Visualizing spin & radiation of the extended electron in electric field (Emission & Absorption of photons)

Hoa van Nguyen < hoanguyen2312@yahoo.ca >

Abstract

This article presents the illustrations that show how and why the electron spins and radiates in an external electric field . Bremsstrahlung & Cerenkov radiations , and the processes of Emission & Absorption of photons will be discussed .

1. Introduction

A time-varying electric field **E** (d**E** /dt > 0 or d**E** /dt < 0) produces the rotational induced magnetic field **B** . Maxwell ' s equation $\nabla \times \mathbf{H} = \partial \mathbf{D} / \partial t$ (where $\mathbf{B} = \mu \mathbf{H}$ and $\mathbf{D} = \varepsilon \mathbf{E}$) determines the direction and strength of the induced magnetic field **B** : Figs.1 & 2

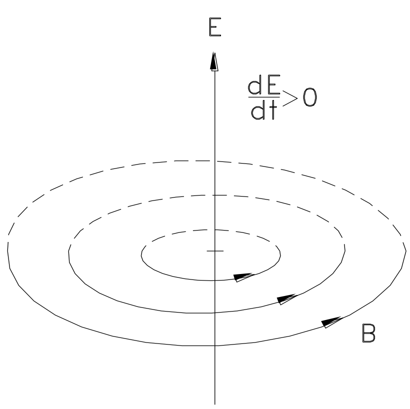

Fig.1 : Direction of the induced magnetic field **B** when d**E** / dt > 0 (**E** increases with time).

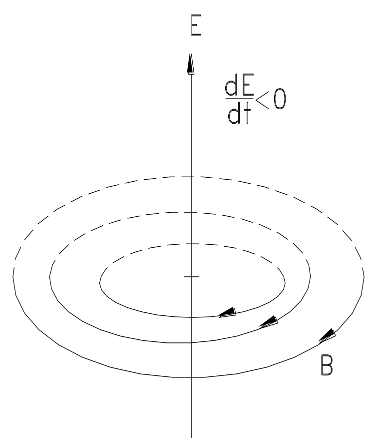

Fig.2 : Direction of the induced magnetic field **B** when d**E** / dt < 0 (**E** decreases with time) .

When the electron is subject to a time-varying electric field **E** , it is actually subject to the main electric field **E** and the induced magnetic field **B** . In a previous article [(1)] we have examined the action of the electric field **E** on the electron : it produces the electric force **Fe** on the electron causing it to move through the induced magnetic field **B** with the velocity V .
In this article , we focus on the action of the induced magnetic field **B** on two components **V'** and **V''** of the velocity **V** : **V'** normal to **E** : **(V' ⊥ E)** and **V"** parallel to **E** : **(V" ∥ E)** .
The induced magnetic field **B** produces different magnetic forces by these two components :
- component **V' ⊥ E** produces magnetic forces **fs** causing the **electron to spin** (section 2)
- component **V" ∥ E** produces magnetic forces **fm** causing **the electron to radiate (** section 4)

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(1) For more details , please read the article : " **Extended electron in constant electric field (Radiation by electric field)** " at www.vixra.org/author/hoa_van_nguyen

2. Visualizing the spin of the electron in time-varying electric field **E**

When the electron is subject to the time-varying electric field **E** , the induced magnetic field **B** (Figs.1 & 2) acts on the normal component **V' ⊥ E** to cause it to spin as shown in two Figs. 3 & 4 for two cases $dE/dt > 0$ and $dE/dt < 0$.

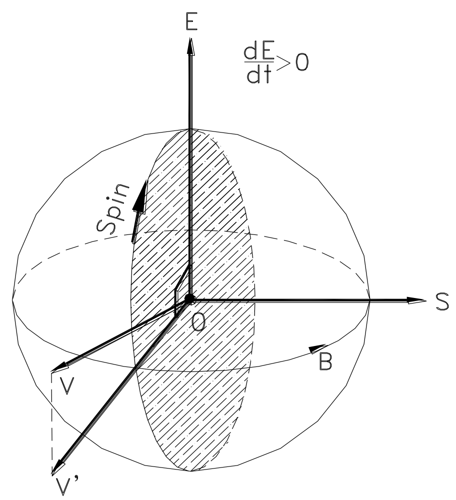

Fig.3 : The spin is caused by the component **V' ⊥ E** : The direction of spin of the electron is shown when d**E** /dt > 0 . Spin axis **OS** is normal to the plane (**E , V**)

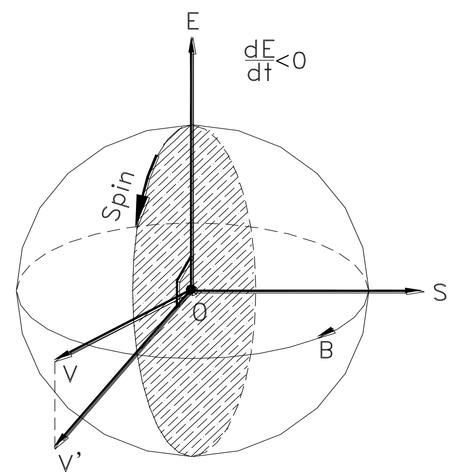

Fig.4 : The spin is caused by the component V' ⊥ **E :** The direction of spin of the electron when d**E** /dt < 0 , Spin axis **OS** is normal to the plane (**E , V)**

In a previous article [(2)] the magnitude of the spinning force **fs** has been determined as

$$fs = (\mu - 1) q V' B \sin \beta \qquad (1)$$

where $\mu > 1$ is the relative permeability of the electron to free space ; q : the electric charge at the end of a dipole ; V' : normal component of the velocity of the electron ; B : the induced magnetic field at the surface of the electron ; β is the angle (**V'I B**) at the surface dipole I .

