Properties of the electrostatic field

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Relationship with the gravitational field

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Abstract:

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

Like the gravitational field, the electrostatic field is characterised by its energy and its limiting range; it is periodically refreshed by waves that ensure the exchange of energy between charges and the field.

Attributing negative energy to electrostatic fields explains the repulsion between charges of the same sign and the attraction between opposite charges. Furthermore, the sharing of interaction energy between charged particles implies that the energy of a particle's electrostatic field is proportional to the energy of that particle's gravitational field.

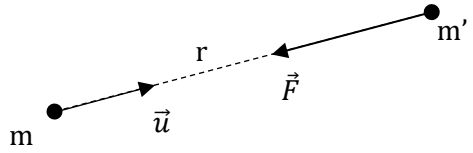
Analysis of the decay of the free neutron allows us precisely to derive the creation of the proton's and electron's electrostatic fields from the interaction energy of the gravitational field associated with these two particles. The interpretation we propose does not require the emission of an electron antineutrino: the final energy of the electron results from the energy loss incurred as it moves away within the electrostatic field.

As regards the proton, the cut-off radius of the electrostatic field can be identified as the radius measured in scattering experiments.

The parameters of the field (energy and radius) associated with the proton or the electron vary as a function of the particles' energy, 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 frequency. This ratio can be equated with the fine-structure constant.

1. Properties of the gravitational field

In Newtonian gravitational theory, gravitational attraction is modelled by a vector field that is proportional to the mass of the field source and varies 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 associated with the other source:



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

We have proposed a new energy-based approach to gravity[1] which preserves the principle of decay as $1/r^2$. However:

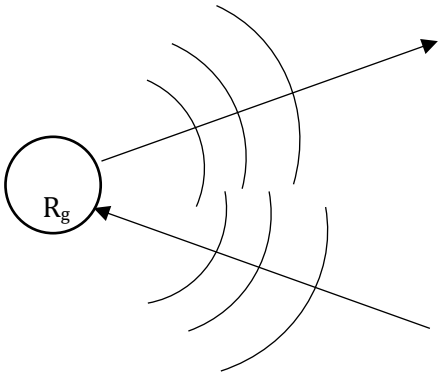
- it is no longer the rest masses of the gravitational sources that are taken into account, but their total energies;
- the rest energy varies as the distance between the sources varies.

The gravitational field, which has a physical reality, is regarded as a distribution of energy throughout space, with the exception of a sphere of radius R_g centred on the source (which allows the total energy of the field, $W_{(g)}$, to remain finite).[2] The energy contained within a spherical shell of radius r and thickness dr is given by:

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

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

- one propagating from the source, gradually transferring its energy to the field;
- the other propagating towards the source, carrying the energy it extracts from the field.



At the field's boundary R_g, each wave carries energy equal to the source's energy (W). At a distance r from the source, the energy carried is given by:

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

At each update of the field, energy is alternately emitted and received in a time:

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

[1] See the note 'Another approach to relativity'.
[2] See the note 'Gravitational field, 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 cited in [2] shows that this choice makes it possible to derive the fundamental equation of dynamics from the gravitational field.

The choice to set the maximum energy carried by gravitational waves equal to the source energy[5] leads to setting the Schwarzschild radius[6] as the limit of the field's extent:

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

For $r \gg R_{(g)}$, we may assume that relation (1.1) remains valid:

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

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

This overall field is obtained, as in Newtonian gravity, 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 assumed isolated sources. Choosing a positive value for k ($k = 1/\,4\pi G$) results in the gravitational field having positive energy, as well as the variation in the interaction energy as the sources move closer together. As the interaction energy is transferred to the sources, their energy increases, which explains their mutual attraction.[8]

The expression for the field's interaction energy, as opposed to the value of the potential energy[9] , reveals a factor of 2 compared with the Newtonian expression. This is due to the variation in rest energy:

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

[5] The note cited in [2] shows that this choice allows the resulting gravitational wave to play the role of the pilot wave envisaged 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] See the note 'Gravitational Field, Fundamental Principle of Dynamics and Quantum Mechanics', paragraph 1.2.2. Interaction of two sources.

[8] See the note 'Gravitational field, Fundamental Principle of Dynamics and Quantum Mechanics', paragraph 1.3.2. Interacting sources: energy exchanges between sources and the field (reproduced in the appendix).

[9] With a potential of zero at infinity.

[10] This expression holds for $r \gg R_g$.

