Calculation of the Maximum Displacement Speed of an Electron

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The electron is a constituent of the atom and has a special status. Indeed, unlike the proton and the neutron, the electron is an elementary particle. It is part of the fermions family and is part of the group of leptons. To date, it is the elementary particle that has the highest rest mass.

On the other hand, the highest energy level that an elementary particle in motion can reach corresponds to the energy contained in the Planck mass.

Because of its special status and the precise knowledge, we have of its characteristics, we are able to determine the maximum speed of displacement of an electron in vacuum. This speed is very close to the speed of light without equaling it.

KEY WORDS: Electron, maximum displacement speed, Planck mass

1. INTRODUCTION

In Einstein's relativistic equations, the speed of light in vacuum plays the role of limit velocity [5]. We do not question that point. But is it really the only limit?

There are other constraints to consider. It will be shown that the energy of an elementary particle cannot exceed the energy contained in the Planck mass m_p. Moreover, despite all the research done in particle physics, the electron has the highest rest mass. These two points circumscribe the limits of Einstein's relativity equations applied to the electron.

The purpose of this article is to determine the maximum velocity of displacement of an electron in vacuum.

2. DEVELOPEMENT

2.1. Value of the Physics Parameters Used

Let's outline all the basic physics parameters we intend to use in this article. These values are all available in CODATA 2014 [1].

- Speed of light in vacuum $c \approx 299792458$ m/s
- Fine structure constant $\alpha \approx 7.2973525664(17) \times 10^{-3}$
- Mass of the electron $m_e \approx 9.10938356(11) \times 10^{-31}$ kg

2.2. Maximum Speed of an Electron

Here we want to calculate the maximum speed of displacement of an electron in vacuum. In his equations of relativity, Einstein postulated that the speed of light was an insurmountable speed limit. Without contradicting this postulate, we will show that there are at the same time other limits which cannot be crossed and which must be taken into account.

Let's start by showing that the Planck mass m_p corresponds to the highest energy level that an elementary particle can reach.

Due to the Heisenberg uncertainty principle, the Planck length L_p is considered to be the smallest unit of length. For this reason, a particle with the wavelength equal to $\lambda = 2\pi \cdot L_p$ would have the highest mass and would represent the highest energy level a particle can have.

Considering that this particle can be seen as a wave, we can calculate its energy:

$$E = \frac{h \cdot c}{\lambda} = \frac{h \cdot c}{2\pi \cdot L_p} \qquad \textbf{(1)}$$

Considering that this particle has a mass, the Einstein equation resulting from the special relativity allows calculating the value of its energy [5]:

$$E = m \cdot c^2 \qquad \textbf{(2)}$$

By equating equations **(1)** and **(2)** and isolating the mass m, we obtain:

$$m = \frac{h}{2\pi \cdot L_p \cdot c} \tag{3}$$

The length of Planck L_p is commonly given by the following equation (see CODATA 2014 [1]):

$$L_p = \sqrt{\frac{h \cdot G}{2\pi \cdot c^3}} \tag{4}$$

By replacing L_p of equation **(3)** with equation **(4)**, we find that the mass m is actually the Planck mass m_p (see CODATA 2014 [1]):

$$m_p = \sqrt{\frac{h \cdot c}{2\pi \cdot G}} \approx 2.176470(51) \times 10^{-8} \text{ kg} \tag{5}$$

Therefore, we can conclude that by converting the Planck mass m_p using equation **(2)**, this corresponds to the highest energy level a particle can have.

Here, G is the universal gravitational constant. According to research that has already been presented [3], the universal gravitational constant G is equal to:

$$G = \frac{c^2 \cdot r_e \cdot \alpha^{20}}{m_e \cdot \beta} \approx 6.673229809(74) \times 10^{-11} \text{ m}^3/(\text{kg} \cdot \text{s}^2) \tag{6}$$

This value corresponds fairly well to the value measured and available in CODATA 2014 [1] where $G \approx 6.67408(31)\times 10^{-11}$ m^3/(kg·s^2).

The problem is that if all the particles in the universe had the Planck mass, the universe would be at rest. This is obviously not the case according to the observations that can be made. Everything is moving.

Einstein has shown that by giving a velocity v to an object which has a mass at rest equal to m_0, we increase its mass to obtain a mass m' by relativistic effects [5]:

$$m' = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{7}$$

If a particle has the highest energy level, that is, it has the Planck mass m_p, it is impossible to give it any more speed. A particle which, at rest, has a mass equal to the Planck mass cannot have a velocity other than zero. Since nothing is static in the universe, such a particle is an utopia and does not exist.

