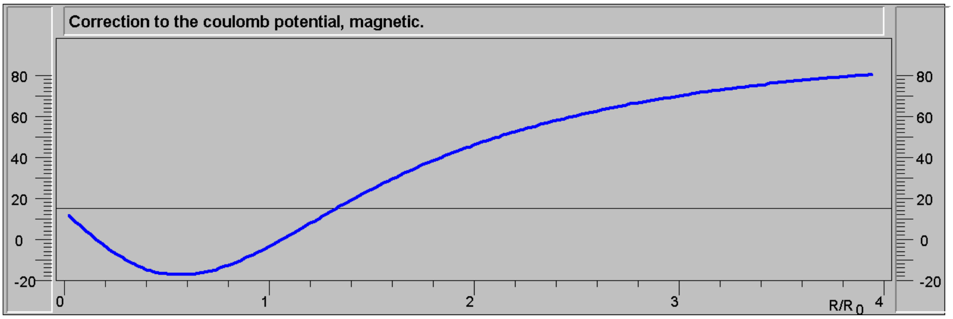

Fig 2.2. The behaviour of the correctional factor for the magnetic part.

In difference to two objects turning around each other we do not need to bother about the complications with the orbital motion, like the Thomas frequency. Else we can use the same formulas if just change the velocity vector from orbital to linear.

We add them together in their right proportions in the next figure. It is slightly different from the one shown in part I.

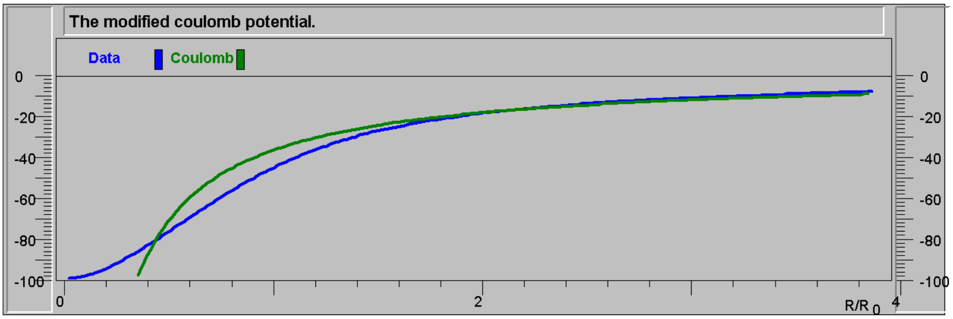

Fig 2.3. The effective potential with the correction applied.

3. Extracting data on the ratio of strong to electromagnetic forces.

We will here describe the procedure to extract the values. It involves two kinds of corrections. One is the corrections due to background. Such corrections are about 30% for smaller values of the Yukawa coupling G_Y but drops to about 10% at the largest values. The other one is a correction we make when the electromagnetic to weak ratio is off from the known value. At lower G_Y it is normally zero while becoming 5-10% at most at the larger values of G_Y.

The first correction takes the raw value down while the second goes the other way around. This is a lucky situation since it tends to move points towards the line, not away. This means that we do not create the effect observed.

The background turns up like oscillations above the largest peak in R, fig 3.1. We clearly see how that peak is distorted when the background increases. Compare to fig 2.2 in part II. In that case the energy was lower and the dip in energy much sharper why we got rid of the background.

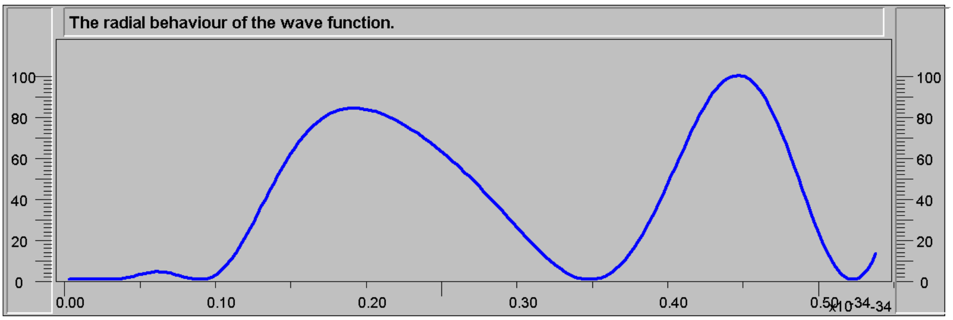

Fig 3.1. The probability density $R^2 \Psi \Psi^*$.

The procedure is to use the first oscillation above the peak and subtract a certain fraction of it to obtain a distribution that falls off nicely. The position of the peak of the oscillation is shifted down by twice the half width. This is the spacings of the oscillations. The oscillation itself is subtracted as well as a check-up. We show the result in fig 3.2.

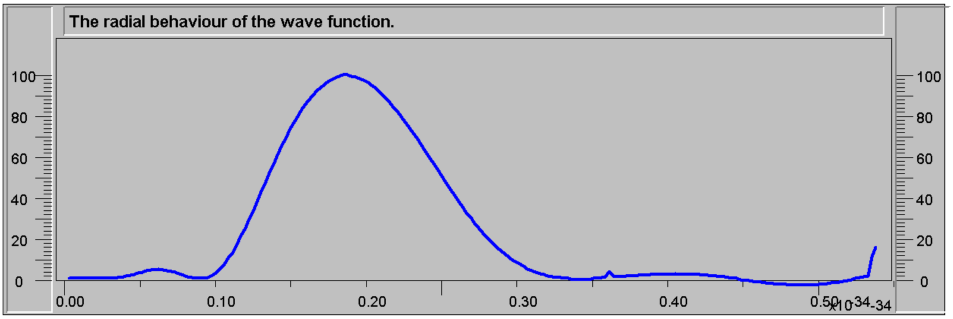

Fig 3.2. The probability density $R^2 \Psi \Psi^*$ with correction.

The subtraction is perhaps not perfect, but we add an error of 5% to the total error to cope with the uncertainty in the procedure.

We note that the distribution of R at larger energies seems to have a faster fall off than at lower energy. Which means not quite like the one in fig 2.2, chapter 2, part II. That one was taken at lower energies with no background. We had a case at larger energies where the background was estimated to only 1.3% and which looked like the one above. We also discussed this in connection with the Dirac equation that the tail will be suppressed when the energy goes up, Fig 12.3, part II.

Concerning the second type of correction, we have investigated points close by in the Yukawa coupling G_Y but which differ in the raw value of the electromagnetic to weak ratio. We find that the correlation between the two ratios are in practise one to one when the electromagnetic to weak ratio is off by less than about 5%. This means that one unit of correction of the electromagnetic to weak ratio is applied on the other ratio. However, when the correction becomes larger we use a reduced amount. The reduction will gradually decrease to about 85% when it is off by about 10%. Points with larger discrepancies are rejected. Instead we try other values or parametrisations to find a better ratio. The result is that close by points agree after applying the correction (within a few per cent). The error in this procedure is estimated and added to the total error.