2. Construction of the electrostatic field

2.1. Analogy with the gravitational field

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

$\vec{F} = q'\vec{E}(\vec{r}) = (qq'/4\pi\varepsilon_0 r^2)\vec{u}$ where $\vec{E}(\vec{r})$ is the electrostatic field vector. (2.1)

The first difference compared with gravitational interaction lies in the fact that charges take the form of elementary charges which cannot be combined. We shall therefore consider the interaction between elementary charges of positive or negative value (e).

Secondly, charges of the same sign repel one another, whilst charges of opposite signs attract one another. To explain the repulsion between charges of the same sign, it is necessary to choose a negative value for the coefficient k in formula (1.7) as applied to the electrostatic field:

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

This results in an electrostatic field with negative energy for an isolated charge.
Choosing $k = -\varepsilon_0/2$ 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 between charges involves an exchange of energy between the charges and the field via refreshment waves. However**,** a third difference must be noted: one cannot a priori associate an energy with a given charge, as one does with the mass of a gravitational source.[11] And the charges remain constant, unlike the energy of the sources of the gravitational field.

The average energy W_q of the electrostatic field is half the energy W exchanged by the outgoing waves. If, due to an interaction between charges, the energy of the incoming waves differs from W, the difference will be transferred to the charge-bearing particles. It is only this difference that alters the total energy of the particles and explains the attraction or repulsion.

One final point: if the charges are in motion, it is necessary to introduce the magnetic field associated with their motion.[12] It should be noted, however, that the magnetic field does not involve any exchange of energy with the sources.

[11] See section 2.3. The energy of a particle's electrostatic field is proportional to the energy of that particle's gravitational field.
[12] See the note 'Magnetic field. Relationship with the electrostatic field'.
In the case of the gravitational field, the effect of the gravitomagnetic field is too small to be taken into account, except at relativistic speeds.

By applying the same reasoning used to construct the electrostatic field as we did for the gravitational field, we obtain the characteristics set out in the following table:

	Gravitational field [13]	***Electrostatic field***
Field created by a gravitational source or an isolated elementary charge		
Field vector	$\vec{G}(\vec{r}) = -(GW/\mathbf{c}^2 r^2)\,\vec{u}$	$\vec{E}(\vec{r}) = (e/4\pi\varepsilon_0 r^2)\,\vec{u}$
Energy density of the field [14]	$\delta W_g(r) = (R_g/4\pi r^4) W_g$ $= (1/4\pi G)(G\,W/\mathbf{c}^2\, r^2)^2$	$\delta W_q(r) = (R_q/4\pi r^4)\, W_q$ $= -(\varepsilon_0/2)\,(e/4\pi\varepsilon_0 r^2)^2$ [15]
Relationship between radius and field energy	$R_g\ W_g = GW^2/\mathbf{c}^4$ (2.3)	$R_q\ W_q = -e^2/8\pi\varepsilon_0$ (2.4)
Field energy	$W_g = W/2$ [16]	*See below*
Field radius	$R_g = 2GW/\mathbf{c}^4$ Schwarzschild radius	*See below*
Refresh period	$T_g = 2R_g/\mathbf{c}$	$T_q = 2R_q/\mathbf{c}$
Field created by two gravitational sources or two elementary charges		
Interaction energy	$Ei_g = 2\,G\,W\,W'/c4\,r_0$ (2.5) $(r_0 \gg R_g)$	$E_{iq} = -e\,e'/4\pi\varepsilon_0\,r_0$ [17] (2.6)

Energy and radius of the electrostatic field: these two parameters are related by equation (2.4). What energy should be assigned to the fields of the positive and negative charges?
We shall examine this point in Section 2.3 (Distribution of 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. This will also be discussed in section 2.3.

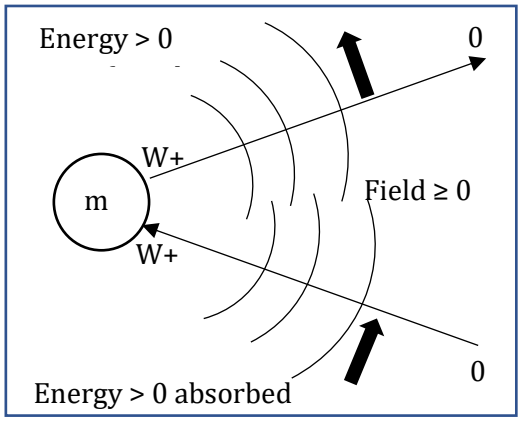
[13] This is the gravitational field proposed in our new approach.
[14] The energy density of the field can be expressed in two ways:
- on the one hand, in terms of the radius and the total energy of the field,
- and secondly, in terms of the square of the field vector.

