Properties of the electrostatic field 18/01/2024

Link with the gravitational field

Pascal DUBOIS

Keywords: gravitational field; gravitation; gravitational interaction; Schwarzschild radius; electrostatic field; electric field; electrostatic interaction; charge; neutron decay; proton; electron; neutrino; proton radius; fine structure constant.

Summary:

The approach adopted to construct the gravitational field can be transposed to the electrostatic field: electrostatic interaction results from an exchange of energy between charged particles and the global field they create.

Like the gravitational field, the electrostatic field is characterised by its energy and its limiting radius of action; it is periodically refreshed by waves ensuring the exchange of energy between charges and field.

Assigning negative energy to electrostatic fields explains the repulsion of charges of the same sign and the attraction of opposite charges. The sharing of interaction energy between charged particles implies that the energy of the electrostatic fields is proportional to the energy of the gravitational fields of these particles.

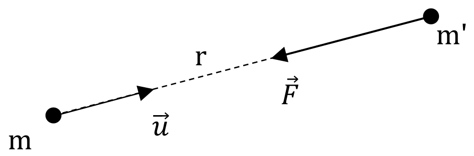
Analysis of the decay of the free neutron makes it possible to derive the creation of the electrostatic fields of the proton and electron from the interaction energy of the gravitational field associated with these two particles. The interpretation that we propose does not require the emission of an antineutrino of the electron type : the final energy of the electron results from the loss of energy undergone during the separation in the electrostatic field.

In the case of the proton, the limiting radius of the electrostatic field can be identified with the radius measured by diffusion experiments.

The parameters of the field (energy and radius) associated with the proton or electron vary according to the energy of the particles, but are characterised by their product, which is constant. This constancy reflects the constancy of the ratio between the energy frequency of the waves and the refresh rate. This ratio can be likened to the fine structure constant.

1. Properties of the gravitational field

In Newtonian gravitational theory, gravitational attraction is modelled by means of a vector field proportional to the source mass of the field and varying inversely with the square of the distance from it. The force exerted between two sources is equal to the product of the mass of one source and the field vector attached to the other source:



$$\vec{F} = m' \vec{G}(\vec{r}) = -(Gmm'/r^2)\,\vec{u} \qquad (1.1)$$

We have proposed a new energetic approach to gravitation[1] preserving the decay principle in $1/r^2$. On the other hand :

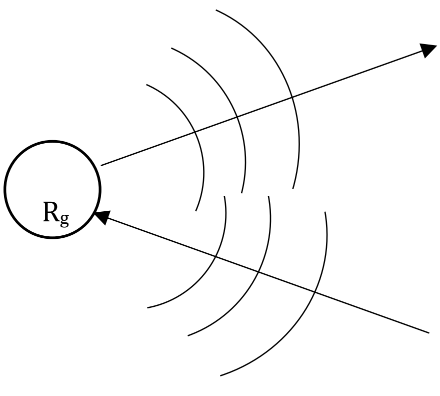
- it is no longer the rest masses of the gravitational sources that are taken into account, but their total energies ;
- the rest energy varies when the distance between the sources varies.

The gravitational field, which has a physical reality, is considered as a distribution of energy in the whole space, except for a ball of radius R_g centred on the source (which allows to keep a finite value to the total energy of the field W_g).[2] The energy contained in a spherical shell of radius r and thickness dr is written :

$$dW_c = (R_g/r^2)\, W_g\, dr \qquad (1.2)$$

The field is periodically refreshed by two spherical gravitational waves travelling at the speed of light[3]:

- one propagating energy from the source which it gradually transfers to the field ;
- the other propagating the energy it takes from the field back to the source.



At the R_g boundary of the field, each wave carries energy equal to the energy of the source (W). At distance r from the source, the energy transported is :

$$W(r) = (R_g/r)\, W \qquad (1.3)$$

Each time the field is refreshed, energy is alternately transmitted and received in a time :

$$T = R_g/\mathbf{c}. \quad ^4 \qquad (1.4)$$

[1] See note on "Another approach to relativity".
[2] Cf note "Gravitational field, the fundamental principle of dynamics and quantum mechanics" .
[3] These waves are not of the same nature as those defined in the theory of general relativity.
[4] The note quoted at[2] shows that this choice makes it possible to establish the fundamental equation of dynamics from the gravitational field.

The choice of taking the maximum energy transported by gravitational waves to be equal to the energy of the source[5] leads us to take the Schwarzschild radius[6] as the limit of extension of the field:

$$R_g = 2\ G\ W/\ \mathbf{c}^4 = 2\ Gm/\mathbf{c}^2 \qquad (1.5)$$

For $r \gg R_g$ we can assume that relationship (1.1) remains valid:

$$\vec{F} = (W'/\mathbf{c}^2)\ \vec{G}(\vec{r}) = -\ (G\ W\ W'/\ \mathbf{c}^4\, r^2)\ \vec{u} \qquad (1.6)$$

The gravitational interaction consists of an exchange of energy between gravitational sources and the global field created by these sources.

