BORN:

A

universe

IV

Hans Gennow

In our first book we showed how the fundamental particles protons, electrons and neutrinos could be created out of vacuum through a fundamental quantum mechanical process. 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 of black holes.

In our third book we followed this up with the formation of the halo of the galaxies and the formation of stars and planets. Our result fits well with observations. We also found that our candidate for dark matter, the neutrino, has become more likely since recent searches for exotic particles have failed. The neutrino is the dominating species.

We have in this book continued the story with an investigation of the cosmic microwave background. We first find that the atomic nuclei are produced at the beginning of the galaxy halo evolution long before stars are formed. Later on, atoms may form giving rise to a primordial photon distribution in agreement with a black body of 3000K. It evolves to a 2.7K distribution by photons scattering against free electrons. Analysing the CMB maps we find they are consistent with statistical fluctuations.

In our second book we could show how the forces can be determined by the gravitational force through a fundamental quantum mechanical process. This means that we can determine the magnitude of their couplings.

In all we have a consistent physical picture of how nature can create a universe with the known fundamental particles and their corresponding forces. This includes the various dark phenomena.

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Prologue

0. About this book.

This book is a continuation of our earlier books on how a universe can be build. This time we will describe the process that leads to the cosmic microwave background as we observe it today.

In our first 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 built. 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 of black holes in the centre of the galaxies. 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.

In our third book we continued that simulation now augmented with the formation of the halo of a galaxy as well as stars and planets. We compared our findings with observations that have come available since our first book. It turned out that the outcome is in good agreement with these observations.

We also would just like to mention our study in the second book. We asked the question what kind of mechanism can give rise to exactly three forces other than the gravitational one. 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. When a vacuum bubble starts to open up to produce a pair of particles the gravitational force must be erected to assure the conservation of energy. Performing a quantum mechanical treatment of this process we could determine the couplings of all the forces with a very nice outcome.

We will begin with a short résumé of the relevant parts of our earlier books. It is needed for the understanding of what comes next. Please check out our books 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 continue the build of the universe after a short review. It contains some additions to our third book (chapter 2 and 3).

In part III we will discuss the CMB spectra. It begins with the creation of the atomic compounds and continuous with the creation of atoms and photons and finally an analysis of the CMB spectra together with a discussion.

Part I

The creation of the fundamental particles.

0. Introduction.

In our first book 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 built. 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. The story continued in our third book with the formation of the galaxy haloes and stars and planets. Furthermore, we found that phenomena like dark matter and dark energy have quite natural explanations. We quantified these phenomena in our third book. We called are model “the Freezening” because it resembles the process where water freezes to ice. We will begin with a short résumé of the relevant parts of our first and third book. It is needed to understand how the evolution comes about.

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 expect about three million bubbles per meter.

Now suppose that something is created and flies away. What will make them return? If they do not, 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 will mean that something else must compensate the missing momentum. The earth itself, presumably. However, if there instead were two spaceships 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 1 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 us 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

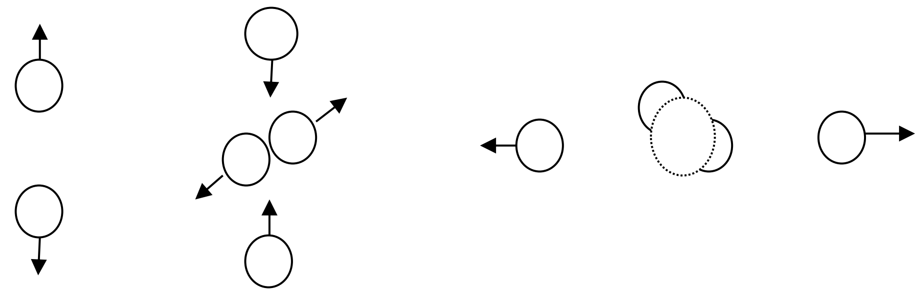

Fig. 4.1. The formation of a bound pair.

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.

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 additional details we refer to our first 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>2 R_0 always).

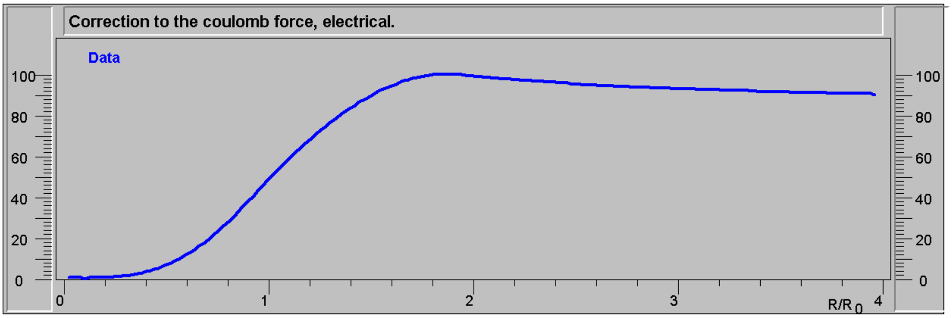

Fig 4.2. The behaviour of the correctional factor for the electrical part.

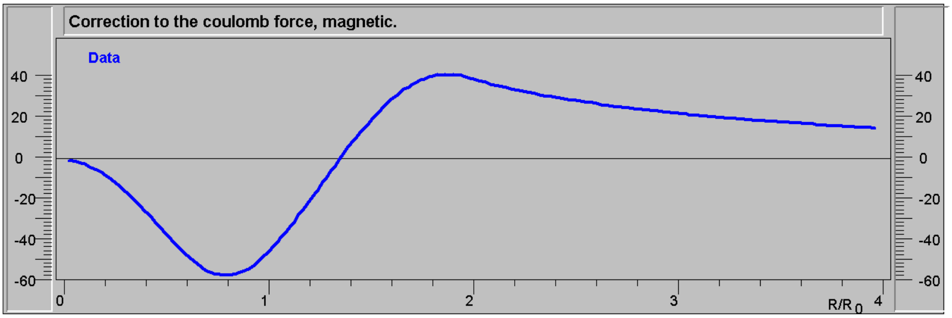

Fig 4.3. The behaviour of the correctional factor for the magnetic part.

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.

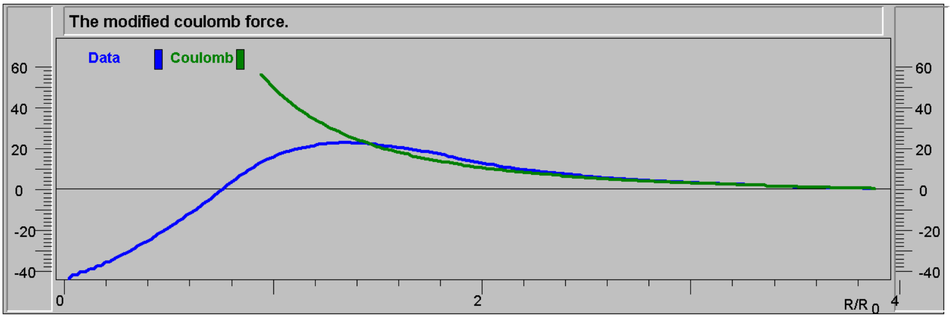

Fig 4.4. The effective force with the correction applied.

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.

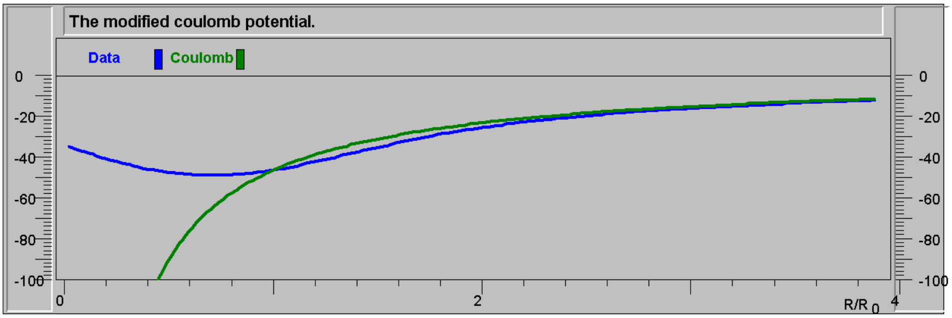

Fig 4.5. The effective potential with the correction applied.

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 these 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 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.

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.

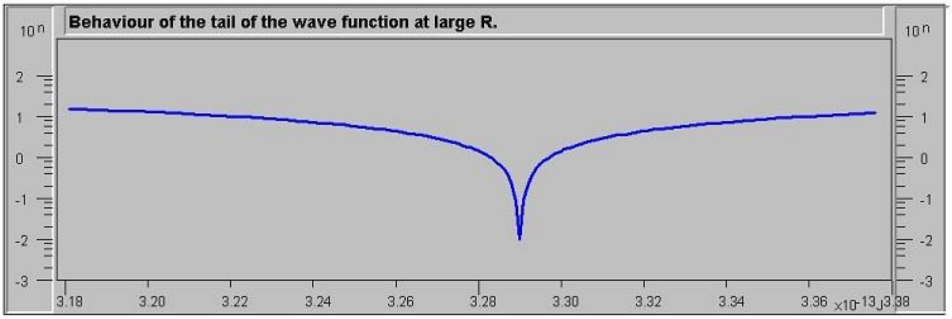

Fig 4.6. The behaviour as a function of the binding energy in units of joule.

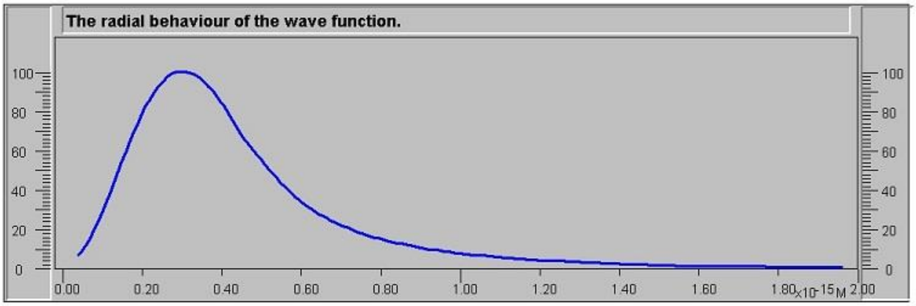

Fig 4.7. The radial probability density $R^2\Psi\ \Psi^*$.

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.:

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

Of interest could also be the gyromagnetic ratio of the electron. If we have an orbiting charge, the ratio of the magnetic moment to the angular momentum L is

$$\frac{\mu_e}{L} = \frac{g}{2} \bullet \frac{e}{m},$$

where g=1. For an electron the spin g factor is 2 instead. We have investigated this and therefore calculated

$$g = \frac{2\int \omega t^2 f(r) / \sqrt{1-\omega^2 t^2 / c^2}\, dV}{\frac{1}{m}\int W_E(r) * \omega t^2 f(r) dV}.$$

dV is the volume element (cylindrical coordinates with t the distance to the axis) and the function f(r) is the weight function. This function makes the field constant with r inside the volume. W is the field energy content and ω the angular frequency. All is explained in detail in the Appendix.

Table 3.

The gyromagnetic ratio g as defined in text.

Calculated	2.02 ±.08
Angular speed	$4.0*10^{23}$ [rad/s]

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]	$1.53 \pm .08 * 10^{-10}$	$1.50 * 10^{-10}$

An interesting quantity is the ratio of the magnetic moments of protons and electrons. The result is given in Table 8.3.

Table 8.3.

Ratio of magnetic moments μ_p / μ_e.	
Measured	2.76
Calculated	1.34 ± .08
Anomalous moment	1.42
Neutron moment	-1.91

The calculated value does not reach the measured one. However, remembering the anomalous moment of the neutron, we could expect such a one also for the proton. Exactly what it is expected to be, we do not know.