[15] As explained above, W_q has a negative value.
[16] W_g is the average value of the gravitational field's energy.
[17] As regards the interaction energy, we may assume that equation (2.4), which gives E_{iq} holds true regardless of the distance r0 between the charges, owing to their invariance, as noted above.

2.2. Interacting charges

Let us begin by recalling the refresh scheme adopted for the gravitational field and how we explain the attraction between gravitational sources through an exchange of energy between the source and the field.

Gravitational field

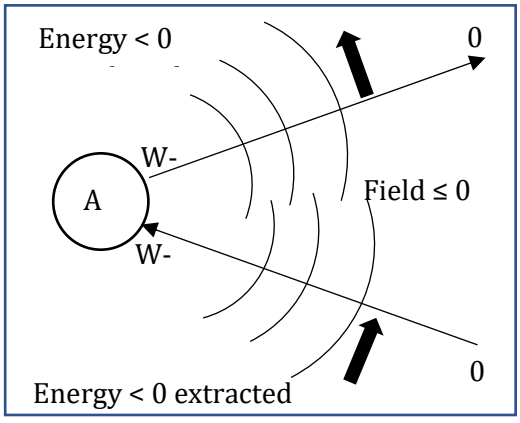


The field energy is positive. The wave energy varies between W+ and 0; outgoing waves **give** up positive energy, whilst incoming waves **absorb** it.
When two sources interact, each incoming wave extracts positive energy from the field created by the other source. This extracted energy increases as the sources move closer together (which corresponds to a change 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 negative energy field (oscillating between W- and 0), but also refreshment waves that either release or absorb positive or negative energy. The distinction between the two types of field is made as follows:

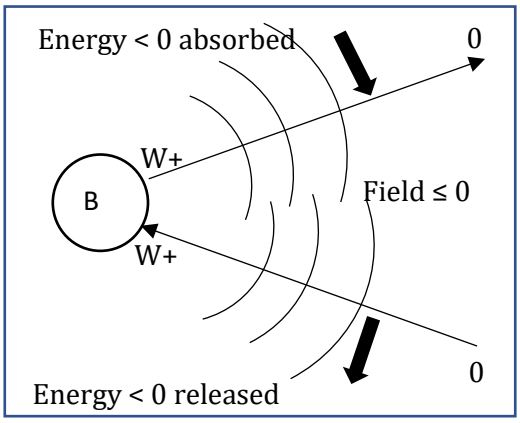
- for type A, outgoing waves (of negative energy W-) transfer this energy to the field, whilst incoming waves extract it to bring the field's energy back to 0;
- for type B, outgoing waves (with positive energy W+) draw energy W- from the field, whilst incoming waves transfer energy to it to bring the field's energy back to W-;

Type A electrostatic field



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

Type B electrostatic field



The energy of the field is negative. The energy of the waves varies between W+ and 0. Outgoing waves **extract** negative energy, whilst incoming waves **release** it.

Interaction between two charges B1 and B2:

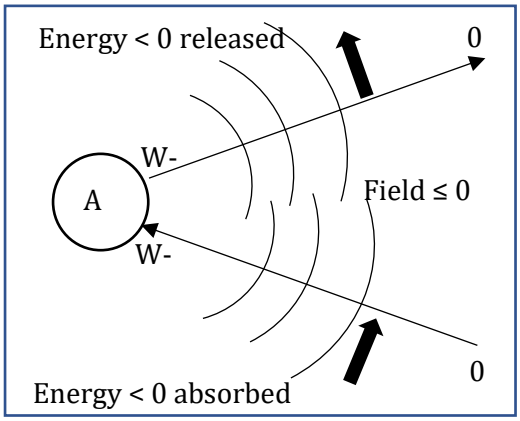
B1 extracts some energy (ΔW-) from the field of B2 ; it therefore extracts (W-) – (ΔW-) from its own field.