This global field is obtained, as in Newtonian gravitation, by vector addition of the individual fields. At each point in the resulting field, the energy density is proportional to the square of the norm of the field vector:[7]

$$\delta E(r,r') = k\ \|\ \vec{G}(\vec{r}) + \overrightarrow{G'}(\overrightarrow{r'})\ \|^2 = k\ \|\ \vec{G}(\vec{r})\ \|^2 + k\ \|\ \overrightarrow{G'}(\overrightarrow{r'})\ \|^2 + 2k\ \vec{G}(\vec{r})\ \overrightarrow{G'}(\overrightarrow{r'}) \qquad (1.7)$$

The term $2k\ \vec{G}(\vec{r})\ \overrightarrow{G'}(\overrightarrow{r'})$ represents the interaction energy added to the field energy of the sources assumed to be isolated. Choosing a positive value for k ($k = 1/\ 4\ \pi G$) gives a positive energy to the gravitational field and to the variation in interaction energy as the sources move closer together. As the interaction energy is transferred to the sources, their energy increases, which explains their attraction.[8]

The expression of the interaction energy of the field, opposite the value of the potential energy[9] , shows a factor of 2 compared with the Newtonian expression. This is due to the variation in rest energy:

$$E_{ig} = 2\ G\ W\ W'/\ \mathbf{c}^4\, r \quad ^{10} \qquad (1.8)$$

[5] The note quoted at[2] shows that this choice allows the resulting gravitational wave to play the role of the pilot wave imagined by Louis de Broglie.
[6] This is not surprising since, in the comparison made between our approach to gravitation and the theory of general relativity, we refer to the Schwarzschild metric, which is precisely defined outside the sphere of radius R_g .
[7] cf. note "Gravitational field, Fundamental Principle of Dynamics and Quantum Mechanics", paragraph 1.2.2. Interaction of two sources.
[8] cf. note "Gravitational field, Fundamental Principle of Dynamics and Quantum Mechanics", paragraph 1.3.2. Interacting sources: energy exchanges between sources and field (reproduced in the appendix).
[9] With zero potential at infinity.
[10] Expression valid for $r \gg R_g$.

2. Construction of the electrostatic field

2.1. Analogy with the gravitational field

The force exerted between two fixed charges q and q' is given by Coulomb's law, which is written in a similar way to the law of gravitational attraction :

$$\vec{F} = q' \vec{E}(\vec{r}) = (qq'/ 4\pi\varepsilon_0 r^2)\, \vec{u} \qquad \vec{E}(\vec{r}) \text{ being the electrostatic field vector} \tag{2.1}$$

The first difference with the gravitational interaction is that the charges are in the form of elementary charges that cannot be merged. We are therefore interested in the interaction between elementary charges of positive or negative value (e).

Secondly, charges of the same sign repel each other, while charges of opposite signs attract each other. To explain the repulsion of charges of the same sign, it is necessary to choose the negative coefficient k in formula (1.7) transposed to the electrostatic field :

$$\delta E(r,r') = k \,\|\, \vec{E}(\vec{r}) + \overrightarrow{E'}(\overrightarrow{r'}) \,\|^2 = k \,\|\, \vec{E}(\vec{r}) \,\|^2 + k \,\|\, \overrightarrow{E'}(\overrightarrow{r'}) \,\|^2 + 2k\, \vec{E}(\vec{r})\, \overrightarrow{E'}(\overrightarrow{r'}) \tag{2.2}$$

This leads to an electrostatic field of negative energy for an isolated charge.
The choice $k = -\varepsilon_0/2$ gives the interaction energy of the field created by two charges a value opposite to that of the potential energy.

As with the gravitational field, the phenomenon of attraction or repulsion of charges involves an exchange of energy between charges and the field by means of refreshment waves. But there is a third difference: we cannot a priori associate an energy with a given charge, as we do for the mass of a gravitational source. And charges remain invariant, unlike the energy of gravitational field sources.

What are the consequences?

The average energy W_q of the electrostatic field is half the energy W exchanged by the outgoing waves. Unlike in the gravitational case, this energy is assumed to be invariant[11] . If, due to an interaction between charges, the energy of the incoming waves differs from W, the difference will be transmitted to the charge-carrying particles. Only this difference modifies the total energy of the particles and explains the attraction or repulsion.

The final difference is that if the charges are mobile, it is necessary to introduce the magnetic field associated with their displacement. Note, however, that reasoning based on the electrostatic field alone remains valid if the moving charge moves radially in relation to the charge considered as fixed.

[11] We will see in paragraph 4.2 that this assertion needs to be corrected.

If we construct the electrostatic field in the same way as we did for the gravitational field, we obtain the characteristics shown in the following table:

	Gravitational field [12]	***Electrostatic field***
Field created by a gravitational source or an isolated elementary charge		
Field vector	$\vec{G}(\vec{r}) = -(GW/\mathbf{c}^2 r^2)\,\vec{u}$	$\vec{E}(\vec{r}) = (e/\,4\pi\varepsilon_0\, r^2)\,\vec{u}$
Field energy density [13]	$\delta W_g\,(r) = (R_g\,/4\pi r^4\,)W_g$ $= (1/4\pi G)(G\,W/\mathbf{c}^2 r^2)^2$	$\delta W_q(r) = (R_q/4\pi r^4)\,W_q$ $= -(\varepsilon_0/2)(\,e/\,4\pi\varepsilon_0\, r^2)^2$ [14]
elationship between radius and field energy	$\boxed{R_g\,W_g = GW^2\,/\mathbf{c}^4 \qquad (2.3)}$	$\boxed{R_q\,W_q = -\,e^2\,/\,8\pi\varepsilon_0 \qquad (2.4)}$
Field energy	$W_g = W/2$ [15]	*See below*
Field radius	$R_g = 2GW/\mathbf{c}^4$ Schwarzschild radius	*See below*
Refresh frequency	$T_g = 2R_g\,/\mathbf{c}$	$T_q = 2R_q\,/\mathbf{c}$
Field created by two gravitational sources or two elementary charges		
Interaction energy	$Ei_g = 2\,G\,W\,W'/\,\mathbf{c}^4\, r_0$ (2.5) $(\,r_0 \gg R\,)_g$	$E_{iq} = -\,e\,e'/\,4\pi\varepsilon_0\, r_0$ [16] (2.6)

Energy and radius of the electrostatic field: these two parameters are linked by the relationship (2.4). What energy should be given to the fields of positive and negative charges?
We will examine this point in paragraph 2.3 (Sharing the interaction energy) and in Chapter 3 (Decay of the free neutron).