We have calculated the gyromagnetic ratio of the proton as well.

Table 8.4.

The gyromagnetic ratio g as defined in text.	
Calculated	2.03 ± .08
Angular speed	$3.1*10^{23}$[rad/s]

Concerning the neutrino we note that the correctional terms come out quite different from the other cases due to the heavy mediators.

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)

We have calculated the gyromagnetic ratio of the neutrino as well.

Table 4.

The gyromagnetic ratio g as defined in text.	
Calculated	1.60 ± .08
Angular speed	$9.4*10^{23}$[rad/s]

The cause for this smaller value lies in the strong cut off. With a lighter exchange it will come up to 2. 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/ γ 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.

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

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

$$E_k = GMm\gamma / R . \tag{2}$$

The total energy E of that object is

$$E = mc^2\gamma = mc^2 + E_k . \tag{3}$$

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

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

or

$$\gamma_L = 1/(1 - GM/Rc^2) \equiv \gamma_G . \tag{4}$$

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

$$\gamma_G^2 \cong 1/(1 - 2GM/Rc^2) . \tag{5}$$

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.

In our first book we discussed this subject but could not make any conclusion. However, in our second book when we investigated the possibility that it is the gravitational force that determines the other forces, we found a candidate of mass $1.9*10^{-8}$ kg and radius of $1.7*e^{-35}$ M. Quite a tiny guy but indeed massive. We also discussed how to detect such objects if they are produced. It turned out not to be quite easy.

We can show how the radial dependence comes out from the solution of the Dirac equation for a pair of Gravs, Fig 6.1. We assume they will have similar properties as the other elementary particle. This means a spin as well as electric and magnetic like components. As we have discussed we need a magnetic component to fulfil the balance act. We note that general relativity also give rise to a magnetic like component.

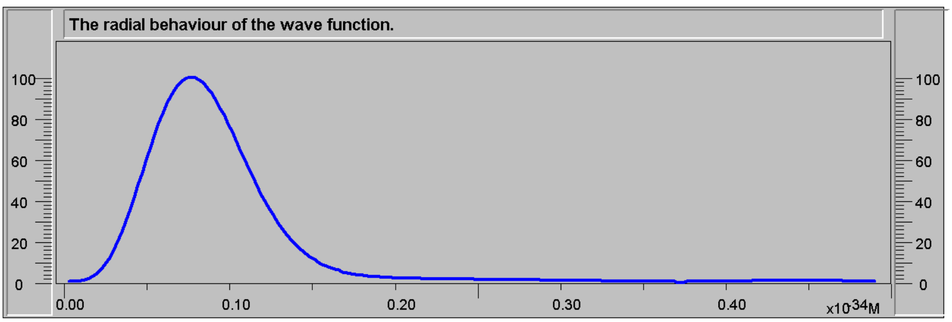

Fig 6.1. The probability density $R^2 \Psi \Psi^*$.

This looks like the electron case, Fig 4.7. The major problem with such heavy objects is that the energy involved is extremely large making the signals broad and weak. The implementation of the gravitational force in the Dirac equation is given in the Appendix.

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 biproduct, 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.

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.

In our first 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 our third book we continued with a study of the formation of the halos of the galaxies as well as the creations of stars and planets. We make a short review in part II.

In part III we will continue the evolution with the formation of atoms and the resulting spectrum of photons which evolves to the cosmic microwave background we see today.

Part II

Building a Universe.

0. Preludes

We will come back to the simulation of the universe we did in our earlier books. We will fill in with some new aspects of it in the following chapters. It starts off with the creation of the galaxy cores. That continues with the simulation of the formation of the galaxy halos and the stars and planets with quite a promising result. In part III we extend this with the creation the atomic elements which lead to the formation of atoms and the creation of photons. At the end we arrive at the cosmic microwave background as we see it today due to photons scattering on free electrons. We finish up by constructing the CMB map.

The existence of the free electrons is described in the next chapter. We will also summarize our findings of the various dark phenomena. New observations call for this. Concerning black holes and dark matter we see a nice agreement.

1. Earlier results.

We will begin with a short review of our first book. Especially we describe the fundamental process so that you will have a better understanding of how it all comes about. In the appendix we describe shortly how our study was performed.

1.1 The dawn

From part 1 we have seen how particles can be created. A vacuum bubble can burst into a number of particles leaving bound pairs left.

The probability for this process must be exceedingly small because otherwise the consequences would be severe for our world. However, the possibility that more than one bubble creates objects at the same time is still conceivable. Strong fields with lot of energy are erected which may trigger other nearby bubbles to produce particles. It will look like a chain reaction in a nuclear plant.

Even if the probability is extremely small, we are in no hurry. Superverse, the container, has always existed and will continue to do so. The question is rather how many universes there are in Superverse. If the probability would be high, we would see new universes building up inside our present one. In fact, a high energy experiment could trigger it. Not very pleasant.

Once a process started, it will most likely continue. A core of bound particles (the ice) would be formed while energetic particles escape (the vapour). That is the reason for “the Freezening”. Since this is a stochastic process it would be a bit erratic, perhaps a good comparison would be with the corona of our sun. We know that material can be thrown out all the way to earth.

We could imagine that small islands are formed that are sped up by absorbing free particles and leave the main core. These islands will develop by their own why we call them Miniverses.

When a bubble produces particles, specifically protons, electrons and neutrinos, it must be clear that it is easier to produce lighter particles than heavier ones. According to the Heisenberg uncertainty relation, the likelihood to produce an electron would be about 2000 times larger than that to produce a proton. We will thus have a certain given mixture of particles produced.

We note that due to the 1/M dependence each species will contribute with the same amount of total mass. It is the number of objects that differ. While time goes on this relation will change due to various interactions between the particles produced.

Charged particles will interact more frequently than neutral ones, especially than neutrinos. We would expect that the neutrinos can continue to the outer parts of the universe with, in the average, a larger speed. This means that the outmost part of the universe will be less visible. As we see the universe will be dominated by neutrinos. Perhaps as much as 90% as we estimated in our first book. Call it dark matter if you like.

1.2 Creation of miniverses.

When the core is building up, statistical fluctuations may cause a newly created bunch of bubbles to escape from the core by getting hit by an enough amount of debris. As we mentioned earlier, we could compare to the corona of the sun, which might throw out particles all the way to earth. These islands will develop on their own.

In the beginning fluctuations are too big for any islands to survive. There are not enough free particles to give them the necessary kick. When things stabilize a bit, it will be more likely. However, if it starts too late it turns out that the amount of debris from the mother will grow so large that the daughter simply will be drowned. Nice mother.

Thus, we have a window in which they are most likely produced. If early created, they tend to become larger. If they start later the central core produces relatively more material that will diminish the daughter. The captured debris can break the bonds of the bound pairs causing annihilations.

Fig 1.2.1 illustrates the process of the creation of miniverses. The numbers give the generation. Gx1 is hence produced by the central core, while Gx2 comes out of Gx1 and so on. Three generations are indicated. The bigger arrows give the direction of flight relative their mother, while the small ones indicate debris generated. All cores produce debris while they are active.

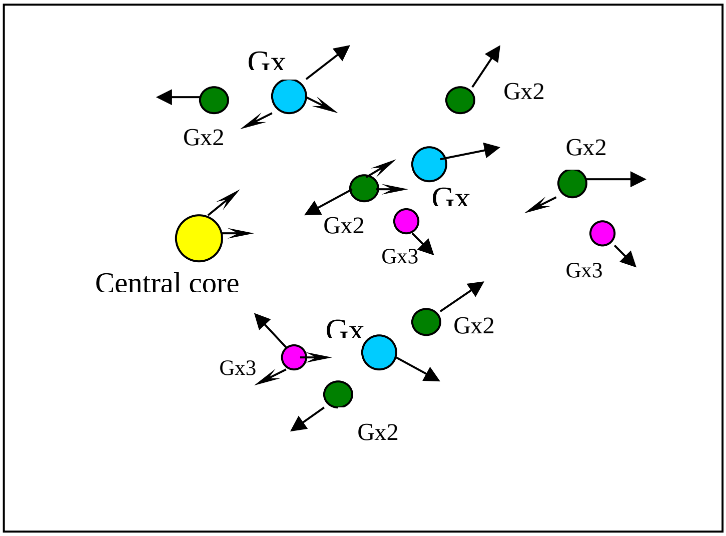

Fig 1.2.1 Production of miniverses (galaxies).

The growing central core will constantly feed the miniverses with material (indicated by small arrows). Part of this material will be absorbed by the cores leading to annihilations. The kinetic energy of the miniverses will increase and so the speed.

Another part of the material will be absorbed into the halo of the miniverses. In the beginning the particles from the central core will be too fast to be absorbed by the halo but later on the difference in speed will become small enough.

The reason for this is that we have assumed that a miniverse will have a smaller initial velocity than the debris. There will off cause be statistical fluctuations in this number. If we start off with a higher speed the material that catches up will give a smaller energy transfer, which means that the speed of the miniverse will not increase as much. In the long run the difference should not be large. The only effect we see is that a faster guy could get a larger mass. This due to the fact, that the absorbed material, now being less, decreases the core less.

We show in Fig 1.2.2 how a core first accelerates and then gently slows down. It shows the first few hours of the evolution.

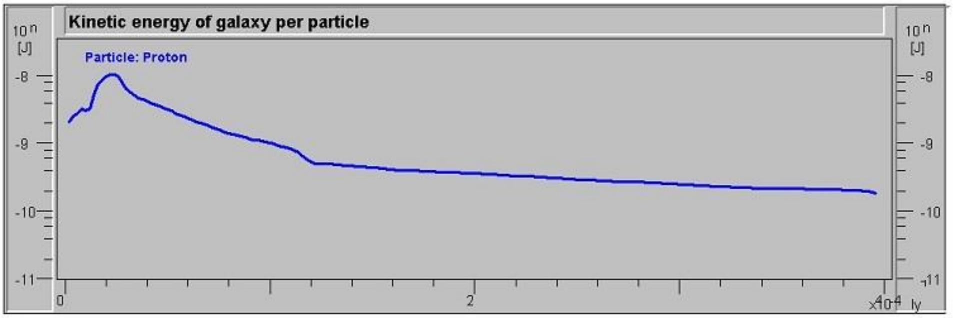

Fig 1.2.2 The kinetic energy of a constituent particle as function of the radial distance.

The halo will off course be spread out. When material is absorbed charged particles will interact more than neutral ones, especially neutrinos. However, as time runs along things should smear out but perhaps with an overweight of neutral stuff at the outskirt.

The miniverse will also absorb material from neighbouring galaxies. This time it will mainly end up in the core since these galaxies move approximately in parallel. This means the particles are too fast to be caught in the halo. However, when time elapses, we will have material flying around in all kind of directions and with varying speeds. We have now (below) simulated the process of catching debris into the halo.

Another sizeable source of debris are the cores that collide. Earlier we just made a simple estimate of the effect and counted it up. However, we estimated that at most 5-6 generations could be created before the amount of debris was so large that the evolution of new cores was stopped. In fact, we see that the last generations come out much smaller than the others. In chapter 2 we will make a proper simulation of the formation of the galaxy halo.

Eventually the process will stop, and we have a galaxy with a massive core. We get a typical core of the order of 10^{37} kg with the size of the sun. However, we see large variations.

1.3 Superverse.

The process we have been describing is in its nature stochastic. We could expect that it has happened not only once but many times.

This means that we need a container to hold them, namely Superverse. Superverse has always existed and its size is infinite. Thus, we could expect that it contains an infinite number of universes.

To explain the existence of superverse we may need something divined. For the moment we have no better idea. However, some day, someone may grasp the ingenuity of nature. That would just be in line with the evolution theory of Darwin.