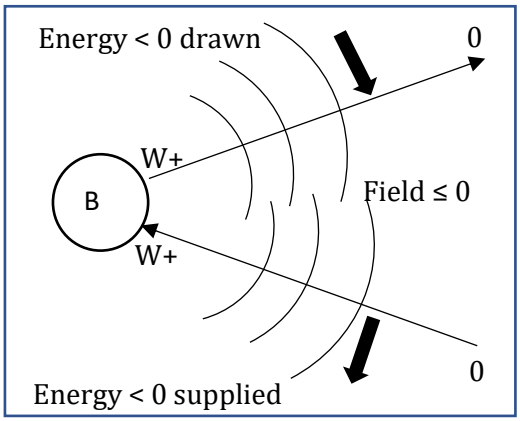
Consequently, B1's field changes from (W-) to (ΔW-). To restore this value to (W-), the incident wave transfers energy equal to (W-) – (ΔW-); its energy changes from 0 to (W+) + (ΔW-).

There is a transfer of negative energy (ΔW-) to the particle carrying charge B1. The same applies, simultaneously, to the particle carrying charge B2.

The closer the charges are, the greater the energy taken from and released to the fields, and the more negative the transferred energy. There is repulsion.

Attraction between a type A charge and a type B charge





The outgoing wave associated with charge B extracts energy (ΔW-) from the field of A (= W-), which takes the value (W-) - (ΔW-) . The incident wave from A extracts this energy to bring the field value back to 0. This results in an energy transfer equal to - (ΔW-) _therefore > 0_ to the particle carrying charge A.

The incoming wave associated with charge A extracts energy (ΔW-) from the field at B, which takes the value (W-) - (ΔW-). The outgoing wave from B extracts energy (W-) from this field, which therefore changes to - (ΔW-). To restore this value to (W-), the incoming wave transfers energy equal to (W-) + (ΔW-); its energy changes from 0 to (W+) - (ΔW-). This results in an energy transfer equal to - (ΔW-) _therefore > 0_ towards the particle carrying charge B.

The change in interaction energy is positive as the charges approach one another. There is an attractive force between the particles carrying charges of types A and B.

By applying the same line of reasoning used for the gravitational field[18] and taking into account the fact that the , which yields $R_q \ W_q$, is invariant, we find that we do indeed obtain the value of the interaction energy given by formula (2.6):

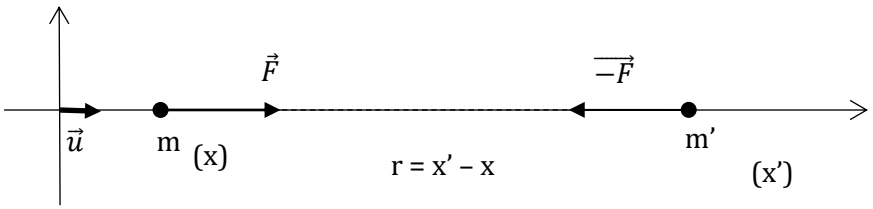
$$E_{iq} = - e e'/ 4\pi\varepsilon_0 \ r_0$$

We shall explain this in more detail below.

2.3. Distribution of the interaction energy

How is the interaction energy shared between the two charges?

Let us begin by recalling the reasoning used to study the attraction between two masses m and m', separated by a distance ,r under the influence of gravity or electrostatic attraction.



Let m and m' denote the masses (in the Einsteinian sense: $m = W/c^2$, $m' = W'/c^2$, where W and W' represent the total energy), q and q' the charges, and $\vec{v}$ and $\overrightarrow{v'}$ their velocities.

The system is considered to be isolated. Let us adopt the reference frame in which the total momentum is zero at the initial instant of the interaction ($m_0 \overrightarrow{v_0} + m'_0 \ \overrightarrow{v'_0} = 0$). We also assume that the magnetic effect is negligible.

The force of attraction is: $\vec{F} = (K/r^2) \ \vec{u}$ where: $K = G\ m\ m'$ for gravitational attraction

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

Applying the fundamental principle of dynamics:

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

From equation (2.7), we obtain by integration: $m\vec{v} = - m'\overrightarrow{v'}$ (2.8)

(which reflects the conservation of momentum).