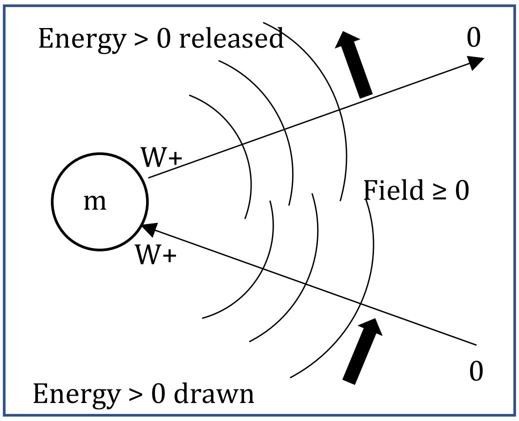
Refresh periodicity: the choice $T_q = 2R_q\,/\mathbf{c}$ is proposed by analogy with the gravitational field. It will also be discussed in section 2.3.

[12] This is the gravitational field proposed in our new approach.
[13] The energy density of the field can be expressed in two ways:
- from the radius and total energy of the field,
- from the square of the field vector.

[14] As explained above, W_q has a negative value.
[15] W_g is the mean value of the energy of the gravitational field.
[16] As far as the interaction energy is concerned, we can assume that the relation (2.4) giving E_{iq} is valid whatever the distance r_0 between the charges, because of the invariance of the latter, as mentioned above.

2.2 Interacting charges

Let's start by recalling the refreshment scheme adopted for the gravitational field and how we explain the attraction of gravitational sources by an exchange of energy between source and field.



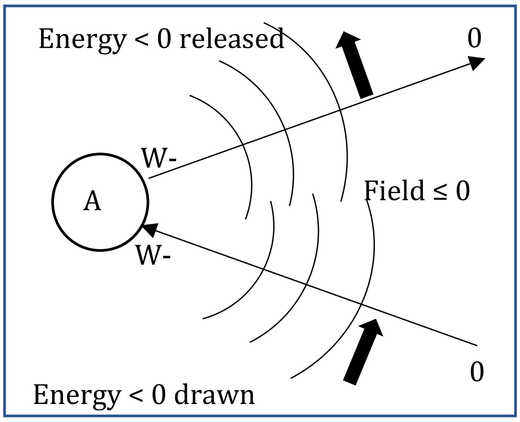
Gravitational field

The field energy is positive. Wave energy varies between W+ and 0; outgoing waves **give up** positive energy, incoming waves **take** it **up**.
When two sources interact, each incoming wave draws positive energy from the field created by the other source. This energy increases as the sources move closer together (corresponding to a variation in positive interaction energy) . The transfer of this energy to the sources explains the attraction.

To extend this type of analysis to the electrostatic field, it is necessary to introduce not only a field of negative energy (oscillating between W- and 0), but also refreshment waves giving off or taking off positive or negative energy. The distinction between two types of field is made as follows:

- for type A, the outgoing waves (with negative energy W-) give this energy to the field, while the incoming waves take it from to bring the field's energy back to 0;
- for type B, the outgoing waves (with positive energy W+) take energy W- from the field, while the incoming waves give it up to reduce the energy of the field to W-.

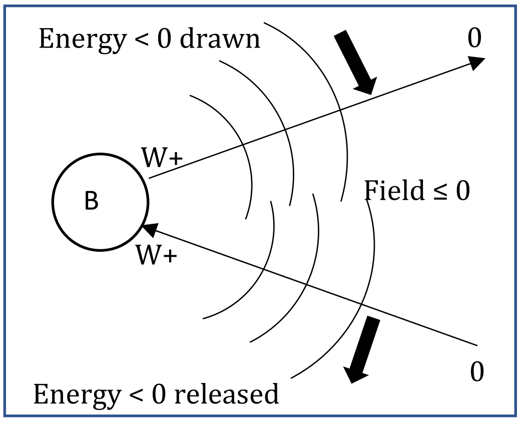
At this stage, it does not appear possible to determine to which positive or negative charge the type A or B field should be assigned.



Type A electrostatic field

This is the exact opposite of the gravitational field.
The energy of the field is negative. The energy of the waves varies between W- and 0; outgoing waves **give up** negative energy, incoming waves **take** it **up**.
When two type A fields interact, each incoming wave draws negative energy from the field created by the other charge. The energy taken increases in absolute value as the charges move closer together (corresponding to a variation in negative interaction energy). The transfer of this negative energy to the particles carrying the charges explains the repulsion.

Type B electrostatic field



The field energy is negative. Wave energy varies between W+ and 0. Outgoing waves **take up** negative energy, incoming waves **give** it **up**.

Interaction of two charges B1 and B2 :

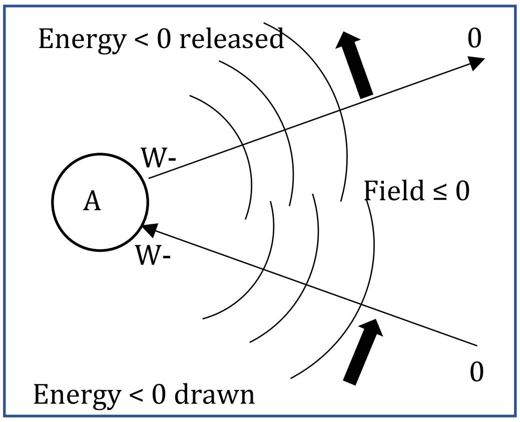
B1 takes energy (ΔW-) from B2's field , so it takes (W-) - (ΔW-) from its own field.

