ISSN: 2754-4753

Journal of Physics & Optics Sciences

SCIENTIFIC Research and Community

Review Article

Open Access

Test on the Interaction between Two Electrons

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ABSTRACT

The aim of this paper is to calculate if there exists an equilibrium position between 2 free electrons in a vacuum. In fact, they repel each other by the Coulomb force but they attract each other by their magnetic moment, like magnets.

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Received: August 23, 2024; **Accepted:** August 26, 2024; **Published:** November 04, 2024

Introduction

- **Why such a Simple Topic?**

The purpose is to work on the nature of the elementary particles, starting with the electron, with the point of view of an engineer, i.e., having at last a tool in my hands with which I would be able to build something.

- **Why so Late in My Life?**

Such a project has been a permanent goal in my life, as soon as I understood in the late 1980's that an engineer must proceed with 2 different kinds of projects:
First Kind of Project: The project is established on reliable science and the engineering team is skillful and work hard.
Result: Success.
Second Kind of Project: The project is not established on reliable science and the project lasts, as long as funding is available.

To undertake such a «crazy» project as a study of interaction between 2 particles, it is advisable to be old.

- **Why in French and in German?**

To work efficiently, it is necessary to be free. Not to be prisoner of a defined school or a defined language, which would become a must, whatever I would write.

- **Which Kind of Benefit may be Expected from such a Work?**

The thinking about the matter was nearly frozen for hundred years. Some kind of restart after so much frozen years may would bring a hope and even interesting results in the short term. The scope of this present paper is just to assess possibilities, to open perspectives for engineers.

Let
z: the distance between the 2 electrons, assumed to be large compared to the electron radius
r: the radius of the electron = 3.87×10^{-13} m, according to [3], not recognized
q: the charge of the electron = 1.60×10^{-19} C
m: the mass of the electron = 9.11×10^{-31} kg
c: the speed of light = 3.0×10^{8} m/s
G: the universal gravitational constant = 6.68×10^{-11} N m²/kg²
k c: Coulomb's constant = 8.99×10 9 N m²/C²

$$k_c = \frac{1}{4\pi\epsilon_0} = 8.99\times10^9\,Nm^2C^{-2}$$

μ0: magnetic permeability of the vacuum = $4\pi\times10^{-7}$ H/m not to be confused with the magnetic moment of the electron **μ**

μ = $\vec{\mu}$: magnetic moment of the electron = -9.28×10^{-24} J/T or Am² (everyone agrees)

Coulomb Force

Repulsive force since the 2 electrons are negatively charged, therefore of the same sign.
We assume point electrons.

$$F_e \approx \frac{1}{4\pi\epsilon_0}\frac{q^2}{z^2} \qquad (1)$$

With

$$\frac{1}{4\pi\epsilon_0}q^2 = k_c q^2 = 2.30\times10^{-28}$$

The calculation is easy since, at this stage, I consider the electrons as point.

Gravitational Force

Attractive force between the 2 electrons

$$F = G\frac{m^2}{z^2}$$

With $Gm^2 = 5.54\times10^{-71}$
So effectively negligible compared to the Coulomb repulsion.

Magnetic Force

Since each electron behaves like a small magnet, there are two effects

- Firstly, the electrons will orient themselves, like the needle of a compass in order to align themselves north south north south
- Secondly, once oriented, they will attract each other, like two magnets.

The rotation of electrons to align the magnetic poles occurs rapidly over the stability of an equilibrium position and with Bremsstrahlung losses. The aim of this paper is not to calculate the resulting transient regime.

We therefore now assume the electrons are aligned with the z axis being the north south north south poles.

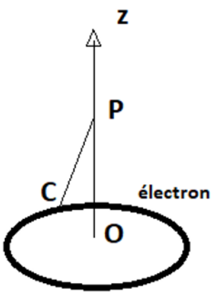
And we're going to estimate the resulting force of attraction.