The change in kinetic energy for each of the masses is given by:

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[18] See the note 'Gravitational Field, Fundamental Principle of Dynamics and Quantum Mechanics', paragraph 1.3.2. Interacting sources: energy exchanges between sources and the field (reproduced in the appendix).
Due to the invariance of the product R_qW_q, the energy of the electrostatic field is identical for the fields of the two charges at the same distance from them.

$$dW = \vec{F}\,\vec{v}\;dt \qquad \text{and} \qquad dW' = -\vec{F}\,\overrightarrow{v'}\;dt \quad [19] \qquad (2.9)$$

(2.8) and (2.9) → $m'\,dW' = m\,dW$

And therefore: $dW = (m'/(m + m'))(dW + dW')$

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

Since $r = x' - x$, we have: $dr/dt = dx'/dt - dx/dt = (\overrightarrow{v'} - \vec{v})\,\overrightarrow{u}$

Taking (2.9) into account: $dW + dW' = -\vec{F}\,(\overrightarrow{v'} - \vec{v})\,dt = -K/r^2\,dr$

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

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

The change in total kinetic energy is equal to $-(K / r^2)\,dr$, that is:

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

$(q\,q'/4\pi\varepsilon_0\,r^2)\,dr$ in the case of electrostatic attraction.

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

In the case of electrostatic interaction, the distribution of interaction energy according to the same rule implies that the refresh period of the electrostatic field is inversely proportional to the mass of the charged particle.
Indeed: $(1/m)/(1/m + 1/m') = m'/(m + m')$ and $(1/m')/(1/m + 1/m') = m/(m + m')$
These ratios apply to a draw from the same amount of energy, as the product $R_q \times W_q$ is identical for both elementary charges.

Since the period is proportional to the radius of the field[21] and the energy of the field is inversely proportional to this radius, the energy of the electrostatic field is proportional to the mass, and therefore to the energy of the gravitational field.

This proportionality between the energy of the electrostatic field and the energy of the gravitational field associated with the charge-bearing particle suggests that the electrostatic field can be explained in terms of the gravitational field. This is what we shall do in the following chapter, which is devoted to the analysis of the decay of the free neutron.

[19] It should be noted that, in the gravitational case, this variation accounts for only half of the total energy variation, the other half arising from the variation in rest mass.
[20] See the note 'Gravitational field, Fundamental Principle of Dynamics and Quantum Mechanics', paragraph 1.3.2. Interacting sources: energy exchanges between sources and the field (reproduced in the appendix).
[21] See the table in paragraph 2.1.

3. Decay of the free neutron

Based on the phenomenon of free neutron decay, can we propose an explanation for the emergence 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 decays into a proton (p), an electron (e-) and an electron antineutrino ($\bar{\nu}$ -):

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

The decay energy Q is equal to the difference between the rest energies before and after the reaction:

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

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

It should be noted that it was the experimental observation of the variability in the electron's kinetic energy that led to the hypothesis that a neutrino carries off part of the energy.

3.1. Creation of the electrostatic field

We shall denote by:

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

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

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

- The gravitational interaction is not effective (due to the presence of the field W-); it gives rise to the electrostatic interaction. The field W- gives rise to the fields W_q and $W_{q'}$:

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

  and the electrostatic interaction energy results from the transfer of all or part of the gravitational interaction energy:

  $$E_{iq} = E_{ig} - X$$

- At a great distance (the measurement location), the energy of the proton–electron system is reduced by E_{iq} due to the separation of the two particles from one another.

The process is illustrated in the diagram below:

[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.

Origin	Order of magnitude distance R_g	Distance $R_X >> R_g$	Long distance
Neutron alone	Proton–electron dissociation Gravitational interaction energy	Electrostatic field	Measurement of the electron's kinetic energy E_{ce}
$\mathbf{m_n}$	$\mathbf{m_1}$ ○ $\mathbf{m_1}$ ' Interaction energy E_{ig} Field W^- = - E_{ig}	$\mathbf{m_1}$ ○ $\mathbf{m_1}$ ' Dissociation of the field W^- Interaction energy E_{iq} = E_{ig} - X	$\mathbf{m_2}$ $\mathbf{m_2}$ ' ○ Zero interaction energy X = $E_{cé}$

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

The assumptions made lead to the following expression:

$$E_{ig} = \mathbf{m_n} - \mathbf{m_p} - \mathbf{m_é} = Q$$

$$\mathbf{m_1} + \mathbf{m_1}' = \mathbf{m_n} \qquad \mathbf{m_2} + \mathbf{m_2}' = \mathbf{m_n} - E_{iq}$$

$$\mathbf{m_2} \approx \mathbf{m_p} \rightarrow \quad \mathbf{m_2}' = \mathbf{m_n} - \mathbf{m_p} - E_{iq} = \mathbf{m_n} - \mathbf{m_p} - E_{ig} + X = \mathbf{m_é} + X$$

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

And: $E_{iq} = E_{ig} - E_{cé}$

The energy attributed to the antineutrino can be identified as the electrostatic interaction energy E_{iq}.