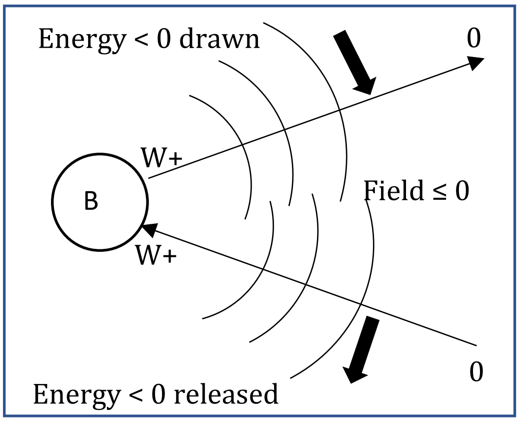
As a result, the B1 field changes from (W-) to (ΔW-). To bring this value back to (W-), the incoming wave gives up energy equal to (W-) - (ΔW-), so its energy changes from 0 to (W+) + (ΔW-).

Negative energy (ΔW-) is transferred to the particle carrying the charge B1. The same applies, concomitantly, to the particle carrying the charge B2.

The closer the charges are to each other, the more energy is drawn from and transferred to the fields, and the more negative the energy transferred. There is repulsion.

Attraction between type A and type B charges





The outgoing wave linked to charge B takes energy (ΔW-) from the field of A (= W-), which takes the value (W-) - (ΔW-) . The incoming wave from A takes this energy to reduce the value of the field to 0. The result is a transfer of energy equal to - (ΔW-) _so > 0_to the particle carrying the charge A.

The incoming wave linked to charge A takes energy (ΔW-) from the field of B, which takes the value (W-) - (ΔW-). The outgoing wave from B takes energy (W-) from this field, which therefore changes to - (ΔW-). To return this value to (W-), the incoming wave gives up energy equal to (W-) + (ΔW-), so its energy changes from 0 to (W+) - (ΔW-). The result is a transfer of energy equal to - (ΔW-) _so > 0_ to the particle carrying charge B.

The variation in interaction energy is positive when the charges come together. There is attraction between the particles carrying charges of type A and B.

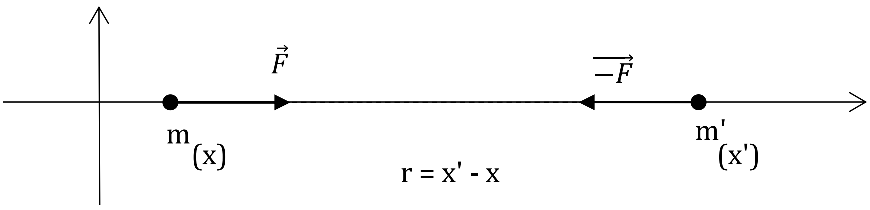
By reproducing the reasoning for the gravitational field[17] and taking into account the fact that the product $R_q W_q$ is invariant, we can immediately verify that we obtain the interaction energy value given by formula (2.6) :

$$E_{iq} = - e e'/ 4\pi\varepsilon_0 r_0$$

2.3. Sharing the interaction energy

How is the interaction energy shared between the two charges?

Let's start by recalling the reasoning used to study the attraction of two masses m and m' separated by a distance r under the effect of gravitation or electrostatic attraction.



Let's denote by m and m' the masses (in the Einsteinian sense: $m = \mathbf{W/c^2}$, $m' = W' \mathbf{/c^2}$, W and W' representing the total energy).

The force of attraction is : $||\overrightarrow{F}|| = K/r^2$ with : $K = G\, m\, m'$ for gravitational attraction

$K = - q\, q'/ 4\pi\varepsilon_0$ for electrostatic attraction

In application of the fundamental principle of dynamics :

$$||\overrightarrow{F}|| = K/r^2 = d(m\, v)/dt = - d(m\, v')/dt \qquad (2.7)$$

From equation (2.7) we deduce by integration: $m\, v = - m'\, v'$ [18] (2.8)

Equation (2.8) expresses the conservation of momentum, which here is equivalent to the principle of action and reaction. The mass + charge system is considered to be isolated.

---

[17] cf. note "Gravitational field, Fundamental Principle of Dynamics and Quantum Mechanics", paragraph 1.3.2. Interacting sources: energy exchanges between sources and field (reproduced in the appendix).
Because of the invariance of the product $R_q W_q$, the energy of the electrostatic field is identical for the fields of the two charges at the same distance from each other.

[18] Assuming zero speeds at infinity.

The change in kinetic energy of each of the masses is written as :

$$dW = F\, v\, dt \text{ and } dW' = - F\, v'\, dt \quad [19] \tag{2.9}$$

(2.8) and (2.9) → $m'\, dW' = m\, dW$

So: $dW = (m'/(m + m'))(dW + dW')$

$dW' = (m/(m + m'))(dW + dW')$

Since $r = x' - x$, we have: $dr/dt = dx'/dt - dx/dt = v' - v$

Given (2.9): $dW + dW' = - F\, dr = - K/r^2\, dr$

$$dW = - (m'/ (m + m')) (K /r^2)\, dr \tag{2.10}$$

$$dW' = - (m/ (m + m')) (K /r^2)\, dr$$

The variation in total kinetic energy is equal to $- (K /r^2)\, dr$, i.e. :

$- (G\, m\, m'/ r^2)\, dr$ in the case of Newtonian attraction,

$(q\, q'/ 4\pi\varepsilon\, r_0{}^2)\, dr$ in the case of electrostatic attraction.