Calculation of the Magnetic Field on the Axis
One of the two electrons produces on the other and reciprocally a magnetic field B which we will classically estimate using the law of Biot and Savart [4].

$$\mathrm{d}\vec{B}(\vec{r}) = \frac{\mu_0}{4\pi} I\mathrm{d}\vec{l} \times \frac{\vec{r} - \vec{r}'}{|\vec{r} - \vec{r}'|^3}$$

dl or is a length portion of the trajectory of the electric charge in the electron at C.
r – **r'** is the vector **CP** which connects this portion of trajectory to the point P of the axis Oz on which we want to evaluate the magnetic field **B**.

The symbol × is a vector product.



Classically, but still not entirely, because to use this law, you have to make a hypothesis about the nature of the electron.

Professors traditionally avoid the subject.

Assuming that they are very eager to respond, they are divided into at least 4 categories
- Hypothesis of the point electron, but that explains neither the spin nor the magnetic moment
- Spherical electron hypothesis, not much better
- Hypothesis of the flat disk-shaped electron
- Toroidal electron hypothesis [5] which eventually made its way to Wikipedia. It's the Parson magneton [7] and it dates back more than 100 years ago.

The interest of the Parson magneton is that an engineer [3] can do something with it. Unfortunately for science, Parson was seriously injured during the First World War and unfortunately for science, his ideas were taken up by a certain Gilbert N. Lewis, so popular today in National Education, but who never won the Nobel Prize.

So, to calculate the magnetic field in the axis by Biot & Savart, I adopt the toroidal model of the electron, that is to say an electric current I in a circular loop, with a speed of 300,000 km/s , total charge 1.6×10^{-19} C.

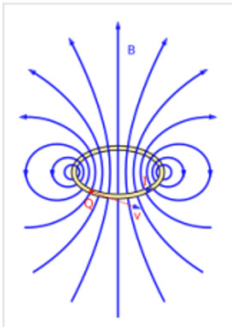
For it to produce the magnetic moment μ on which everyone agrees, the calculation on which everyone should agree gives

$\mu = \pi r^2 I$

$$I = \frac{qc}{2\pi r}$$

so

The numerical application gives the average radius of Dave's electron on which we have never managed to agree but which I adopt since it is the most reasonable hypothesis [3,8].



Magnetfeld in einer Stromschleife

Magnetic Field in a Current Loop
Source: Wikipedia

The exact calculation of the magnetic field is much easier to do along the axis of symmetry Oz, with O the center of the electron, than in the general case since only the z component remains. And that's what we need here.

The result of the exact calculation of the magnetic field produced by a toroidal electron on the Oz axis gives after curvilinear integration along the trajectory of the electron:

$$B = \frac{\mu_0}{2} \frac{Ir^2}{(r^2 + z^2)^{\frac{3}{2}}}$$

After simplification, it remains

$$B = \frac{\mu_0}{4\pi} \frac{qcr}{(r^2 + z^2)^{\frac{3}{2}}}$$

For z>>*r*, that is to say when the 2 electrons are far from each other

$$B \approx \frac{\mu_0}{4\pi} \frac{qcr}{z^3} \approx \frac{\mu_0 \mu}{2\pi z^3}$$

And the magnetic field at the center of the electron, where it is maximum for z=0, is worth:

$$B \approx \frac{\mu_0}{4\pi} \frac{qc}{r^2} \approx \frac{\mu_0 \mu}{2\pi r^3}$$

Calculation of the Magnetic Force
Knowing the magnetic field on the axis at distance z, we can deduce the force that the first electron generates on the second from its potential magnetic energy E_m.

$$\vec{F} = -\vec{\nabla} E_m = \vec{\nabla}(\vec{\mu} \cdot \vec{B})$$

The potential energy of the second electron in the magnetic field of the first is according to [9]

$E_m = -\boldsymbol{\mu}.\mathbf{B}$ (scalar product of the 2 vectors **μ** and **B**)

so

$E_m = -\mu B$ (simple multiplication of μ by B scalars since the 2 vectors are aligned, without forgetting the sign)

For $z >> r$:

$$E_m \approx \frac{-\mu_0 \mu^2}{2\pi z^3}$$

The force is the gradient of the energy [9] but, since here the force is along the z axis, the force is simply the derivative of the energy with respect to z. We subsequently avoid the discussion on sign conventions.

$$F_m = -\frac{dE_m}{dz}$$

Always for $z >> r$:

$$F_m \approx \frac{-3\mu_0 \mu^2}{2\pi z^4} \qquad (2)$$

We see that the magnetic force (2) decreases in z^{-4} while the electric force (1) decreases in z^{-2} as a function of the distance; which moreover corresponds to sensory experience: the nail only sticks to the magnet once it is almost in contact.

