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Using a New Phenomenon of Electronic Oscillations Near the Positive Electrode to Generate Powerful Microwave Radiation

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Abstract. A novel microwaves generator scheme is introduced, where electrons perform oscillations within the electric field of a positively charged electrode. This phenomenon is based on a recently developed theory of the interaction of electrons with electric fields, which predicts the presence of a repulsive force acting on an electron near strongly positively charged bodies. Along with the usual attractive force acting at a distance, this newly discovered repulsive force causes specific oscillations of electrons in the vicinity of a positively charged electrode, leading to the generation of electromagnetic radiation. The proposed generator represents a new variant of a vircator, wherein a virtual cathode is formed in front of, rather than behind, a positively charged anode.

Keywords: repulsive force, electronic oscillations, microwave generator, vircator

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1. Introduction

In recent years, an innovative theory on the interaction of electrons with electric fields has been advancing in Armenia [1, 2]. This new theory markedly diverges from the conventional one at high potentials comparable to or surpassing $mc^2/e = 0.51$ MV. A pivotal aspect of this novel theory, absent in traditional theory, is the existence of a repulsive force acting on an electron in proximity to a positive charge. Together with the usual attractive force acting at a distance, this repulsive force can cause specific oscillations of an electron near positively charged bodies. In a prior study [2], radial oscillations of an electron around a positively charged sphere under the action of this force were explored. The present manuscript extends this research to the motion of an electron between two charged parallel planes. It is shown that the electron performs sinusoidal oscillations when the potential difference between the planes is more than 2×0.51 = 1.02 MV.

2. Basic equations

Consider one dimensional motion of an electron along z-axis in a uniform electric field of a condenser, which is formed by two charged planes z=0 (cathode) and z=L (anode). The potential of anode is U>0, and cathode is grounded, so the potential inside the condenser is $\Phi(z) = Uz/L$.

The electron trajectory z(t) can be calculated using the relationship between the total energy E and the generalized momentum **P** of the new theory, which is written as [1-3]

$$E^2 - (c\boldsymbol{P})^2 = \left(mc^2 + e\Phi\right)^2 , \qquad \boldsymbol{P} = \frac{E\boldsymbol{v}}{c^2} . \tag{1}$$

Here **v** is speed of electron, c is speed of light m is electron mass, and e is electron charge. Suppose that initially the electron is in rest near the cathode (at the point z = 0), then its total energy is E =

mc^2 and it moves along z-axis. For such one-dimensional motion from (1) it is obtained the equation:

$$t(z) = \frac{E}{c}\int_0^z \frac{dz}{\sqrt{E^2 - \left(mc^2 + e\Phi\right)^2}} \ . \tag{2}$$

Substituting here the expression for potential $\Phi(z) = Uz/L$, and integrating, the following equation of electron trajectory is obtained

$$z(t) = L\frac{1-\cos\left(\frac{uct}{L}\right)}{u}, \qquad u = \frac{|e|U}{mc^2} \ . \tag{3}$$

Here t varies from 0 to infinity, if $u > 2$. However, if $u < 2$, t varies in interval from 0 up to t_0, which provides $z(t_0) = L$. This means that if $u < 2$ the electron reaches the anode at time t_0. However, if $u > 2$ the electron does not reach the anode, because z(t) becomes less than L. It reaches the maximum distance from the cathode $z_{max} = 2L/u$, performing sinusoidal oscillations.