These are the interaction energy values given earlier.

In the case of gravitation, the shares of interaction energy assigned to each of the masses :
$m'/(m + m')$ for mass m and $m/(m + m')$ for mass m'.
correspond to those calculated from the exchange of energy between sources and field. [20]

In the case of electrostatic interaction, sharing the interaction energy according to the same rule implies that the refreshment period of the electrostatic field is inversely proportional to the mass of the particle carrying the charge.
In fact: $(1/m) /(1/m + 1/m') = m' / (m + m')$.
If we consider that the period is proportional to the radius of the field[21] , then the ratio of the energies of the electrostatic fields must be proportional to the ratio of the masses, and therefore to the ratio of the energies of the gravitational field of each particle.

This proportionality between the energy of the electrostatic field and the energy of the gravitational field associated with the charge-carrying particle leads us to explain the creation of the electrostatic field from the gravitational field.
This is what we will do in the next chapter, which is devoted to the analysis of the decay of the free neutron.

[19] Remember that, in the gravitational case, this variation represents only half of the total variation, the other half coming from the variation in the rest mass.
[20] cf. note "Gravitational field, Fundamental Principle of Dynamics and Quantum Mechanics", paragraph 1.3.2. Interacting sources: energy exchanges between sources and field (reproduced in the appendix).
[21] see table in paragraph 2.1.

3. *Decay of the free neutron*

Based on the phenomenon of the decay of the free neutron, can we suggest an explanation for the appearance of the electrostatic field ?

The decay of the free neutron is presented as a process involving the weak interaction, during which a neutron (n) not bound to other nucleons spontaneously disintegrates into a proton (p), an electron (e -) and an electronic antineutrino ($\bar{\nu}$ -) :

$$n \rightarrow p + e^- + \bar{\nu}^- \tag{3.1}$$

The decay energy Q is obtained from the difference between the rest masses before and after the reaction:

$$Q = (m_n - m_p - m_é)\, \mathbf{c}^2 = 0.782 \text{ MeV} \tag{3.2}$$

Q is converted into kinetic energy, which is divided between the electron and the antineutrino. [22]

It should be noted that it was the experimental observation of the variability of the kinetic energy of the electron that led us to imagine the existence of the neutrino carrying away part of the energy.

3.1 Creation of the electrostatic field

We use the terms :

- W_q and R_q average energy and radius of the electrostatic field of the proton (of mass m),
- $W_{q'}$ and $R_{q'}$ average energy and radius of the electrostatic field of the electron (of mass m').

We imagine that the creation of the electrostatic field results from the following mechanism:

- Proton-electron dissociation initiates a gravitational interaction characterised by an interaction energy E_{ig} , the counterpart of which is the creation of a negative energy field. $W- = - E_{ig}$.

- At a distance R_X at which the gravitational interaction has become negligible, the electrostatic field becomes operative: the fields W_q and $W_{q'}$ are created from W- :

  $$W_q + W_{q'} = W- = -E_{ig}$$

  and the electrostatic interaction energy results from the transfer of all or part of the gravitational interaction energy: $E_{iq} = E_{ig} - X$

- At very great distances (measurement location), the energy of the proton-electron system is reduced by E_{iq} due to the distance between the two particles.

---

[22] In this classical analysis, it is assumed that, due to the conservation of momentum, the kinetic energy transferred to the proton is very small.

The process is shown in the diagram below:

Origin	Order distance R_g	Distance $R_X >> R_g$	Long distance
Neutron alone	Proton - electron dissociation Gravitational field	Electrostatic field	Measuring the electron's kinetic energy
$\mathbf{m_n}$	$\mathbf{m}$ ○ $\mathbf{m_n - m}$ Interaction energy E_{ig} Field W- = - E_{ig}	$\mathbf{m}$ ○ $\mathbf{m_n - m}$ Dissociation of the W- field Interaction energy $E_{iq} = E_{ig} - X$	$\mathbf{m}$ $\mathbf{m_n - m} - E_{iq}$ ($E_{cé} = X$) ○ Zero interaction energy

(we assume that the electron moves radially away from the proton) $\mathbf{m} = m\,\mathbf{c}^2$

The assumptions made lead us to write :

$$E_{ig} = m_n\,\mathbf{c}^2 - m_p\,\mathbf{c}^2 - m_é\,\mathbf{c}^2 = Q$$

$X = E_{cé}$ measured kinetic energy of the electron

The energy of the antineutrino can therefore be identified with the electrostatic interaction energy E_{iq}.

3.2 Characteristics of the proton and electron fields

We are going to calculate the values of the energy and radius of the proton and electron fields:

$$W_q R_q = W_{q'} R_{q'} \quad \rightarrow W_{q'} = (R_q / R_{q'})\, W_q = (m'/m)\, W_q$$ [23]

$$W_q + W_{q'} \;- = -E_{ig} \quad \rightarrow W_q\,(1 + m'/m) = -E_{ig}$$

$$W_q = -\,(m/(m + m'))\,E_{ig} \qquad (3.3)$$

$$W_{q'} = -\,(m'/(m + m'))\,E_{ig}$$

At the distance R_X [24] we have: $m \approx m_p$ and $m' = m_n - m \approx m_n - m_p$

This gives: $W_q = -\,0.99862\,E_{ig}$ and $W_{q'} = -\,0.00137\,E_{ig}$ (3.4)

Given equation (2.4), the radii of the fields are :

$$R_q = 0{,}72083\;10^{-15} / E_{ig} \quad \text{and} \quad R_{q'} = 0.52542\;10^{-12} / E_{ig} \qquad (3.5)$$

(E_{ig} being expressed in MeV and R_q and $R_{q'}$ in metres)

---

[23] See paragraph 2.3. The refreshment period (and therefore R_q and $R_{q'}$) is inversely proportional to the mass of the particle.