Calculation of the Distance at which the Forces would Balance
Still in the approximation of small electrons compared to their distance: $z >> r$, let us solve the equation $F_e = F_m$.

With: $\epsilon_0 \mu_0 = \frac{1}{c^2}$, it comes easily

$$z \approx \frac{2\sqrt{3}\mu}{qc}$$

Let $z \approx 6.7\ 10^{-13}$ m, that is to say less than twice the radius of the electron, therefore too little to be able to conclude given the approximations made.

This result corresponds to sensitive experience: 2 electrons are not known to stick to each other.

Return to the Coulomb Force and References
To move forward more precisely, it would be necessary to carry out all the calculations of vector and curvilinear integrals in the general case, electric, magnetic, then electromagnetic, while being aware of the limits of science. It would be time-consuming at this point. To extend the discussion, we can, for example, refer to [17].

So back to the references: who can have continued these studies after Parson , Compton and Dave who are no longer in this world, after Bill who has not given any sign of life for 2 years?

Bill had oriented his work, just as interesting as Dave's, perhaps even more interesting, but also in other directions, the science being very vast and very rich [8,10].

In response to my question, how to progress in the study of the subject, Bill recommended that I follow Oliver Consa to Barcelona [12].

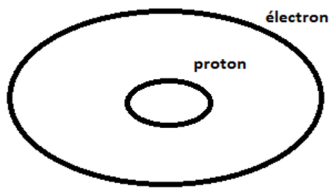
By analyzing the website of Bill and Dave [11], the work of Günther Landvogt [13] in Hamburg also appears.

And there is also "Jean de Climont" who lists every year all the "strong heads" or "dissidents", including me [14].

For example, it appears:
Patrick Cornille, formerly of the CEA,
Philip Kanarev from Krasnodar

Perspectives
The Hydrogen Atom
Do the same study but consider an electron and a proton to reflect on the hydrogen atom.
We can conjecture that the electron and the proton will attract each other until the electron and the proton form 2 concentric and coplanar circles.

It remains to calculate the forces that one exerts on the other.



It will be a question of verifying whether this hypothesis is plausible and of evaluating who has recently looked into the question from this aspect.

A Sociological Study
Who are these people because of whom we are "dissidents"? In what way would they be worthy of faith?
Erwin Schrödinger [1]
Werner Heisenberg [1]

My personal goal is to have a simple, even simplified, particle model that allows me to move forward as an engineer. For example, being able to answer questions such as: checking if water actually freezes at 0°C and actually boils at 100°C without the need for a thermometer.

And therefore, be able to respond to the social problem as it should arise, for example following this article from Zürcher, signed Toni Stadler according to which we must establish cause and effect links with prospects for progress. [15]

Until now, my only publication approaching this subject was in Qingdao (China) in 2017 at the invitation of Ukraine and China. The goal was to avoid war. For the moment, it is failure [16].

Summary
- **German:** Dieser Aufsatz soll Sie dazu ermutigen, sich mit der Struktur der Materie zu beschäftigen, beispielsweise anhand der Arbeiten von Dave Bergman, Bill und Joseph

Lucas, Oliver Consa und einigen anderen. Als Dissidenten abgestempelt zu werden zeigt, dass es etwas zu tun gibt.

- **French:** Cet essai a pour but de vous encourager à travailler sur la structure de la matière, par exemple en vous inspirant des travaux de Dave Bergmann, de Bill, de Joseph Lucas et de quelques autres. Le fait d'avoir été traités et d'être toujours traités comme des dissidents montre qu'il y a vraiment quelque chose à faire.
- **English:** This Essay should She in addition encourage to study the structure of matter to employ, for example based on the works of Dave Bergman, Bill and Joseph Lucas, Oliver Consa and some others. As dissidents stamped to become shows that there is something to do gives.

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