If a particle has the highest energy level, that is, it has the Planck mass m_p, it is impossible to give it any speed. A particle which, at rest, has a mass equal to the mass of Planck can not have a velocity other than a zero velocity. Since nothing is static in the universe, such a particle is a utopia and does not exist.

So what is the elementary particle that has the highest rest mass (and therefore the highest energy level)? In nature, this elementary particle is the electron.

Although large accelerators keep finding new particles, we do not think that an elementary particle with a mass greater than that of the electron would have gone unnoticed until now. Let us elevate this observation to the rank of a postulate:

Postulate: ***The electron is the elementary particle that has the highest rest mass there is***.

The Planck mass m_p is an impassable high limit for the mass of the electron, even if it is accelerated at a relativistic velocity v_e.

Let's transform equation **(7)** to get:

$$m_p = \frac{m_e}{\sqrt{1-\frac{v_e^2}{c^2}}} \tag{8}$$

The velocity v_e of the electron found using this equation will necessarily be less than the speed of light.

By isolating v_e, we get the maximum speed of an electron:

$$v_e = c \cdot \sqrt{1-\frac{m_e^2}{m_p^2}} \approx c \cdot \left(1-\frac{m_e^2}{2 \cdot m_p^2}\right) \tag{9}$$

Using various works we have done on the speed of light [2], on the universal gravitational constant G [3] and on the constant N (number without unit corresponding to the maximum number of photons that can be contained in the universe) [3], we are able to make the following approximation:

$$\frac{v_e}{c} \approx 1 - \frac{\alpha^2}{2 \cdot \beta \cdot N^{1/3}} \approx 1 - 8.76 \times 10^{-46} \tag{10}$$

This last equation makes it possible to appreciate how much it is possible to accelerate an electron. The velocity v_e obtained is very close to the speed of light in the vacuum c without being equal to it.

Equation **(10)** can be found with equations **(5)** and **(6)** as well as equations **(13)** and **(14)** which are shown below.

The c constant plays the role of a speed limit. Let us mention work that we have done in the past [4] which shows that even light does not reach the speed limit c (even if we call this constant "speed of light in vacuum"). This is caused by the fact that it is impossible to give more energy to a particle than that contained in the universe (which is obvious in itself). For this reason, the maximum speed of light v_L is given by the following equation:

$$v_L = c - \varepsilon_v \approx c \tag{11}$$

In this equation, ε_v has been called "speed quantum" [4]. It is the smallest unit of speed that can exist.

$$\varepsilon_v = \frac{c}{2N} \approx 2.34 \times 10^{-114} \text{m/s} \tag{12}$$

In our first article on the speed of light [2], a cosmological model was designed where the material universe is expanding at a rate of $\beta \cdot c$. Using a 4 equations and 4 unknowns system, the value of β was found:

$$\beta = 3 - \sqrt{5} \approx 0.76 \tag{13}$$

In this model [2], the material universe is expanding [9] at an average speed of around 76% of the speed of light c. Still according to the same cosmological model [2], the material universe is itself circumscribed in another, larger sphere, which we have called the luminous universe, which is expanding at the speed of light. In this model, the speed of light increases over time [2] due to the fact that the universe is expanding and moving away from a center of mass that influences the refractive index of the vacuum. Moving away from the center of mass, the refractive index of the vacuum[1] [6, 7, 8] decreases progressively to tend towards 1. In a universe that tends towards an infinite dimension, the speed of light tends towards a limit that we named it *k*, which is about twice the speed of light today.

In another article presented in 2013 [3], the number *N* was calculated. This number corresponds to the maximum number of photons that can be contained in the universe. The number *N* is connected to the fine structure constant [3], which makes it possible to evaluate its value precisely as follows:

$$N = \frac{1}{\alpha^{57}} \approx 6.30 \times 10^{121} \tag{14}$$

The number *N* is part of a conjecture that Dirac made on large numbers [10].

3. CONCLUSION

The electron can be accelerated at a speed that is very close to that of light without reaching it.

The capacity of an electron to move with a speed approaching the speed of light is limited by the fact that its energy can not exceed that contained in the mass of Planck. The calculations described in this work have just put a limit on the power to accelerate a particle such as the electron.

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