2 Collecting debris.

2.1 The formation of a Galaxy halo.

In our first book we discussed the effect of debris but did not perform a simulation, merely estimated the impact. We found that the halo of the galaxies could grew to a couple of thousand times the mass of the core. The larger the core is the larger the galaxy. This agrees with what recently was reported by NASA.

For a simulation we first need to know the frequency of collisions. We must realize that it will be quite crowded in the beginning of the development. Chaotic we would say. A major fraction will collide making things quite messy. Cores may collide later but rarely. We concluded in our first book that if 5-6 generations of galaxies are created that is done in only 15 minutes. During that period the amount of debris will become so large that it will choke further evolution of cores.

Secondly, we need to know the energy of the debris. As we explained earlier, cores are built from bound pairs of particle-antiparticle. When the bonds are released, they will have their maximum energy, corresponding to a mass worth of energy. However, they will collide whereby some will lose energy while others will gain. We have assumed a distribution with overweight of rapid ones. The exact form of this distribution will not affect the result notably. We select from this distribution by drawing a random number. In all what do we work with average aspects.

For every step we take we add up a chunk of debris depending on the solid angle as seen from the source. We calculate relative speeds and apply an energy loss on that chunk when added. At the beginning we assumed it to be 20% but along with the halo is growing it is reduced.

It turns out that the halo mass varies around a couple of 1000 times the mass of the core. The result is in good agreement with the estimate we made in our first book. This gives galaxies of the order of $5*10^{40}$ kg but with variations of a factor ten up or down. The cores themself can also vary quite a bit depending on how and when they are produced as we explained in our first book. A later, fast generation e.g., comes out a bit smaller due to time dilation. It grows in a slower pace. Its halo will also become smaller.

The halo has acquired 95% of its mass after a day or so. This could be compared to the cores themselves that build in a few minutes. However, it will take some time to collect the debris. We show in fig 2.1.1 how this evolves. After a rapid rise it seems to level off, but it will continue to grow a bit more. The plot shows the first few hours.

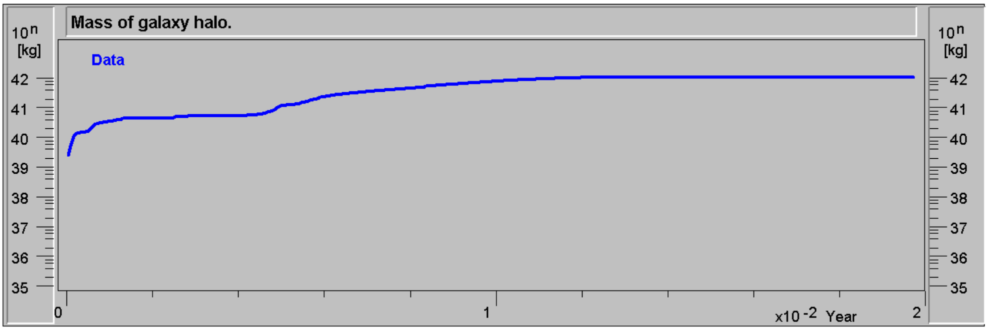

Fig 2.1.1. The evolution of the halo of a galaxy.

The size of the halo will grow in a slower pace. We had a look at the density of the halo and applied a reduction of the halo energy depending on that. When it is crowded in the beginning, we assume that the particles can lose 20% of their kinetic energy on the average. When it is less crowded the energy loss will be smaller, again on the average. The exact amount of energy loss is not important, it is just a question of how long time it will take until stable.

This leads to galaxies with radius of the order of a few 10^{21} M, i.e. a few 100 000 light years. At the beginning the radius is relatively smaller due to the debris being in the average relative fast. Due to energy loss the halo will broaden by time, but that takes a considerable time. We must remember that the debris collected by the core originally come from all kind of directions. By time, a preferred rotational direction will crystalize. We show in fig 2.1.2 the evolution of the size of the halo. It shows the first 5 million years.

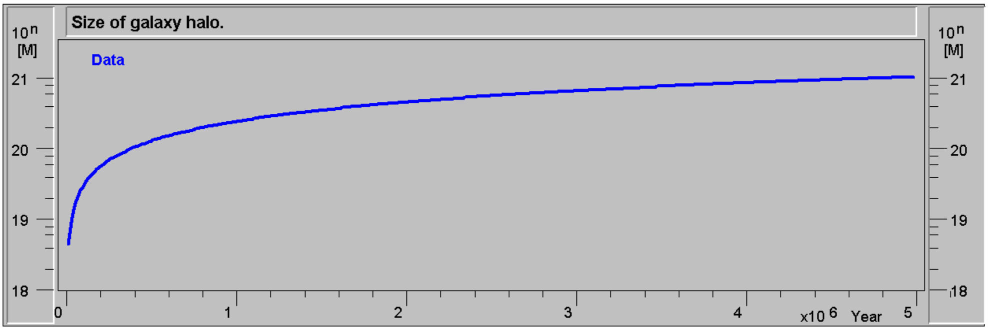

Fig 2.1.2. The evolution of the halo of a galaxy.

The halo will grow during some million years about. During that time, the average density of the halo has dropped to about 10^{-25} kg/m^3. In a recent measurement [1] of the interstellar density outside the solar system the density was found to be about $3*10^{-22}$ kg/m^3 of hydrogen. This was achieved by the NASA probe New Horizons. 2015 the probe past Pluto and got some nice pictures. However, the average halo is about a factor 10 larger than the distance of the sun to the centre of the galaxy. This means that if we scale our density we would be in the neighbourhood of that measured value.

We note that the radius of the galaxies may vary by a factor 10 up or down as with the mass. In the former case the radius is in fact what a resent measurement, of the outer radius of the Andromeda galaxy indicates, project AMIGA [2]. They found an external gaseous halo around it. The inner halo is about 500 000 light-years in size. This was achieved by help of the Hubble space telescope.

When the first disruptive period of the halo evolution is over, we could think that atoms start to form. Exactly how long time this will take is not quite easy to estimate. We could use the density of the halo to find something out, but it is not clear cut. During this period material will clump together and stars will start to form. If it takes some million years to build a halo, stars may be formed during that time and the answer will be given in the next chapter. Anyhow, our findings are quite different from what is pictured in the Big Bang story. That story does not explain how the elementary particles are created, so how can one make any predictions whatsoever on the evolution? They assume that some kind of potential existed at the beginning but who created that?

In 2019, astronomers reported on a tidal disruption event detected by the TESS facility and denoted ASASSN-19bt [3]. A star that came close to a supermassive black hole was simply torn apart. The supermassive black hole that generated ASASSN-19bt weighs around 10^{37} kg, just like the one in SgrA* in the center of our galaxy. It sits at the center of a galaxy called 2MASXJ07001137-6602251 located around 375 million light-years away in the constellation Volans. The mass of the galaxy is estimated to 10^{40} kg. In their analysis they have set the radius of the core to that of the sun. Whether this is an estimate or not is not quite clear. From what we can judge it does not look unreasonable. This is in line with our prediction of the radius of such an object but perhaps a bit biased conjecture you may say.

It is quite amusing to see that all these numbers mentioned above fit rather well with our results.

[1] P.Swaczyna et al, APJ, Vol 903, no 1, 2020
[2] N. Lehner et al, APJ 900:9, 2020.
[3] T. Holien et al, APJ, 883, no2, 2019.

2.2 The formation of a stars and planets.

After the formation of the galaxy halo we can have a look on how atoms may form and gather up to stars and planets. In our first book we never came so far. We have seen in the last chapter that a typical galaxy comes out to $5*10^{40}$ kg and with a radius of some 10^5 light-years.

As we noted the density of the halo is quite large at the beginning of the halo formation. The distance between particles is in fact much smaller than the size of the hydrogen atom. We will expect a lot of collisions taking place. Protons colliding can give rise to neutrons and a lot of pions. Neutrons can combine with protons to start to build heavier atomic cores. However, they will have to move with about the same speed for this to happen. Things will have to settle down before it can happen, and it will take some time. The pions will decay into muons predominantly due to the Q-value. Muons will decay to electrons. In these steps of decays neutrinos will be created. Their energy will not be so large due to the multiplicity (many particles that like to share the available energy). They may end up in the outer parts of the halo.

Furthermore, it will be quite chaotic. We will hardly expect atoms to be formed. However, when the halo grows the density drops and the distance between particles get large enough to form atoms, mainly hydrogen. We have assumed a mixture with 15% helium. This happens approximately when the halo has grown to a size of 10^{15} M. We are talking about after some years of the evolution. When time passes on heavier compounds will form but we stay with the given mixture. The result will not change notably.

Under these conditions we can start to accrete atoms into lumps. In doing so we calculate the time it takes to collect particles. When the mass of the star grows the speed of the particles that get collected increase and the amount added likewise increase. This process is quite slow at the beginning but accelerates fast. When the halo grows the chunk added will gradually become smaller due to the smaller density of the galaxy halo and the process slows down and ends in a natural way. By this procedure we can achieve a reasonable estimate of the time needed to build a star.

At the end we find stars of the order of 10^{30} kg. Their sizes are about that of our sun. Their distance to the centre of the galaxy comes out to the order of 50 000 light-years. When we build the stars, we also form a halo around them. We see that the size of the halo encompasses the planets of our sun.

We note that the density of the galaxy halo has dropped down by the time the star is build. A star has reach 2% of its final mass around some 100 million years. The time to build a star is close to 10^{10} years (98.5%). Just as with the creation of the central cores, the masses of the galaxies as well as the masses of the stars we see variations of a factor 10 up or down. The numbers we give are averages (medians). You may take it as an uncertainty in our calculations. However, we must expect to see a variation of values. We are in fact looking at a sample of cores that evolve to galaxies. They have been produced under different conditions and we must expect to see variations. We show in fig 2.2.1 the evolution of a star. It shows the first $5*10^9$ years.

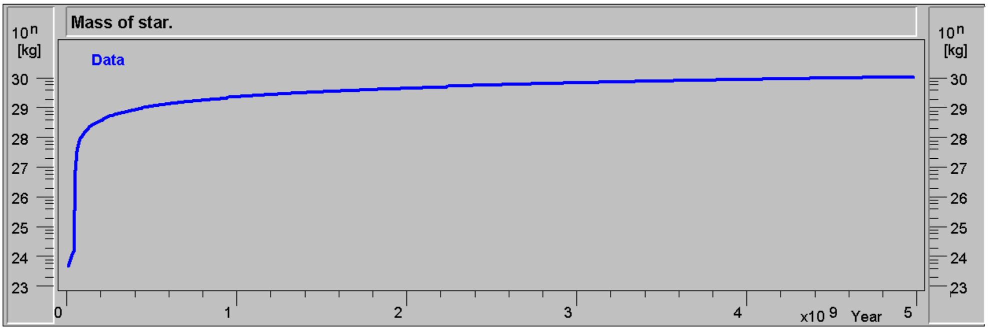

Fig 2.2.1. The evolution of the mass of a star.

As mentioned, we have tried to build planets as well. The situation is now a bit more complicated. The relative distance to a star is much smaller than that of a star to the core of the galaxy. Debris being collected by a planet may instead turn towards the star. In principle we would need to calculate the forces from the star and the planet on the debris on every occasion. This is an impossible task, so what we can do is to construct a simple algorithm which we can apply in an average sense.

We must also wait for heavier elements to form. The particles that fly around must not be too differentiated in speed (energy). If they are, the result would just be some elastic or inelastic collision. The difference in energy should not be more than about the binding energy. We judge this from the average distance between particles which just corresponds to a certain density of the halo.

We can imagine that when planets start to build there will still be hydrogen floating around so that at first, we will have a portion of hydrogen collected. Heavier elements will fill up by time thereby compressing the core. Nuclear reactions may start so that there will be a hot interior of the planets. If this process started earlier, before enough heavier elements have formed, we would just get a new star.