Applying formula (2.6), we can consider that the electrostatic interaction becomes effective from a distance between the proton and the electron equal to:

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

3.2. Characteristics of the proton and electron fields

We shall now calculate the values of the energy and radius of the proton and electron fields:

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

At distance R_X: $W_q + W_{q'} = -E_{ig} \rightarrow W_q (1 + m'/m) = -E_{ig}$

$$W_q = -(m/(m + m'))\, E_{ig} \quad (3.3) \qquad \text{and} \qquad W_{q'} = -(m'/(m + m'))\, E_{ig} \quad (3.3')$$

where: $m \approx m_p$ and $m' = m_n - m \approx m_n - m_p$

[23] See section 2.3. The refresh period (and therefore R_q and $R_{q'}$), is inversely proportional to the particle's mass.

From which it follows that: $W_q = -0.99862\ E_{ig}$ and $W_{q'} = -0.00137\ E_{ig}$ (3.4)

Taking equation (2.4) into account, the field radii are given by:

$$R_q = 0.72083\ 10^{-15}/\ E_{ig} \quad \text{and} \quad R_{q'} = 0.52542\ 10^{-12}/\ E_{ig} \qquad (3.5)$$

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

With $E_{ig} = Q = 0.782$ MeV:

Proton field: $W_q = -0.781$ MeV $\quad \mathbf{R_q = 0.921 \times 10^{-15}\ metres}$ (3.6)

Electron field: $W_{q'} = -1.07\ 10^{-3}$ MeV $\quad R_{q'} = 0.671\ 10^{-12}$ metres (3.6')

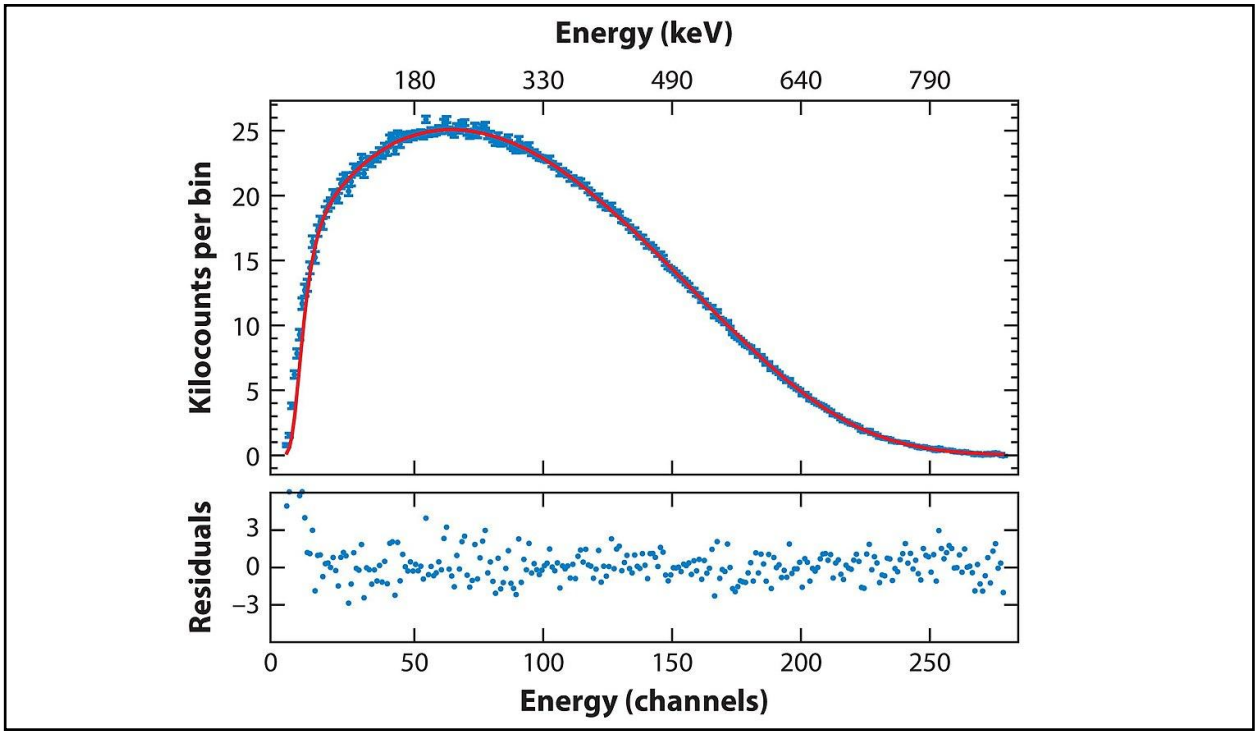
The value of R_q can be compared with the proton's charge radius, as determined experimentally:

$$\mathbf{R_p = 0.83\ 10^{-15}\ metres} \qquad (3.7)$$

The 10 per cent discrepancy between the results in (3.6) and (3.7) raises questions about the value assigned to the decay energy Q:

a) Measurement of the electron's kinetic energy

The graph below shows the distribution of the electron's kinetic energy obtained from an experiment. [24]



We can see that the maximum energy is not 0.782 MeV but 0.872 MeV. (3.8)

[24] Figure taken from the thesis by C. M. Roick, *"Particle Detection and Proton Asymmetry in Neutron Beta Decay"* Department of Physics. Technical University of Munich. 14 August 2018.

b) Determination of Q from the calculation of E_{ig}:

- if we use the distance R_g (the cut-off radius of the proton's gravitational field) to calculate E_{ig} ,
- and if we assume that the laws of gravitation, formulated for weak-field conditions, are valid throughout the entire range of the field,[25]

the calculation yields the following value for the gravitational interaction energy:

$$E_{ig} = (\exp(1) - 1)(m_{é}\,\mathbf{c}^2) = \underline{0.878}\ \text{MeV} \quad [26] \qquad (3.9)$$

The results (3.8) and (3.9) are very close. Let us assume that the observed energy difference ($0.096\ \text{MeV} = 0.878 - 0.782$) is attributed to the rest mass of the neutron.[27] Repeating the calculations yields the following value for the field radius:

$$\mathbf{R_q = 0.823 \times 10^{-15}\ metres} \qquad (3.10)$$

The field radius can then be identified as the proton's charge radius R_p given above (3.7)**.**

Equations (3.6) and (3.6') must be corrected if we take $\underline{E_{ig} = 0.878\ \text{MeV}}$:

Proton field: $W_q = -0.877\ \text{MeV}$ $R_q = 0.823 \times 10^{-15}$ metres (3.11)

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

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

- **allows us to derive the creation of the proton's and electron's electrostatic fields 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 energy loss it undergoes as it moves away within the electrostatic field;**
- **provides the value of the proton's radius.**

This interpretation gives the fields a physical reality and assumes that the loss of interaction energy results in an exchange of energy with them, via waves that constantly refresh them.

It does not require us to imagine the creation of particles carrying the interaction energy.

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

[26] With $m_e\,\mathbf{c}^2 = 0.511\ \text{MeV}$ rest energy of the electron.

[27] This overestimation (of 0.01 per cent) cannot arise from the neutron's kinetic energy: the experimental energy distribution is obtained from the decay of neutrons with very low kinetic energy (less than $3\ \text{meV}$).

4. Discussion of the properties of the electrostatic field

4.1. Review of the field's characteristics

Let us summarise the characteristics of the electrostatic field associated with 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 an energy distribution beyond a sphere of radius R_q centred on the charge, updated by a system of spherical waves travelling at the speed of light.

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

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

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

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

Refreshment waves alternately release or absorb negative energy, each for a duration equal to $R_q/\mathbf{c}$. The distinction between positive and negative charge is linked to the type of field:

- type A field with an outgoing wave releasing energy and an incoming wave absorbing it;
- Type B field with an outgoing wave that extracts energy and an incoming wave that releases it.

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

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

In the case of the interaction between two charges e and e' separated by a distance r_0, the interaction energy density is 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, and positive for two charges of opposite signs.

It is the transfer of this energy to the charge-bearing particles that explains why we observe either repulsion or attraction. 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 charge-bearing particles.

4.2. Field variability

Equations (3.11) and (3.11'), which give the energy of the electrostatic fields of the proton and the electron, are valid at the distance R_x at which these fields are generated. 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}. [28]

When the total energy of the proton or electron changes, we must take into account that the characteristics of their electrostatic fields are altered. Indeed, in section 2.3 we emphasised the proportionality that must exist between the energy of the electrostatic field and that of the gravitational field. Introducing the average energy of the gravitational fields of the proton and the electron:

$$W_{gp} = m\,\mathbf{c}^2/2 \text{ and } \quad W_{ge} = m'\,\mathbf{c}^2/2$$

Equations (3.3) and (3.3') can be written as:

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

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

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

$$K_{qg} = -2\,(E_{ig}/m_n\,\mathbf{c}^2) = -1.8687\ 10^{-3} \tag{4.2}$$

We postulate that this applies regardless of the cause of the energy variation.