Differentiating (3) two times we obtain the acceleration of electron, and multiplying it by the mass – the force F acting on the electron

$$F(t) = \frac{mc^2u}{L}\cos\left(\frac{uct}{L}\right) = \frac{mc^2u}{L}\left(1 - \frac{uz(t)}{L}\right) \ . \tag{4}$$

From this formula it follows that the force acting on the electron can be either positive, or negative. There is a boundary plane $z = L/u \equiv z_c$, which separates two regions with the opposite signs of the force. The quantity z_c is called critical distance. In the region $0 < z < z_c$ the force acting on the electron is positive, i.e. directed towards the anode, and in region $z_c < z < L$ negative, directed towards the cathode. The motion of an electron (initially at rest at z = 0) is described by Eq.(3) as follows:

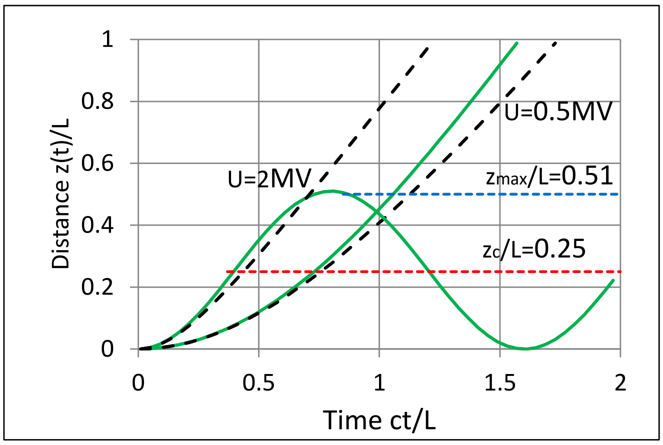

Fig.1. Green solid lines demonstrate trajectory of an electron, launched from the cathode with zero speed at different potentials of the anode, computed by Eq.(3). Black dashed lines demonstrate the same, computed by eqiations of conventional theory. Blue dotted lines demonstrates the maximum distance z_{max} of electron from the cathod at U = 2 MV. Red dotted line demonstrates the critical distance z_c at U = 2 MV.

The electron begins to move from the cathode to the anode under the influence of a positive (attractive) force. At $u < 1$ ($U < 0.51$ MV) the trajectory z(t) is monotonically increasing function with time, and the velocity also monotonically increases up to reaching of electron the anode. At

1 < u < 2 (0.51 MV < U < 1.02 MV) the electron trajectory again increases monotonically, and the electron reaches the anode, although after passing the critical distance z_c it slows down in the interval $z_c < z < L$. However, if potential U exceeds 1.02 MV (u > 2), the electron does not reach the anode. It reaches a maximum distance $z_{max} = 2L/u$, is stopped by a potential barrier and begins to move back to the cathode. The higher the anode potential, the less the electron approaches the anode. Having reached the cathode, the electron stops and starts moving towards the anode again. Thus, at u > 2 sinusoidal oscillations occur (see Fig.1, 2) with the amplitude L/u and angular frequency cu/L. However, one should take into account radiative energy losses, due to which the amplitude of oscillations will gradually decrease. Thus, specific damped oscillations of the electron are established between the two planes, which can be used as a source of electromagnetic radiation.

It should be clarified the following feature of oscillations. From Eq.(3) it follows that the speed of electron dz/dt has the maximum value, equal to the speed of light at the critical distance $z = z_c = L/u$ (Fig.2). Representing critical distance as

$$z_c = \frac{L}{u} = \frac{Lmc^2}{|e|U} = -\frac{mc^2 z}{e\Phi}, \tag{5}$$

one can see that at $z = z_c$ the equation $e\Phi = -mc^2$ is fulfilled. When substituting this equation in (2) the denominator becomes E, and equation of motion in a small vicinity of critical distance is $t(z) = z/c$. This once again points to the problem of the electron speed being equal to the speed of light at the critical distance.