We find a typical planet of the size and mass of Jupiter, fig 2.2.2. It is positioned somewhere around Neptune. As we pointed out before there are large variations. The time scale has increased to 10^{10} years about (98.5% of their final masses). We are approaching the age of the earth. It is interesting to note that the spread of the masses and the distances of the planets to the star looks like a representation of our own solar system. Off course not in detail. We are investigating various galaxies, and this is the variation we see. One representative planet per galaxy.

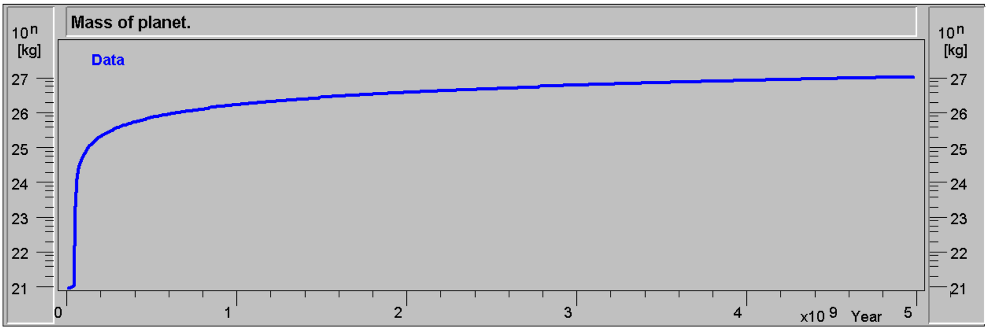

Fig 2.2.2. The evolution of the mass of a planet.

It looks like the evolution of stars and planets follow each other. However, the first seed of a star happens after about a month in contrast to a year for planets. This is just what we stated above when we said the evolution is quite slow at the beginning. Furthermore, we observe that the density of the galaxy halo is close to its final value when the stars and the planets are getting a bit fatter. That is the reason for a similar evolution.

We could summarize by

Typical structure	Mass [kg]	Size
Galaxy core Galaxy halo Star Planet	10^{37} $5*10^{40}$ 10^{30} Like Jupiter	Like Sun 300 000 Ly Like Sun Like Jupiter

We note that the values given can vary a bit. They are just medians.

3. The Dark sector and missing particles.

We discussed this in our last book, but we think a reminder would not be wrong. We like to clarify the connection to our findings. New observations come along all the time. We will also come back to the question of missing antiparticles.

3.1 Black holes.

From part 1 we have seen how particles can be created. A vacuum bubble can burst into a number of particles leaving bound pairs left. This process will thus conserve energy. Strong fields with lot of energy are erected which may trigger other nearby bubbles to produce particles. It will look like a chain reaction in a nuclear plant.

Once a process started, it will most likely continue. A core of bound particles would be formed while energetic particles escape. Thus, we get a core consisting of pairs of bound particle-antiparticle. The binding energy prevents them to annihilate. The density of such an object is enormous, the distances between the pairs are about 2 fm ($2*10^{-15}$ M). Compare to solid hydrogen, around 10^{-10} M.

It is interesting to note that a typical object comes out to 10^{37} Kg and with a radius of about the sun. As we mentioned in chapter 2.1 recent observations confirm our result. The more observations that come along, the stronger the statement that in practice all galaxies have a massive core becomes.

It is said in the literature that nothing can escape. Such a statement must be modified. As we have discussed when an energetic particle impinges on such an object it might break the bonds of a bound pair. The remnants will have enough energy to escape some distance. A normal light ray will on the other hand not come far, not even a standard gamma ray. But it all depends on the mass of the core.

It has been discussed whether the supermassive black holes can be explained by accretion. This seems to be unlikely as argued by [1] in a review. It is also stated that the role of massive primordial black holes in the Universe is much more significant than previously thought which supports our story.

[1] A D Dolgov, Physics-Uspekhi, Volume 61, Number 2
.

3.2 Dark matter.

As we see the universe will be dominated by neutrinos. Perhaps as much as 90% as we estimated in our first book. Call it dark matter if you like.

Searches for various kind of exotic particles that could explain dark matter have been made. Axion and axionlike particles [1] as well as sterile neutrinos [2,3] both report negative results. Likewise, a search for WIMPs reports a negative result [4]. This also holds for leptophobic dark matter searches [5].

A recent report [6] from the XENON collaborations claims to see an effect of solar axions. However, looking at their data we do not find it extremely significant and to our mind far from what would be required for such a conclusion. There is also a background caused by tritium that must be accounted for correctly.

As we explained above, we expect each species will contribute with the same amount of total mass due to the Heisenberg relation in the creation of the universe. It is the number of objects that differ. While time goes on this relation will change due to various interactions between the particles produced.

Charged particles will interact more frequently than neutral ones, especially than neutrinos. We would expect that the neutrinos will be the dominating species. Perhaps as much as 90% as we estimated in our first book.

In a report [7] it is claimed that gravitational lensing may be an effect of dark matter. As we explained we could expect neutrinos to gather up and give such an effect.

[1] Manuel Meyer et al, arXiv 2006.06722v2[astro-ph.HE]4 Aug 2020
[2] M.G. Aartsen et al, Physical review D102,052009 (2020)
[3] J.H. Choi et al, Physical review Letters 125,191801 (2020)
[4] A.Aguilar-Arevo et al., Physical review Letters 125,24803 (2020)
[5] A.Aguilar-Arevalo etal.,arXiv;2109.14146v1 [hep_ex]29Sept2021
[6] E.April et al., Physical review D102,0720004 (2020)
[7] M. Menighetti et al., Mon. Not. R. Astron. Soc. 472,3177(2017)

3.2 Where did the antiparticles go?

Rest assure, they are there. From part 1 we have seen how particles can be created. A vacuum bubble can burst into a number of particles leaving bound pairs of particle-antiparticle. When the process evolves it leads to massive cores again containing equal amounts of the species. Debris that are produced during this process we let annihilate to 80%. We assume the rest will get separated so that we have islands of pure matter respectively antimatter.

As we stated in hour first book a neighbour solar system might be made of antimatter. Before we try to travel to another system we should investigate what holds. Such travels will most likely take place in some not-too-distant future. Our statement has recently been strengthened by the possible detection of antihelium nuclei by AMS-02 according to [1].

[1] Simon Dupourqué, Luigi Tibaldo, and Peter von Ballmoos

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4. Summary part II.

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 biproduct, 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 first 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 the centre of the galaxies.

In this part we have augment that study with the formation of the halos of the galaxies as well as the creations of stars and planets as explained in detail in our third book. We note that the result is in good agreement with observations.

We have also discussed dark matter which we can explain as due to neutrinos which we found to dominate the universe. Lumps of neutrinos can give rise to lensing as has been observed.

This is the basis of what we call “the Freezening”, a new model of the creation process of our universe. It is important to note that this a physical description. It starts off from the production of real particles from which we build our universe.

In part III we will continue with the formation of the atomic compounds, atoms, and the production of photons. Lastly we will construct the Cosmic Microwave Background (CMB) spectrum.

Part III

The cosmic microwave background.

0. Preludes

In part I and II we have seen how a universe can be built. It starts off with the creation of the elementary particles which leads to galaxies having a massive core (SMBH as people like to call it). From that we create a galaxy halo which leads to the formation of stars and planets.

What we have left to do to make the picture complete, is how atomic nuclei can be formed and with that the creation of atoms. That in turn leads to the formation of photons which give rise to the cosmic microwave background.

1.1 The cosmic microwave background.

We have seen how the debris created during the evolution of the cores leads to the halo of the galaxies. We have shown how stars and planets can be formed from the debris. We are now going to investigate that process in more detail. We would like to find out how the various atoms can be formed. It all starts with the formation of compounds already after some hours of the halo evolution. The particles flying around right at the beginning are simply too energetic to bind. Due to collisions the particles will slow down while the halo expands. When the situation calms down further, atoms can be formed. There are numerous electrons available.

To achieve this goal, we first must find out how the various elements can be created. In the next step we investigate the formation of photons. The procedure consists of treating the behaviour of genuine particles. We have protons and neutrons flying around who can collide and form nuclei. We will do this in the next chapter.

1.2 The formation of the atomic elements.

Right at the beginning of the formation of the galaxy halo the particles are too energetic to be able to bind. There will just be elastic and inelastic collisions between the original protons whereby neutrons can be formed. Protons can also turn into neutrons by interacting with electrons, which are quite numerous. The particles will lose energy through these processes and eventually slow down enough to be able to bind together in an atomic nucleus.

The distance between particles is quite small at the beginning, fig 1.2.1.

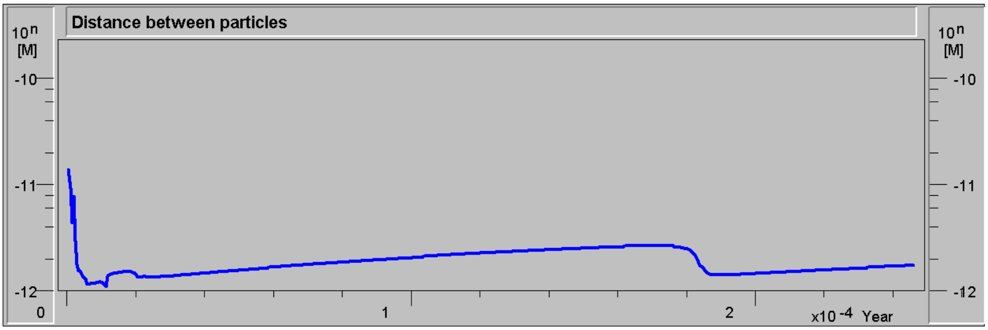

Fig 1.2.1. The distance between particles during the first hours.

The bump to the left shows that the halo just is starting to build up. It has only collected a smaller amount of debris, i.e. somewhat larger distances. As time goes along the distances will increase, fig 1.2.2. We make a cut on the energy of the protons of 30 MeV to avoid the first energetic ones, which however are infrequent at the time we start to form compounds. About a few MeV in average.

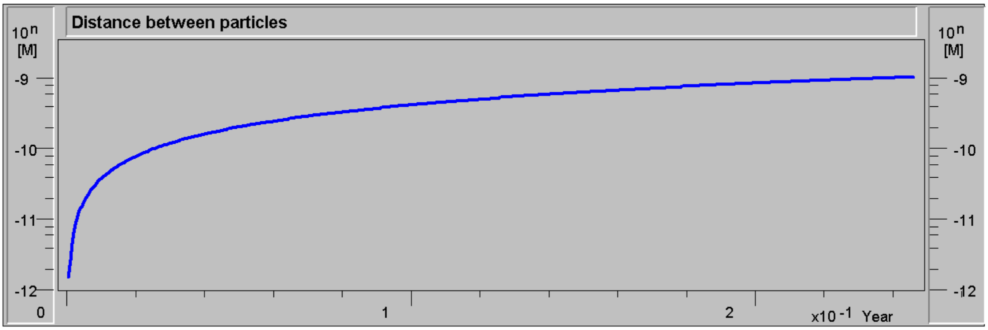

Fig 1.2.2. The distance between particles during the first few months.

The distance will continue growing when the halo expands. After a year it comes up to 10^{-8} M. This is the time when we start to form the atoms.

For each debris we calculate the cross section for an interaction. From the distribution of nuclei, we choose one by drawing a random number. The size of the nuclei is estimated from the formula $R=A^{1/3} * 1.2$ e-15 M. We add a proton or a neutron, again by drawing a random number. We check that it does not lead to an unstable nucleus. If there is a neutron deficiency we eject an alpha particle. If the other way around we eject one or more betas turning neutrons into protons. We have assumed there is about the same number of protons as neutrons to begin with. The procedure will make sure that we achieve the right neutron to proton balance irrespective of the mixture of incoming protons and neutrons.