[24] We will see later what is the value of R_X .

With E_{ig} = Q = 0.782 MeV :

Proton field: W_q = - 0,781 MeV R_q = 0,921 10^{-15} mètre (3.6)

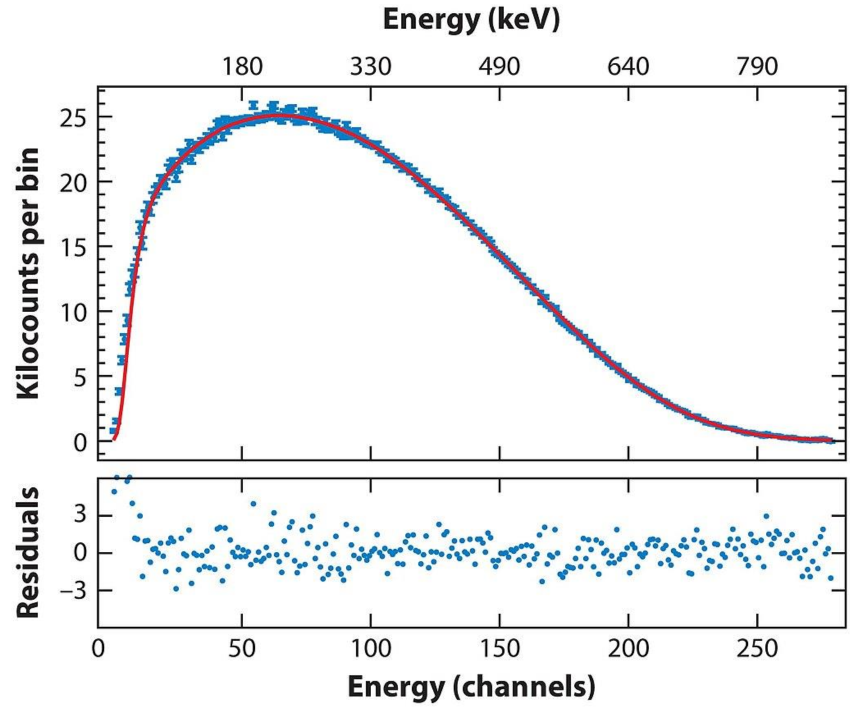
Electron field: $W_{q'}$ = - 1,07 10^{-3} MeV $R_{q'}$ = 0,671 10^{-12} mètre (3.7)

The value of R_q can be compared with the charge radius of the proton, determined experimentally:

$$\mathbf{R_p = 0.83\ 10^{-15}\ metre} \tag{3.8}$$

The 10% deviation from the experimental value raises questions, given the following observation:

The graph below shows the distribution of the electron's kinetic energy. [25]



We can see that the maximum energy is not 0.782 MeV but 0.872 MeV.

On the other hand :

- if we use the distance R_g (limiting radius of the neutron field) to calculate E_{ig},
- and if we assume that the laws of gravitation formulated for weak field conditions are valid throughout the field,[26]

we can calculate the gravitational interaction energy as follows:

$$E_{ig} = (\exp(1) - 1)(m_e \mathbf{c}^2) = 0.878\ \text{MeV} \quad ^{27} \tag{3.9}$$

[25] Figure taken from C. M. Roick's thesis *"Particle Detection and Proton Asymmetry in Neutron Beta Decay"*. Physik Department. Technische Universität München. 14/08/2018.

[26] See note "Extension of the laws of gravitation. Black holes. Gravitational spectral shift".

[27] With $m_e \mathbf{c}^2$ = 0.511 Mev rest energy of the electron.

These results raise questions about the value of the neutron's rest mass.

Let's assume that the energy difference observed (0.096 MeV = 0.878 - 0.782) is attributed to the neutron's rest mass. [28] Repeating the calculations leads to the following value for the field radius :

$$R_q = 0.823\ 10^{-15} \text{ metre}$$

We find the experimental value of the proton radius R_p given above (3.8)**.**

Relations (3.6) and (3.7) must be corrected if <u>E_{ig} = 0.878 MeV</u> is used:

Proton field: W_q = - 0.877 MeV R_q = 0.823 10^{-15} metre (3.10)

Electron field: $W_{q'}$ = - 1.29 10^{-3} MeV $R_{q'}$ = 0.557 10^{-12} metre (3.11)

<u>*Now let's look at the interaction energy*</u> : $E_{iq} = E_{ig} - E_{cé}$

Applying formula (2.6), this is associated with the distance between the loads given by :

$$R_X = (e^2 / 4\pi\varepsilon_0) / (E_{ig} - E_{cé})$$

For any value $E_{cé}$ < 0.878 Mev of the (measured) kinetic energy of the electron, everything happens as if the electrostatic field were formed at a distance between proton and electron that is greater the greater the kinetic energy.

Finally, it should be noted that the analysis we have just carried out does not, at this stage, provide any basis for determining the type of A or B field to be attributed to the proton or the electron.

In conclusion, with regard to the decay of the free neutron, the interpretation we propose :

- **allows the creation of the electrostatic fields of the proton and electron to be derived from the interaction energy of the gravitational field associated with these two particles;**
- **does not require the emission of a third particle: the electron's final energy results from the loss of energy it undergoes as it moves away in the electrostatic field.**

The choice is between :

- an interpretation that gives physical reality to the fields and assumes that the loss of interaction energy results in an exchange of energy with them, via waves that constantly refresh them;
- an interpretation that assumes the creation of particles carrying the interaction energy.