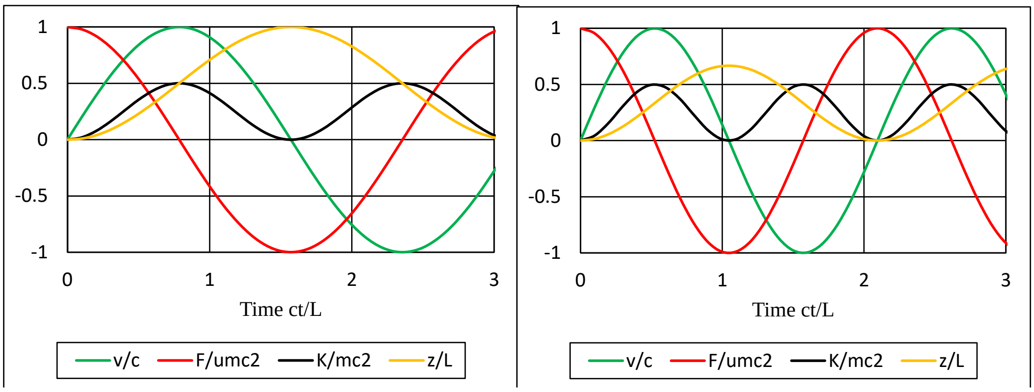

Fig. 2. Time variations of speed v/c (green line), force F/mc^2u (red line), kinetic energy K/mc^2 (black line) and distance from the cathode z/L (yellow line) at u = 2 (left panel), and u = 3 (right panel).

This problem occurs because the electron is considered as a point charge, so the problem is eliminated if the electron is considered as a small sized charge. Then the denominator in (2) becomes slightly less than E at the critical distance $z = z_c$, which leads to a value of the electron velocity less than c. The smaller the assumed electron size, the closer the electron's speed is to c and the greater its mass at the critical distance. In traditional theory, this would lead to the problem of an electron's infinitely increasing kinetic energy near a critical distance, depending on its assumed small size. However, in the new theory this does not lead to any problems with the kinetic energy: it remains finite and independent of the supposed small size of the electron. Indeed, in our considered case, the kinetic energy of the electron K(z) at a distance z is presented as

$$K(z) = \int_0^z F(z)dz = \int_0^z \frac{mc^2 u}{L}\left(1 - \frac{uz}{L}\right)dz = \frac{mc^2 z}{z_c}\left(1 - \frac{z}{2z_c}\right). \tag{6}$$

From this it follows that at the critical distance $z = z_c$ the kinetic energy reaches its maximum value $mc^2/2$. Fig.2 shows time variations of the speed, force, kinetic energy, and distance from the cathode.

3. Generator scheme and features

The proposed generator consists of 2 plates, as shown in Fig.3: an anode and a cathode, which is made of a material that emits electrons under the influence of an electric field (cold cathode).

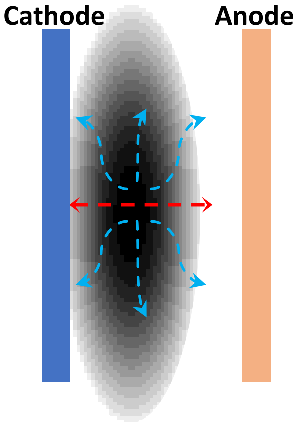

Fig. 3. The sketch of proposed generator. The black cloud is the oscillating electrons shown by the red arrows, and the blue arrows are the emitted radiation.

The anode is charged to a potential above 1.02 MV. This potential acts in twofold: (i) it tears the electrons away from the cathode, creating a flow of electrons towards the anode, and (ii) it creates a repulsive force near the anode sufficient to push the electrons back away from the anode, causing them to oscillate. Oscillating electrons emit microwaves in radial directions. The electrons oscillate around a critical distance without reaching and heating the cathode and anode. Due to this, higher energy conversion efficiency is expected. The frequency of oscillation can be changed by varying anode potential, and the amplitude of oscillations, so wide range of radiation frequencies can be obtained. Generator can operate in both pulsed and continuous mode.

4. Conclusions

Thus, we have investigated a new phenomenon of electron oscillations in a uniform electric field between two charged planes. The mechanism of these unusual oscillations is based on the existence of a repulsive force acting on an electron near a highly positively charged anode. These oscillations can be used to generate electromagnetic radiation over a wide range. The proposed generator can be considered as a new type of vircator, in which a virtual cathode is formed in front of, rather than behind, a positively charged anode.

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