In fig 1.2.3 the result is displayed.

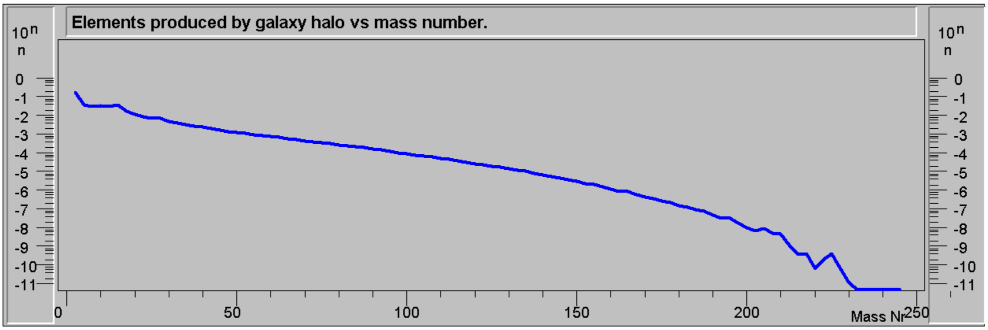

Fig 1.2.3. The abundance of elements as function of the mass number.

As seen, the spectrum ends at a mass of about 245. The reason is that we need a more refined stepping. Unfortunately, the execution time simply becomes too large. When we started off, we used a courser stepping but quickly realised that by refining it we could reach further. When we compare to recent observations [1] for the above region, we anyhow find an acceptable agreement. The middle region is perhaps slightly too large. However, when stars star to contribute the shape might change a bit. Fig 1.2.3 just shows the primordial distribution which we will not observe today.

The procedure does account for more subtle details like energetic incoming protons that might split a nucleus. We split it into one piece of 2/3 and one 1/3. In doing so we must take care for the varying binding energies. A deuteron has 2 MeV binding energy rising to 8 MeV for elements above around 20. However, we see just a small effect, probably because the frequency of protons with enough energy is not too large. When we look at the measured spectrum of compounds we note a small enhancement around iron. The binding energy is at maximum in this region. Which means that incoming protons should be less harmful in that region. Energetic electrons could also penetrate the atomic levels and hit a proton in the nucleus. All this could be implemented in more detail, but this was not our aim, we just wanted to find out if we could come close to reality.

It is interesting to note that the spectrum measured [1] is from our solar system. As we see, the spectrum we arrive at is created long before stars are built. By time, the stars will help filling it out. We have not tried to simulate that process since it is a bit tricky, but in principle the same. The curve will continue to drop, and the higher elements will not contribute in any noticeable way since they are rare. The spectrum we build starts as soon as the galaxy halo builds up. Particles are quite energetic and if we convert it to a temperature, we find it to be the same as in the centre of a star, in fact a bit hotter to begin with.

Having this noted, we can make a more profound conclusion. The energies the particles have is due to the original process of creating the particles. When the halo starts to build by fragments from i.e., colliding cores, released particles can have an energy worth of a mass at most. Due to collisions when trapped into the halo their energy will drop to a level corresponding to the conditions in the centres of the stars. Thus, we can take this as a proof that our description of how the universe was created is correct. If it would be wrong we would hardly achieve the result shown.

As soon as the halo starts to build up compounds can be created. Half the spectrum in fig 1.2.3 is filled within a few hours, the spectrum will be close to be filled after less than a day, but it will continue for about a year. The halo is reaching its maximum density at the first moment, namely 10^9 kg/m^3, just about a million times the density of our earth. The size of the halo is only of the order of 10^{10} M while the mass of the halo is close to its final value. As mentioned earlier we are investigating various galaxies produced under different conditions. They vary in size and mass. We see that the net number of elements that come out may differ a bit (10% or so). A smaller galaxy can give less elements and the cause for this is that the density at the beginning is somewhat smaller.

In this process we also allow already formed nuclei to collide with others. However, we restrict to the lightest elements. Heavier elements will simply be too slow to cause an interaction but also because the abundances drop fast so that the contribution will be small. This can be seen from the following plot, fig 1.2.4. We note that we only need to consider the lightest elements. The chance that heavier elements will make an impact is quite small due to the steep fall off.

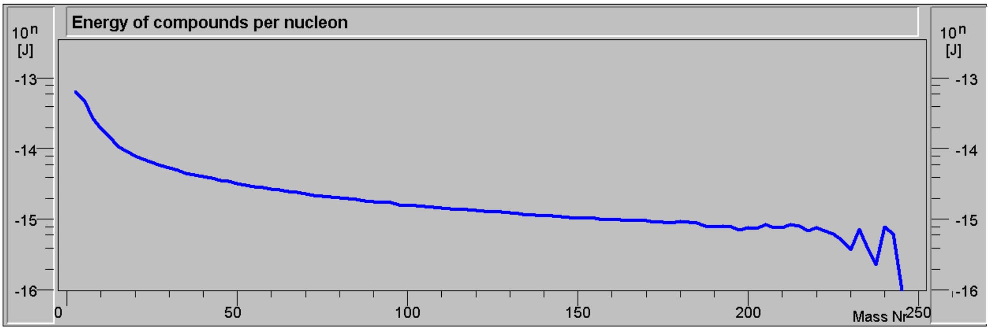

Fig 1.2.4. The kinetic energy of compounds as function of the mass number.

We note that incoming protons can have several MeV at the beginning which cannot be seen since it is the average over a bin that is plotted.

Summary

Compounds are created just at the beginning of the evolution of the galaxy haloes before stars appear.

This means that the belief that compounds only are created by the stars is not quite correct.

Having elements, we can start to construct atoms, which we will do in the next chapter. But we will have to wait some time. The reason follows from the following fig 1.2.5.

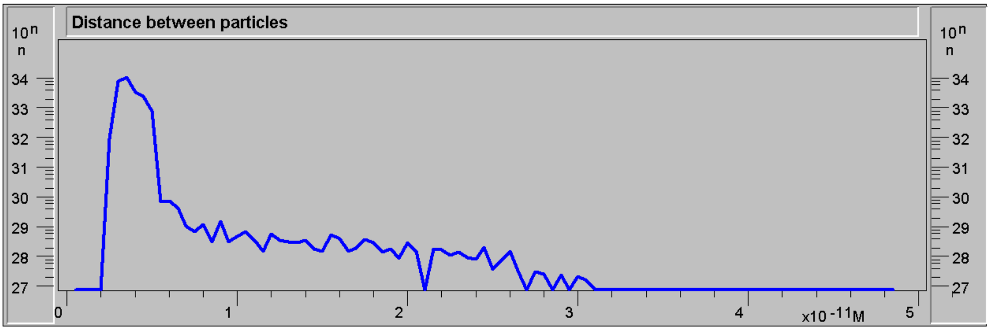

Fig 1.2.5. The distance between particles during the first hours.

As seen, there is simply no space for atoms to form. The size of the smallest atom, hydrogen is far outside the scoop of the plot.

[1] John J. Cowan et al, Rev. Mod. Phys. 93, 015002 – Published 1 February 2021

1.3 The formation of atoms and photons.

It will take some time before atoms can be formed. The moment when the compounds are formed the density of the halo is close to its maximum. There is simply not space enough for atoms to form. Also, things must calm down because otherwise the atoms will lose any captured electrons within the next nanosecond or so. In fact, atoms start to build after half a year about. The size of the halo is still only about 10^{-2} ly but the density has dropped to .2 kg/m^3 about. This is the requirement we will apply to start to build atoms. We will have a look on what this means concerning the distance between particles below.

The created nuclei can accumulate free electrons which will lead to the production of photons. There are many more electrons available then there are other types of particles (not counting the numerous neutrinos). The completed atoms will also be bombarded by especially protons thereby ripping off one or more electrons or all if a direct hit on the nucleus. We consider the energies of the protons to estimate that process. We will also have full atoms colliding. We look at the energies involved to estimate how many electrons might be ripped off.

We will need a chart of binding energies of the various elements. The problem is that it is not easy to get the levels of heavier atoms due to the effect of screening. Outer levels are screened by the innermost electrons. We simply start off from hydrogen using the Dirac relativistic formulation of energy levels. To get the energy levels for heavier elements we apply the Hartree-Fock model to calculate the screening effects. We approximate it by a simple algorithm as discussed by for instance [1].

The electrons captured can jump directly to a matching hole or true a ladder depending on their energies. This happens when there are unfilled lower levels. The hole might also be filled by those in higher levels before capture. We look at the wave function to judge the probability for such events. As you understand things are getting quite complex. The ladder is traversed in steps such that the rule $\Delta l = ^{\pm}1$ is fulfilled, but occasionally through a double step as judged from the wave function. The weight of the event will drop by every step taken.

We check out that we fill the levels according to expectations. We cannot fill all elements completely, 40% of the elements are completely filled, heavier elements partially. However, heavier elements will have no impact due to their low abundances. We could do better, but the computing time will increase rapidly, and nothing gained.

We show in Fig 1.3.1 how the spectrum of photons comes out. The vertical scale just shows the relative number of entries (weighted).

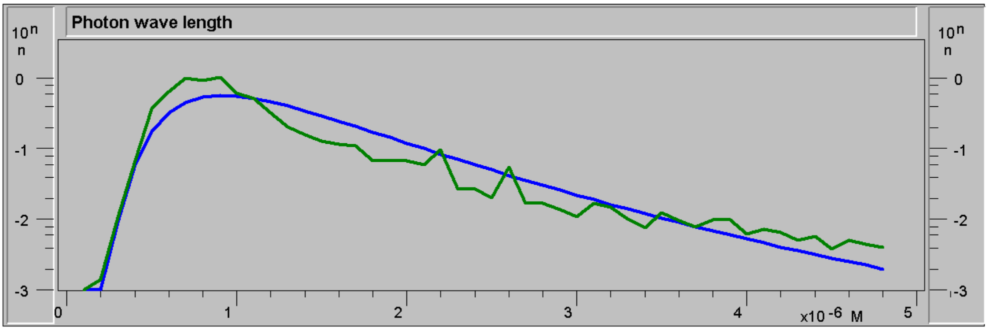

Fig 1.3.1. The distribution of photons created as a function of the wavelength. The curve is a blackbody with 3000K.

The data is shown in green. The blue curve is a black body spectrum with temperature of 3000K. Our calculated curve falls off a bit steeper, but we must stress the fact what you now are looking at is the primordial distribution of photons. That distribution you will not observe today. We must be aware that by time photons will scatter around and smear out the distribution. There are plenty of free electrons available to scatter the photons.

Now we must mention that in creating this photon distribution we did not take into account the scattering of photons of especially free electrons. The reason is that we wanted to compare with the findings of others. In fact, just a check-up of our procedure. We want to be sure that we start off from a reasonable distribution. We will deal with the effect of scatterings in the next chapter.

Photons may kick up an electron to a higher orbit. The hole will be filled by the electrons in the higher levels now falling down and eject photons of less energy. The free electrons can do the same thing. This process will continue to present days. We will deal with this in the next chapters. We could mention that the primordial distribution (before considering scatterings) in the Big Bang scenario should come out just the same.

This happens before stars start to contribute. The stars will start to build as soon as there are atoms available which is just what we are creating. But it takes some time before the stars are full grown, or at least start to glow. As we found out in our last book, a typical star has reached 2% of its final mass after about 100 million years. It is indeed a slow process at the beginning but then it accelerates. Compare to our present time scale, a limited number of years.