[28] This increase (of 0.01%) cannot be due to the kinetic energy of the neutron: the experimental energy distribution is obtained from the decay of neutrons with a very low kinetic energy (less than 3 meV).

4. Discussion of the properties of the electrostatic field

4.1. Reminder of field characteristics

Let's summarise the characteristics of the electrostatic field created by an isolated elementary charge:

The field can be represented in two ways:

- by an electric field vector : $\vec{E}(\vec{r}) = (e/\ 4\pi\varepsilon_0\ r^2\ )\ \vec{u}$
- by a distribution of energy beyond a sphere of radius R_q centred on the charge, refreshed by a system of spherical waves travelling at the speed of light.

The energy density of the (negative) field is given by :

$$\delta W_q\ (r) = -\ (\varepsilon_0\ /2)(\vec{E}(\vec{r}))^2$$

The total (average) energy of the field W_q is related to the radius R_q by the relation :

$$R_q\ W_q = -\ e^{\ 2}/\ 8\pi\varepsilon_0 \qquad (2.4)$$

Refreshing waves alternately give off or take off negative energy, each for a duration equal to R_q **/c**. The distinction between positive and negative charge is linked to the type of field:

- type A field with an outgoing wave giving energy and an incoming wave at taking it;
- type B field with an outgoing wave taking energy and an incoming wave giving energy.

The energy carried by the refreshment waves is positive for type B, negative for type A.
At the limit R_q , it is: $\pm\ 2\ W_q$.

As explained below, the type A field must be assigned to the proton and the type B field to the electron.

If two charges e and e' interact at a distance of r_0 , the interaction energy density can be obtained from the relation :

$$\delta E_{iq}\ (r) = -\ \varepsilon_0 \overrightarrow{E}(\vec{r})\ \vec{E}'(\overrightarrow{r'})$$

which leads to: $$E_{iq} = -\ e\ e'/\ 4\pi\varepsilon_{\ 0}\ r_{\ 0} \qquad (2.6)$$

The interaction energy is negative for two charges of the same sign, positive for two charges of opposite signs.

It is the transfer of this energy to the particles carrying the charges that explains whether repulsion or attraction is observed. Analysis of the distribution of this energy between the particles shows that the energy of the electrostatic fields is proportional to the energy of the gravitational fields of the particles carrying the charges.

4.2. Field variability

The relations (3.10) giving the energy of the electrostatic fields of the proton and electron are valid at the distance R_x at which these fields are created. At this distance, the electron has a total energy equal to $(m_n - m_p)\,\mathbf{c}^2$ corresponding to a kinetic energy equal to E_{ig} .

When the energy of the electron changes, we must consider that the characteristics of its field are modified. Indeed, in paragraph 2.3 we emphasised the proportionality that must exist between the energy of the electrostatic field and that of the gravitational field (it should be remembered that, in our approach to gravitation, it is the total energy that is taken into account and not the rest mass). By introducing the average energy of the gravitational fields of the proton and electron :

$$W_{gp} = m\,\mathbf{c}^2/2 \qquad \text{et} \qquad W_{gé} = m'\,\mathbf{c}^2/2$$

the relations (3.3) can be written as :

$$W_q = -\,2\,(E_{ig}/m_n\,\mathbf{c}^2)\,W_{gp} \tag{4.1}$$

$$W_{q'} = -\,2\,(E_{ig}/m_n\,\mathbf{c}^2)\,W_{gé}$$

The proportionality coefficient between the energy of the electrostatic field and the energy of the gravitational field is:

$$K_{qg} = -\,2\,(E_{ig}/m_n\,\mathbf{c}^2) = -\,1{,}8687\ 10^{-3} \tag{4.2}$$

If the electron is reduced to zero speed ($W_{gé} = m_é\,\mathbf{c}^2/2$) [29] , the energy and radius of its electrostatic field have the value :

$$W_{q'} = -\,0{,}477\ 10^{-3}\ \text{MeV} \qquad\qquad R_{q'} = 1{,}506\ 10^{-12}\ \text{mètre} \tag{4.3}$$

Comparison with the values given in (3.11) shows that the field energy varies from :

$$\Delta W_{q'} = (-\,0.477\ 10^{-3} + 1.29\ 10^{-3})\ \text{MeV} = 0.813\ 10^{-3}\ \text{MeV}$$

which represents approximately -1/1000th of the variation in energy of the electron

This correction must be taken into account : part of the variation in electrostatic interaction energy is attributable to the individual electrostatic field of the charge and not to the gravitational energy of the particle.

Let's clarify this by going back to the reasoning in paragraph 2.2 (Interacting charges). We are in the case of interaction between charges of type A and type B: the variation in energy transferred is negative when the charges move apart.
The energy variation of the outgoing electron wave is therefore also negative. Since, in absolute terms, the energy of the wave varies like that of the field, the refreshment waves must be of positive energy W +.

The electron's electrostatic field is therefore of type B and the proton's field is of type A.[30]

---

[29] This corresponds to the case where $E_{iq} = E_{ig}$.
[30] Perhaps the charge sign convention should be reversed !

Let's denote the change in electrostatic energy by ΔW.

The equations to be considered are: $\Delta W_{gé} - \Delta W_{q'} = \Delta W/ 2$ [31]

$$W_{q'} = K_{qg} W_{gé}$$

$$W_{q'} + \Delta W_{q'} = K_{qg} (W_{gé} + \Delta W_{gé})$$

This results in: $\Delta W_{gé} = \Delta W/ 2 (1 - K_{qg})$ et $\Delta W_{q'} = K_{qg} \Delta W/ 2 (1 - K_{qg})$ (4.4)

What happens to the energy released by the change in field strength?