If the electron is brought to rest ($W_{ge} = m_e c^2/2$) [29], the energy and radius of its electrostatic field are given by:

$$W_{q'} = -0.477 \times 10^{-3}\ \text{MeV} \qquad R_{q'} = 1.506 \times 10^{-12}\ \text{metres} \tag{4.3}$$

If the electron's energy is raised to a very high value, the radius of its electrostatic field can be considerably reduced. For example, the radius becomes less than 10^{-17} metres if the energy exceeds 77 GeV. The increase in field strength is demonstrated by high-energy collision experiments.

4.3. Fine-structure constant

By analogy with the reasoning applied to the gravitational field, let us assume that:

- the time taken to emit and receive the field's refresh waves is equal to $R_q/\mathbf{c}$; the refresh period is given by:
$$T_q = 2R_q/\mathbf{c}$$
- the maximum energy (in absolute terms) carried by each wave is equal to $\mathbf{h}\,\nu_q$;
the average energy of the field is:
$$|W_q| = \mathbf{h}\,\nu_q/2$$

[28] Since we assume that the gravitational interaction is negligible, the rest mass remains unchanged and the kinetic energy is therefore equal to the initial gravitational interaction energy.
[29] This corresponds to the case where $E_{iq} = E_{ig}$.

Let us consider the product of the field's refresh period and the (energetic) frequency of the refresh waves:

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

Introducing the fine-structure constant ($\alpha = e^2 / 2\varepsilon_0 \mathbf{hc}$), we obtain:

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

Equation (4.6) provides a simple physical interpretation of the fine-structure constant: this represents (up to a factor of $1/\pi$) the ratio between the energy frequency and the refresh frequency of the electrostatic field.

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

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

Let us introduce the Planck mass ($m_P = (\mathbf{hc} / G)^{1/2}$) and the relativistic mass:

$$T_g \ \nu_g = (2/\pi)\,(m/m_p)^2 \qquad (4.7)$$

Appendix_Extract from the note:

Gravitational field, Fundamental principle of dynamics and Quantum mechanics

1.3.2. Interacting sources: energy exchange between sources and the field

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

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

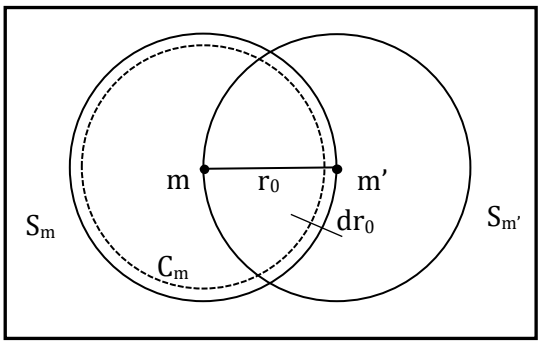


Figure 2

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

Suppose that the sources of masses m and m' approach one another over a distance $|dr_0|$.

The change in interaction energy is due to the transfer of energy:

- of the source m' in the field, created by m, contained within the shell C_m with centre m, radius r_0 and thickness $|dr_0|$; the energy of this shell is: $(R_g/r_0^2)\, W\, |dr_0|$; [30]
- from source m on the field, created by m', contained within the shell $C_{m'}$ with centre m', radius r_0 and thickness $|dr_0|$; the energy of this shell is: $(R_g'/r_0^2)\, W'\, |dr_0|$;

For source m, the energy is extracted over a time T proportional to the energy W; similarly, for mass m', the energy is extracted over a time T' proportional to W'. We shall assume that the energy extraction occurs in proportion to the extraction times:

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

The energies extracted are therefore:

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

Due to the continuous refreshment of the fields, their energy is constantly restored. This explains why the energy drawn by one source from the field of the other can be regarded as interaction energy added to the energies of the fields of the isolated sources.

The change in interaction energy is the sum of the two terms above, namely:[31]

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

[30] To determine the energy extracted, one must take into account the maximum value (W) of the field energy.
[31] This does indeed match the value given by equation (1.13), derived from the average field energy density.