We start to build atoms when the density of the halo is such that the distance between atoms is a couple of times their sizes. The first chunk we get is of the order of 10^7 atoms which decreases when the halo grows. It is split up in some thousand smaller groups. As you understand we cannot treat atom by atom. When we compare the various galaxies, we find almost identical distributions. As we said before, the number of elements created differ somewhat between galaxies, but still, we see no effect of it. The reason is simply that only the lighter elements contribute to the observed spectrum. The abundances of the elements drop very fast as we have seen, and the contribution from heavier ones will be small.

If we change the cut in the halo density we see very little change in the distribution. If we lower it by a factor 10 the upper tail drops a bit. In fig 1.3.2 we plotted the distance between particles.

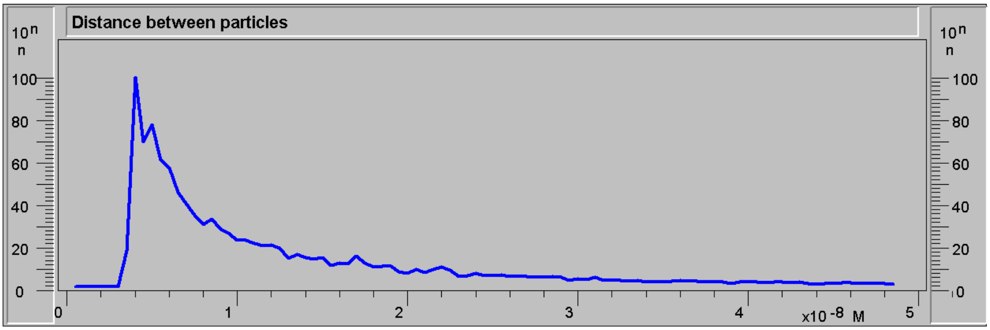

Fig 1.3.2. The distance between particles starting from the build of atoms.

The distribution raises fast due to the cut on the halo density. The tail just shows that the average distance increases when the halo of the galaxy expands. The distance is quite small at the beginning leading to a large energy density. It will however drop fast with the expansion of the halo. The atoms start to build after about half a year when the average distance is a few times the hydrogen size.

It could be of interest to see how the average relative energy of incoming electrons look like, Fig 1.3.3.

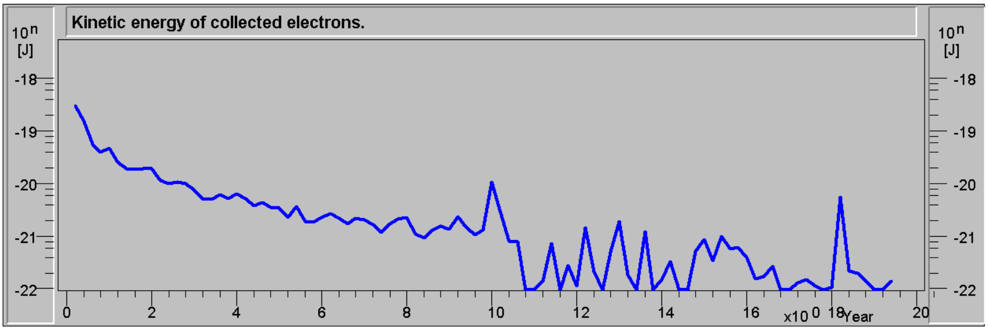

Fig 1.3.3. The relative kinetic energy of electrons as function of time starting from the build of atoms.

At the beginning the energy will be larger but decrease along with the halo growing. The density is extremely large just after the creation of the galaxies but will drop due to multiple collisions between particles while the halo grows. The density of the halo drops by a factor 10^6 till the end of the plot. Only the very first part will essentially contribute to the photon spectra.

[1] Fundamentals of modern physics, Robert Martin Eisberg, Jown Wiley & Sons, Inc, 1961

1.4 The scattering of photons.

The photons we generated in the last chapter can scatter against atoms thereby kicking up electrons in higher orbits. The electrons will fall down creating one or more photons of lower energy. We know the phenomenon as fluorescence.

In doing so we keep track of how many electrons have been captured. An incoming photon most likely excite the outmost ones, but an energetic photon could hit an electron in a lower orbit. It may also eject one completely.

The second process we have considered is the one where photons scatter on free electrons thereby losing energy, namely the Compton scattering. They may also scatter elastically (Thomson scattering) but this is of no interest at present. That will just spread them around.

It turns out not to be very easy. In the first time step we must treat 10^{10} collisions. We must go through every single collision. We split it up in say 10 000 thousand smaller steps. This means that we still have a million collisions to treat for every small step. However, the number of collisions will drop drastically when the halo expands. To achieve this goal, we must find an algorithm (based on recursion) to process a million collisions in single statement. The details are given in the Appendix. In fig 1.4.1 we plot the result.

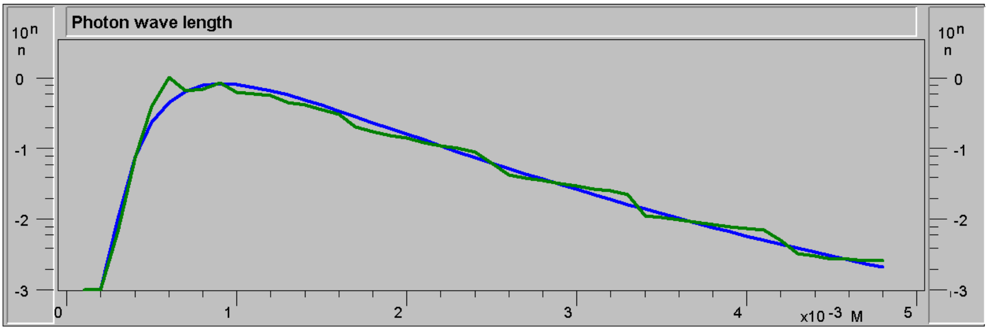

Fig 1.4.1. The distribution of photons after scattering as a function of the wavelength. The curve is a 2.725K black body.

The blue curve is a blackbody with 2.725K. The fit looks quite nice. The statistics we have is meagre. The problem is simply that the computing time runs away if we try to refine it. The mentioned algorithm should not distort the result but just take the runtime down. We tried out a curve with 2.6K to compare with, just to get a feeling of our sensitivity, fig 1.4.2.

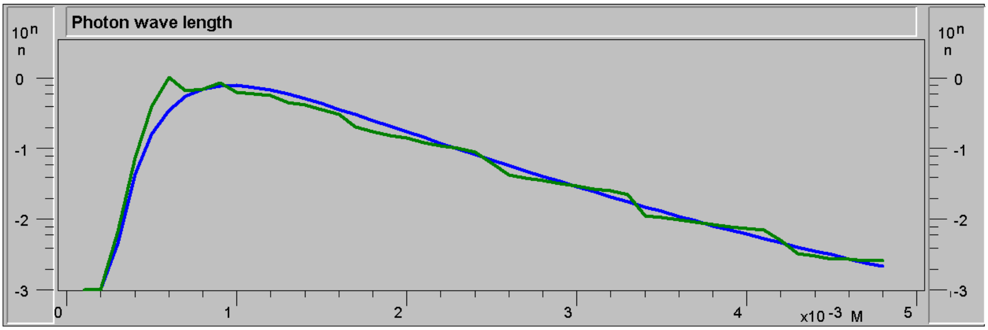

Fig 1.4.2. The distribution of photons after scattering as a function of the wavelength. The curve is a 2.6 K black body.

As seen, a 2.725K distribution looks slightly better, but the difference is not large. This shows that we are coming quite close to observations. Thinking on our approximate procedures we were a bit surprised. The procedure has been scrutinized not just once but many times and we find it solid. To get a feeling of the accuracy we let the number of collisions we apply very a bit. It results in an estimated error of .15 in the temperature. We must emphasise that without the scattering against free electrons we would never achieve a reasonable curve. Photons absorbed by atoms has quite a small effect, if any, on the spectrum and we have not bothered about that process.

You have now seen what scatterings of photons will do. If we come back to the so-called primordial distribution we presented in the last chapter, you may realize it will never occur. The scattering is present all the time during the evolution so that distribution will also change just like the one we just presented.

In the Big Bang story, it is claimed that after atoms have been formed (the recombination) the universe was transparent. The problem is that there are no free electrons in that story that can do the job.

2. The CMB spectra.

As we have described, the elementary particles are created in the very early processes before the galaxy haloes are formed. They fly around in all kinds of directions and are quite energetic. This is not a stable condition under which atomic nuclei can be formed, even less to form atoms. It is not until particles get trapped into a galaxy halo these fundamental processes can begin. As have been noted it still takes some time before the conditions are the right.

The consequence is that it is the galaxies themselves that create the photons that constitute what we now call the microwave background radiation. When this happens, the galaxies are not more than about a few light years from each other. This means that we could expect to have a large contribution of photons coming from other galaxies. The scenario we have pictured is completely different from cosmological models where the evolution starts by an unspecified soup.

However, as we have noted we see no direct difference of the photon spectra between various galaxies. To remind you we are looking on a sample of galaxies produced under somewhat different circumstances. By the time we observe the photons they will have spread out, that is the condition today is not the same as it was earlier.

The conditions at their creation will be completely masked by now. Photons will scatter on free electrons. To remind you there are about 2000 more electrons created than protons at the beginning of the evolution. Part of them will bind in atoms, but only the lightest will count which means that the main bulk will survive. For each10th hydrogen atom a helium atom will be made binding two electrons, which means that the number of electrons counted per proton will not change. The consequence is that there will be numerous scatterings going on since the beginning which certainly will smear out the distribution of photons. In contrast, in the Big Bang scenario it is claimed that there was no scattering after the so-called recombination. In difference, we expect that the distribution of photons should become quite even by time. No trace of what happened once upon a time. That is the reason why we just assume that the density fluctuations will be random. As a result, we just draw a random number to get an estimate of the fluctuations. In fig 2.1 we plot the result over the hemisphere.

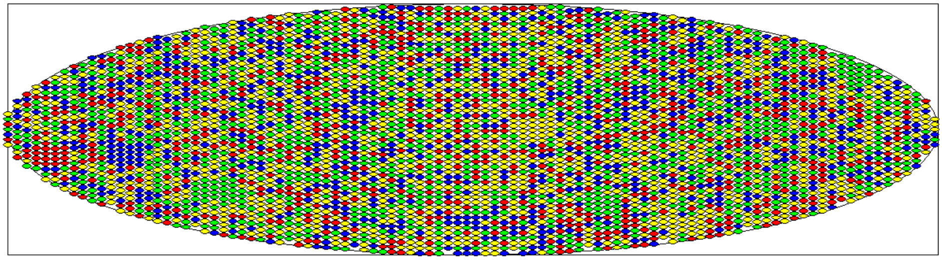

Fig 2.1. The CMB spectrum.

The colour encoding is as follows, red means 1σ larger energy/temperature, yellow 0-1σ, green 0-1σ lower and blue below that. We have not tried to find an absolute scale since that is a bit tricky. We need to know the various sources of photons and their intensities. We also made a map with four times the resolution in Fig 2.2. It contains 32000 entries.

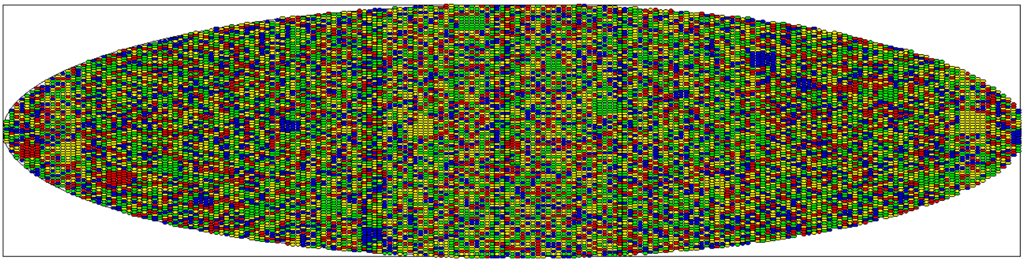

Fig 2.2. The CMB spectrum with four times improved resolution.