- In the case of a decrease in the electron's energy ($\Delta W_{q'} >0$ for the field) , i.e. a deceleration of the charge :

Since the radius of the field increases by $\Delta R_{q'}$, the energy released is that contained in the spherical shell of radius $R_{q'}$ and thickness $\Delta R_{q'}$:

$$2 (R_q / R_q^2) W_{q'} \Delta R_{q'} = -2 \Delta W_{q'} <0$$

- In the case of an increase in the electron's energy ($\Delta W_{q'} <0$ for the field), i.e. an acceleration of the charge :

The outgoing wave evacuates excess energy equal to $-2 \Delta W_{q'} >0$.

Remember that these results concern the proton and the electron in radial displacement.

4.3. Fine structure constant

By analogy with the reasoning for the gravitational field, assume that :

- the duration of transmission and reception of the field refreshment waves is equal to R_q **/c**; the refreshment period is : $T_q = 2R_q /\mathbf{c}$
- the maximum energy (in absolute terms) carried by each wave is equal to $h\, \nu_q$; the average energy of the field is: $|W_q| = \mathbf{h}\, \nu/2_q$

Consider the product of the field refresh period and the (energy) frequency of the refreshing waves:

$$T_q \nu_q = 4 R_q |W_q |/ \mathbf{h\, c} = e^2/ 2\pi\varepsilon_0 \mathbf{hc} \qquad (4.5)$$

By introducing the fine structure constant ($\alpha = e^2 / 2\varepsilon_0$ hc), we get :

$$T_q \nu_q = \alpha /\pi \qquad (4.6)$$

The relationship (2.9) gives a simple physical interpretation of the fine structure constant: this represents (to within a factor of $1/\pi$) the ratio between the energy frequency and the refresh rate of the electrostatic field.

[31] La division par 2 vient du fait que l'équation est écrite avec les valeurs moyennes.

Note:
As far as the gravitational field is concerned, the analogous product $T_g\, \nu_g$ is not constant; it varies as the square of the energy of the source :

$$T_g\, \nu_g = (4\, G \,/\, \mathbf{hc}^5\,)\, W^2$$

So, introducing the Planck mass ($m_P = (\mathbf{hc}\,/G)^{1/2}$) and the relativistic mass :

$$T_g\, \nu_g = (2/\pi)\, (m/m\,)_p{}^2 \qquad (4.7)$$

Annex_Extract from the note :

Gravitational field, Fundamental Principle of Dynamics and Quantum Mechanics

1.3.2 Interacting sources: energy exchange between sources and field

We are now able to propose a mechanism for the exchange of energy between sources and the gravitational field that explains the potential energy.

We consider two sources of mass m and m' separated by a distance r_0.

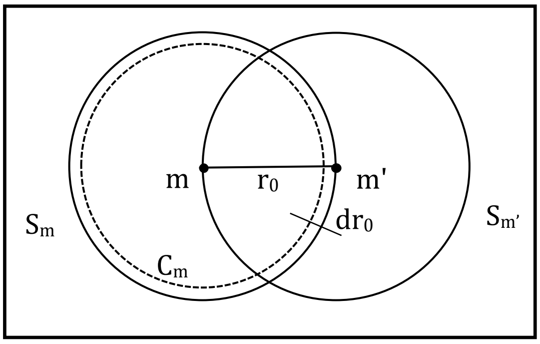


figure 2

In section 1.2.1 we saw that the interaction energy is zero inside the spheres S_m and $S_{m'}$ of radius r_0. This means that :

- the source m' does not interfere with the field of m inside the sphere S_m ;
- the source m does not interfere with the field of m' inside the sphere $S_{m'}$;

Let's assume that the sources of masses m and m' approach each other by a distance $|dr_0|$.

The variation in interaction energy is due to the withdrawal of energy:

- of the source m' on the field, created by m, contained in the shell C_m of centre m, radius r_0 and thickness $|dr_0|$; the energy of this shell is: $(R_g/r_0^2)\, W\, |dr_0|$; [32]

- of the source m on the field, created by m', contained in the shell $C_{m'}$ of centre m', radius r_0 and thickness $|dr_0|$; the energy of this shell is: $(R_g'/r_0^2)\, W'\, |dr_0|$.

[32] To determine the energy drawn, the maximum value (W) of the field energy must be taken into account.

For the source m, energy is drawn off over a time T proportional to the energy W; similarly, for the mass m', energy is drawn off over a time T' proportional to W'. We'll assume that energy is withdrawn in proportion to the withdrawal times :

$$W/(W + W') \text{ and } W'/(W + W').$$

The energies extracted are therefore worth :

- for source m': $(W'/(W+W'))(R_g/r_0^2)\, W\, |dr_0| = 2\, G\, (W^2W'/(W+W'))/\mathbf{c}^4 r_0^2\, |dr_0|$ (1.16)
- for source m: $(W/(W+W'))(R_g'/r_0^2)\, W'\, |dr_0| = 2\, G\, (W'^2W/(W+W'))/\mathbf{c}^4 r_0^2\, |dr_0|$

The continuous refreshing of the fields means that their energy is constantly being restored. This explains why the energy drawn by one source from the field of the other can be considered as interaction energy added to the energies of the fields of the isolated sources.

The variation in interaction energy is the sum of the two terms above, i.e. :[33]

$$dE_i = -\,2\,(G\,WW'/\mathbf{c}^4 r_0^2)\,dr_0 = -\,2\,(G\,mm'/r_0^2)\,dr_0$$

[33] Of course, we find the value given by equation (1.13), taken from the energy density of the mean field.