The spectra shown look like observations. That is, just a random distribution. This means that the anisotropic behaviour that has been claimed seems to be just statistical fluctuations. To investigate the behaviour, we made an analysis in terms of spherical harmonics in the same way as data have been treated. The result is shown in fig 2.3

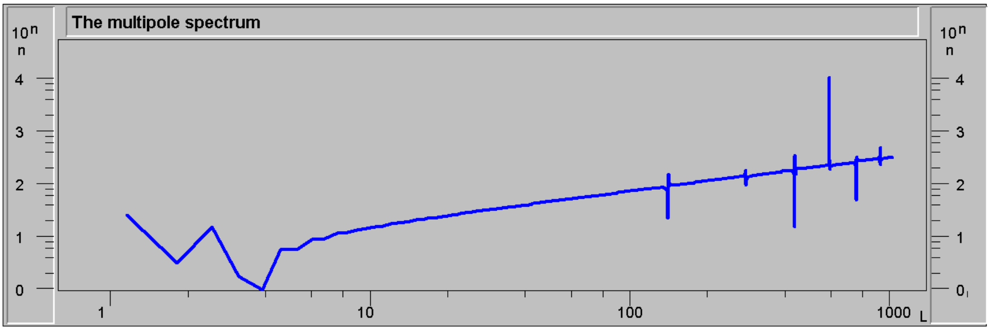

Fig 2.3. The multipole spectrum. The y-axis is logarithmic

As seen we have a level (l=1 is just the starting value) with structures at l=2 and 4 followed by a rise. The y-axis is logarithmic to visualize the low l-region. In difference, data also exhibit a decline after l about 300 but else looks similar. However, our fitting procedure does not seem to be very sensitive to large l-values. It was designed for fits with much smaller number of parameters (order 10-15) and works well in these cases. We have not tried to change it. We thought we should mention it in case this might be the cause for the difference. However, we just do not see the physical importance of the analysis of larger l-values. Comparing the results for the two different maps, we see a small difference, namely that the octupole disappears in the larger map.

There may be another cause for the discrepancy. Acquired data are manipulated in various ways. In at least one case the background from our own galaxy was withdrawn. As we have seen it is the galaxies themselves that create the cosmic background. If we subtract it what will the result be? We also note that one is correcting for our motion around the galaxy. It means that some absolute reference frame has been assumed. If the galaxy itself is creating the photon distribution one can think it as such also follows the rotation. We must remember that the atoms creating the photons is moving along with the galaxy rotation. If the cosmic background does not stem from our galaxy but from an earlier event, should we then not correct for the motion of our galaxy as well? The question is with respect to what.

At the beginning of the evolution the density of galaxies was quite high. When we look into the details we see that when the haloes developed they could almost overlap. The influx of photons from neighbouring galaxies should have been large. On the other hand, the photons should have spread out by now. However, influx later in the evolution could give raise to grains/asymmetries in the photon distribution that have not yet been washed out. We have not tried to implement such a scenario.

Conclusion

> We find that the observed CMB distributions seem to be consistent with statistical fluctuations.
>
> However, we cannot exclude there may be sources of photons that impact more limited regions on top of statistical fluctuations.

We see no reason to assume a perfect isotropic distribution. Possible variations outside of statistical ones seem quite natural. We do not know how the electron cloud is distributed. We could expect that variations in that cloud lead to variations in the photon distribution. We do not need to invoke any fancy exotic mechanism. We must clarify why we arrive at quite a different view than cosmological models based on the Big Bang. No one can deny that the universe is built on the elementary particles. Unfortunately, the Big Bang does not explain how these particles were created, especially the free electrons that are important for the photon spectra. In contrast we have given a possible scenario in part I and the consequences there off in Part II. It is what happened right at the beginning that leads to the different results.

2.1 Polarization.

We see that there might be a possible source for polarized photons. As have been noted there are plenty of free electrons floating around. The density of electrons we expect to be larger in the galaxy plane like other matter.

For a photon from outside of the plane the electron cloud may look like a scattering plane (c.f. a metal surface). The scattering should take place in the outskirt of the electron cloud. Photons scattering deeper down will just get smeared out losing any polarisation. We picture in the next map how we imagine it might look like, fig 2.1.1. Polarisation is shown by white pixels.

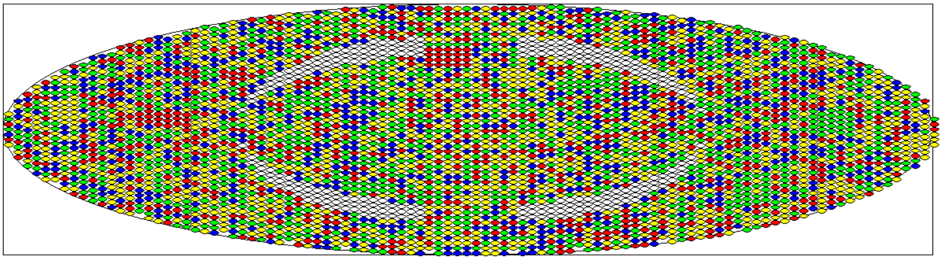

Fig 2.1.1. The CMB spectrum with polarisation indicated in white.

We have to stress that this is not a real calculation but rather a guess of how it may come out.

2.2 Discussion.

The CMB spectra is always discussed in terms of cosmological models all based on the Big Bang. As we have tried to point out there are problems with the latter. The major point is that it does not explain how the elementary particles were created but just assume there was an amount of atoms available before some kind of potential was erected giving rise to an exponential expansion of the universe. All within the Planck time. This led to the so-called recombination from where on no scattering of photons took place.

In difference to our model, we explained how the fundamental particles could be created. Due to the Heisenberg uncertainty principle much more electrons than protons were produced. Neutrinos even more. Even after the formation of atoms there will be a good deal of electrons floating around. This means that there is no last scattering of photons. They will scatter even today and continue to do this for ever.

Our process leads to supermassive objects (SMBHs) that constitute the cores of the galaxies. The creation of these cores evolves quite quickly, in fact around 15 minutes but much slower than the Big Bang. A bit more realistic we would say. There is nothing mentioned about these cores in the Big Bang.

It is interesting to note that in accordance with present observations most galaxies have such a super massive core. These cores are different from the black holes that are formed by dead stars. However, the difference between the two models is more profound. As we explained in our first book the galaxies will move outwards in form of a broad band, which means that the centre of the universe would be more or less empty (except for the very first core and some that might be captured in orbit around the central core).

Exactly how the impact on the CMB might differ we have not tried to figure out. We could just mention that the effect of lensing should come out differently. An outgoing photon would sense the changing gravitational potential in the Big Bang scenario, the ISW effect [1]. In our scenario the outgoing photon would see a gravitational potential close to zero. This means that the incoming and the outgoing photon would be unchanged except for a deflection.

Especially the presence of numerous electrons flying around affects the whole picture. There will be much more scatterings of photons than in the Big Bang scenario (none as claimed). This is the main reason why we expect the effects of various sources to be washed out. Thus, a randomized distribution.

Finally, we note that new results from BICEP3 [2] tell us that inflationary models seem to be unlikely. It would be interesting to see how cosmologists would treat the picture we have given.

[1] Sachs, R. K. & Wolfe, A. M., Perturbations of a Cosmological Model and Angular Variations of the Microwave Background. 1967, ApJ, 147, 73

[2] P.A.R.Ade et al., Phys. Rev. Lett. 127, 151301 (2021)

3. Summary.

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 biproduct, 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. Another consequence is that due to particles now being built by confined fields, the Newton gravitational law must be reformulated. In this new relativistic form various predictions come out quite right.

In our first 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 the centre of the galaxies.

In the third book we augmented that study with the formation of the halos of the galaxies as well as the creations of stars and planets. We note that the results are in good agreement with observations.

In this book we have shown how the atomic nuclei are formed when the galaxy halo is building up, long before there are stars. A bit later, atoms are formed giving rise to a primordial photon spectrum of a black body of 3000 K. Due to scatterings on free electrons the photon distribution boils down to 2.7K. At end we find that the observed CMB spectrum is consistent with statistical fluctuations.

We have also discussed dark matter which we can explain as due to neutrinos which we found to dominate the universe. Lumps of neutrinos can give rise to lensing as has been observed. In recent years reports on searches for various kinds of exotic particles have come forward. All of them with negative results. Our own candidate, the neutrino, now comes up as the most likely candidate.

We also like to mention our findings in our second book. Through a specific quantum mechanical process, we could predict the known forces, specifically the magnitude of their couplings. The forces are created by the gravitational force. It is the most fundamental force of them all and must always be erected when particles are created.

In all we have a consistent physical picture of how nature can create a universe with the known fundamental particles and their corresponding forces. It starts off from the production of real particles from which we build our universe.

4. 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 15 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.

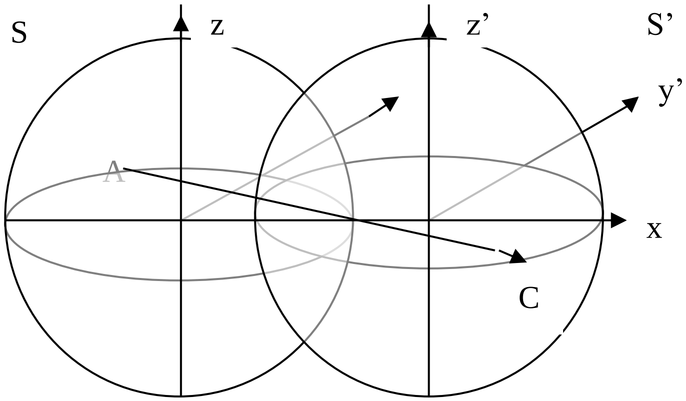

Fig. 1.1 Two objects in close encounter. S' is rotating around S.

To get the effective force we must 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.

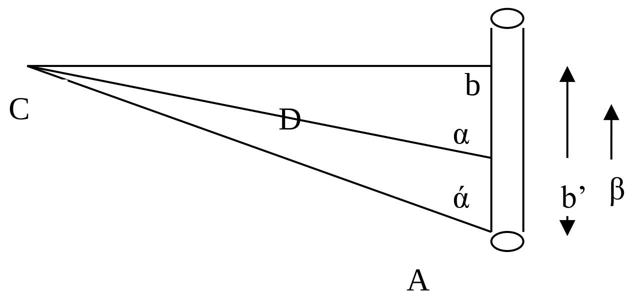

Fig. 1.2. A current element of charges moving with relative speed β.

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

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

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 must 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:

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

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 textbook on the subject):

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

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

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

$$F'' = \frac{1}{r}[-F'(k_1 + k_2) + (k_1(1 - k_2) + A_1 A_2 r^2)\frac{F}{r} + (F' + \frac{k_1 F}{r})\frac{rV'}{A_2}]$$

where $k_1 = 1 - \kappa$, $k_2 = 1 + \kappa$ solving for f,g or $k_1 = -\kappa$, $k_2 = \kappa$ solving for F,G. $\kappa = \pm(j+1/2)$, 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 would 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 = ωr sinθ/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=ω/c

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

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.

1.8 Spin G factor.

In this case the energy content is calculated as a function of the radial distance R. The dipole moment is given by

$$\mu(t) = \omega t^2 f_w / \sqrt{1-\omega^2 t^2} \ ,$$

where t is the distance to the axis. The square root is due to the moving charge density. The weight function f_w goes like 1/r, r the radial distance.

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 wavelength (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.

4.1. The Dirac equation.

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 Dirac 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. 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.

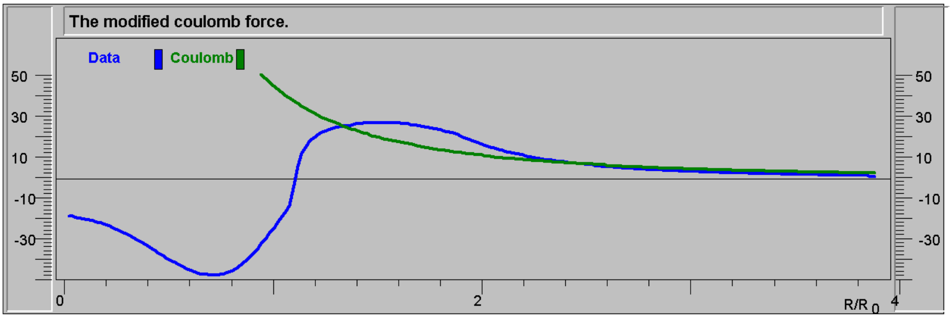

Fig 1.1. The effective force with the correction applied.

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.

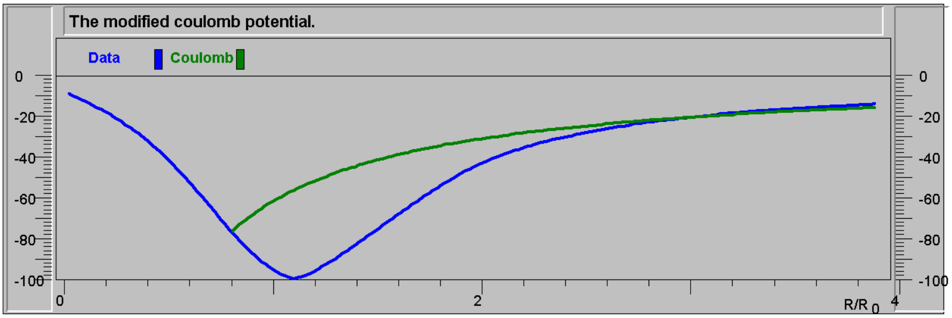

Fig 1.2. The effective potential with the correction applied.

Appendix part 2.

1. The simulation.

The simulation done is a very crude one, but still quite complex. About 20 000 lines of code. A full simulation is not possible. Instead, we must work in another way, namely simulate the average effects. Everything is just the behaviour of average objects. This means that we replace certain details of a true simulation with estimates. We simply estimate, to our best knowledge, the outcome of more fundamental processes. The procedure was to construct simple algorithms.

However, as things evolved, more and more of these estimates could be replaced by actual simulations. It is nice to note that our estimates could be verified by the simulations. It gives us confidence in what we are doing.

We try to break down the evolution process into as many pieces we could think of. The more pieces, the more stable is the result. One process we cannot estimate, namely the probability of creating a miniverse. We simply have assumed that once the process has started as many miniverses there is space for will be produced.

However, the situation is not quite as bad. If the amount of galaxies is wrong, the universe might not build. The amount of galaxies affects the feedback, especially back to the central core. If the amount is too small, the central core will go berserk and swallow everything. If it is too large the galaxies will do that job. A nice balance indeed!

We should perhaps mention that the proper amount fits well with the observed one.

The simulation itself is quite simple. We make small steps in time and start by adding layer to layer to the central core. After a certain time, we allow galaxies to start to form. The starting time we let vary and just repeat the whole calculation. This is the price to pay with this type of simulation.

Also, other parameters we allow to vary to get a feeling for how things behave. Normally a change in one does not do much. The absolutely most important is the one we mentioned above.

The starting time also affects the result. If a galaxy starts to build too late, it will simply be killed by the mother. If it starts too early, it will behave like a new central core. The two cores would just melt together into a core that would eat everything.

After further time has passed, sub galaxies can start to form. One outward and one inward in a chosen direction (normally 30^{o} from the centrum line$^{)}$. The best would have been do draw a random number and create them along we go. However, as said, we do not have those resources. Instead, we again must repeat for some typical directions.

For every step we apply various feedbacks. Halos are built by capturing particles that are not too fast. If so, they will pass by. If they are too slow, they will be captured by the core. It is all steered by how and where they are produced. The most important source in the beginning is the mother of a galaxy. Neighbouring daughters will also contribute as well as close by galaxies from the same generation as the mother. When the amount of cores increase we can expect collisions between them giving rise to even more debris.

The gravitational impact of other objects is taken into account leading to energy loss/gain (on the average off course). The calculation of energy loss is done by a “simple” algorithm. This algorithm was checked against a full simulation of how an object is affected by some milliards of other objects in form of a broad halo. We just let one object pass through the halo to see how it behaved. Off cause, if we are dealing with the effect of just two interacting objects (mother and daughter), we will not need the algorithm.

Part of the debris will continue outwards. When they are slowed down and return, they will be absorbed by the cores (or end up in a halo). They could also take a new turn around the universe. When the later generations start to form the amount of debris around them will be quite substantial and finally prevent any later generations to build.

We think that we have taken the major and most important processes into account. Again, in an average sense. By studying this process from various aspects, we have become confident that we have a product that is working quite well. The limited precision is a bit disturbing, however.

As you might understand, by varying the parameters the net result will change, although not too much. However, we have managed to build a universe that did not last more than some milliard years. Now you may say that are simple model is a flaw, but then you have not got the point. The variation of the parameters corresponds to statistical fluctuation. If you are religious, you might say that God through a pair of dices in creating our universe and this time he got it right.

Some details.

At the beginning a bubble explodes creating two pairs of bound particle-antiparticle while a particle and an antiparticle escape. Just in the moment before they get quantized the fields are at maximum. We assume that it is in this moment nearby bubbles gets triggered and continue the creation process. It is like a chain reaction.

The particles that were created can only to a part escape. One of them can move outwards while the other will move inwards. The latter can scatter and, in this way, move outwards, but not all of them. We assumed that 60% escapes. The trapped one can to a part cause annihilations by breaking the bonds of the pairs. However, to be able to do so it first must have got a kick from other debris to have enough energy. We assumed 70 % of the inwards ones can do this.

We mention these examples just to emphasis on what ones needs to estimate when we do not have a full simulation. There are many more numbers like these, but we cannot mention them all. The numbers above affect the final mass of a core, but from what we see the effects are not major, the order of a factor 2 or so.

When time passes on, newly created bubbles might get a kick from debris and escape from the core. We could compare to the corona of the sun, which might throw out particles all the way to earth. We have assumed that their speed will be about 75% of the debris. Again, this is not crucial. What happens is that a slow one will get a larger energy transfer than a faster one. Again, the difference shows up in the final size of the core. The slow one tends to get a bit smaller due to the annihilations caused by absorbed debris.

These miniverses will speed up by absorbing debris especially from its mother. Part will end up in the core and partially annihilate thereby decreasing the core while its kinetic energy increases. Another part will be captured into a halo. The miniverses will create debris of their own. Part which will hit the central core and other miniverses, part which will move outwards with a speed larger than the ones from the central core.

Another source of debris come from colliding cores. Since we have assumed that it will be quite crowded this will happen. We expect that the result at least will be of the order of the normal production of debris from a growing core. When we calculate the contribution from nearby cores, we just scaled up that result a bit to account for this source. However, this contribution has now been properly included in the full simulation. This was necessary to get a correct simulation of the galaxy halo. Which in turn affects the creation of stars and planets. The effect is that with more debris absorbed, the galaxies will speed up a bit more. However, when they become faster the rate of absorption will diminish. This balance makes the result more stable than one at first could think.

The debris we divide up in two parts. One that has passed by the daughters and one that has not yet come so far. The reason for doing so is due to the calculation of energy loss. Instead of just one average lump the calculation will be more correct.

When we create a new generation, we just make two representatives. One that moves outwards and one inwards. In all interactions we let them have an angle towards the radial line through the centre of the universe. In the next generation the inward one again gives rise to two cores, one outward and one inwards. The same goes for the outward one.

We only treat one hemisphere. When galaxies or debris cross over to the other side they are reverted. In this way we take into account objects coming from the other side of the universe.

We make four generations plus two partial ones that will represent the remaining generations. In principle we could have made more generations, but the problem is that the energy becomes so large that we cannot calculate relative velocities because of the limitations in the precision.

When loss or gain of energy takes place due to the interaction with other objects, these representatives are handled as if there were milliards of them. We simply treat each representative as a halo of some milliard objects. This does not mean that we make a big loop over them, but instead we use a “simple” algorithm. That algorithm was checked against a full calculation using some milliards of objects in form of a halo of some width and letting a test object pass through. The match was quite good.

In all what we are doing the interplay between cores (galaxies) are crucial. They will affect their neighbours in one way or another. Either through the debris generated or through the gravitational force. This leads to a nice balance that make the whole story work. We see that the universe will expand in form of a halo, compare to an inflated balloon.

Appendix part 3.

1. The formation of atoms and photons.

The evolution proceeds in terms of time steps, .05 seconds at the beginning but are gradually increased along we go. We calculate the cross sections for an electron to hit a nucleus and choose randomly a nucleus according to their abundances. When the electrons are collected the number of collisions during a time step is enormous. Even after splitting it up in say 10000 pieces only a fraction can be handled. What is left is counted as the weight of the event.

2. The scattering of photons.

We use the Compton process which can be described by the Klein-Nishina formula.

$$d\sigma = \frac{r_0^2}{2}\left(\frac{\nu'}{\nu_0}\right)^2 (\frac{\nu_0}{\nu'} + \frac{\nu'}{\nu_0} - sin^2\theta)d\Omega$$

where $r_0=e^2/mc^2$, the classical electron radius and θ the scattering angle. Prime denotes the scattered photon with the energy

$$h\nu' = \frac{h\nu_0}{1 + h\nu_0(1 - cos\theta)/mc^2}. \qquad [1]$$

The factor $h\nu_0/mc^2$ tell us that soft photons will exhibit a tiny energy loss. However, after some 10^{10} collisions it will be noticeable. This is the amount we find to be treated when we begin. By time the density of electrons will drop decreasing the number of collisions. In fact, the density drops by roughly a factor 10^{25} from start to end. The procedure takes this into account. One could imagine that the electrons will be absorbed by the stars, which do happen. However, at the end of the evolution the accumulated effect is quite small. So, we can neglect it. We must remind you that it takes some time for the stars to build up. As mentioned in part II, a star has only reached 2% of its final mass after 100 million years.

We split it up in say 10 000 thousand smaller steps. This means that we still have to treat about a million collisions for every step. To be able to handle this number of collisions we use a simple algorithm that simply reduces the number of steps needed drastically. The algorithm is obtained by recursion based on the expressions above. It emulates several repeated collisions. Otherwise, the computing time will explode. Each event corresponds to a bunch of incoming photons.

We choose a random average scattering angle for the algorithm since we are now emulating some million collisions in a single statement. The distribution is relatively flat for low energies which is our case. All according to measurements, e.g., [1].

The recursion is simply achieved by inserting hν' into [1] and repeating. We keep the angle fix and after denoting hν=E and Ɛ=E/mc^2 we get

$$E_n = \frac{E_0}{1 + n'\mathcal{E}(1 - cos\theta)}$$

This after n steps. $n' < n$ is the effective number of scatterings taking into account the energy dependence of the cross section. The effect is small for a single collision but after many scatterings the net effect will be noticeable. If we let the angle vary between the steps we just get an average angle at the end. If n' is 10^6 and we set the average cos θ to 1/2, a 1eV photon would lose half its energy. In contrast, if instead start with a photon in the microwave band it may just lose a permille of its energy during the same number of collisions. We could say that the scattering levels out by time.

[1] E.B. Paul, Nuclear and particle physics, North-Holland, 1969.