Eq.(1) suggests the following consequences :

- If the electric field **E** is *constant in time* , the induced magnetic field **B** is not produced ; and hence spinning forces **fs** are not produced either ; therefore , the electron does not spin in a *constant electric field* .
- If the electron is moving *parallel or anti-parallel* to the time-varying electric field **E** , the normal component **V'** is zero , hence spinning forces **fs** = 0 and thus the electron does not spin when it moves parallel or anti-parallel to **E** .

- In two above cases (**E** is constant in time and the electron moves parallel to **E**) since **fs** = 0 the electron may be *spinning by inertia ; i.e., spin with no spinning forces* .

  And thus , the spin of the electron depends on the component **V' (⊥ E)** of its orbital velocity and on the induced magnetic field **B** ; i.e., on **E** and the time rate of change d**E** / dt . This is the spin- orbit coupling of the electron . When d**E**/dt changes its signs from positive to negative and vice versa , **fs** reverse their directions and so does the spin direction : Figs. 3 & 4 . The spin axis **OS** is normal to the plane **(E , V**) ; i.e., it is normal to the time-varying electric field **E** .

Comment on the report of controlling the spin of the electron by electric field in Science Magazine and Physics World .

A team of physicists in the Netherlands , led by **L . Vandersypen** [(3)] , reported in the Science magazine (Nov. 2007) that they have experimentally controlled the spin of a single electron by using an oscillating electric field .

M . Banks [(4)] reviewed this work of **Vandersypen** , wrote in Physicsworld.com :

" It is possible to control the spin of a single electron by using an electric field rather than a magnetic field , as is usually the case ".

The report did not demonstrate the mechanism that causes the electron to spin , and hence it could not elaborate the reason why the electron can reverse its spin direction by an oscillating electric field . Moreover , it viewed these two types of spin (by time-varying electric field and by time-varying magnetic field) as of the same type . Actually , they have different characteristics in their modes of spin : in the former case , the spinning forces **fs** are magnetic forces [Eq. (1)] and the spin-axis OS is normal to the electric field **E** as shown in Figs.3 & 4 ; while in the latter case , spinning forces are electric forces and the spin-axis lines up with the magnetic field **B** or precesses around it [(5)].

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(2) For more details , please read the article : " **Extended Electron in Time-Varying Electric Field : Spin and Radiation "** at www.vixra.org/author/hoa_van_nguyen
(3) **Vandersypen L. et al ,**" Coherent control of a single electron spin with electric field "
Science 30 Nov. 2007 , Vol.318 , No 5855 , p. 1430 www.sciencemag.org/content/318/5855/1430.abstract
(4) **Banks M .** , " Single spins controlled by an electric field " Physicsworld.com / 31720
(5) For more details , please read the article : " **Extended Electron in Time-Varying Magnetic Field : Spin and Radiation "** at www.vixra.org/author/hoa_van_nguyen

3. Visualization of radiation of the electron in constant electric field E .

The forces that cause the radiation of the extended electron come from two sources :
- from the external constant electric field **E** (which is considered in this section 3) ,
- from the induced magnetic field **B** (section 4) .

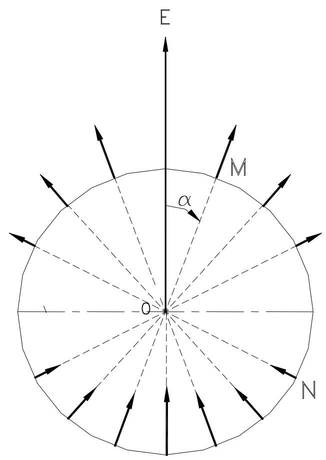

Fig.5 : (For $\varepsilon < 1$) shows electric forces **fe** acting on all surface dipoles of the electron :
- on the upper hemisphere : **fe** are centrifugal
- on the lower hemisphere : **fe** are centripetal

The magnitude of **fe** is fe = $(1/\varepsilon - 1) q E \cos\alpha$,
α is the angular position of the surface dipole M .

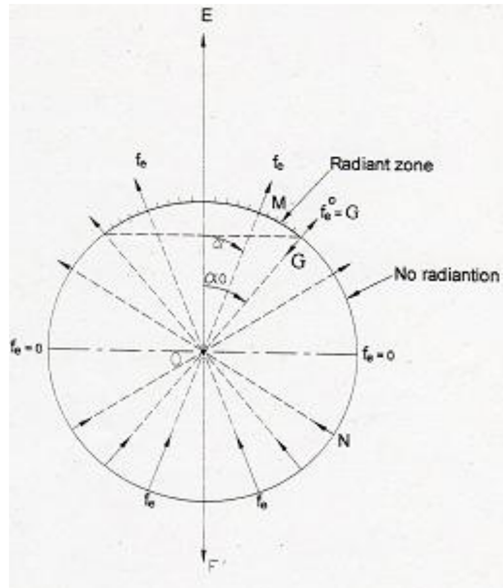

Fig.6 shows electric forces **fe** , cohesive forces **G** and the electric force **F '** that is produced on the core ($- q_0$) of the electron .
The magnitude of **G** is $\mathbf{G} = (1/\varepsilon - 1) q \mathbf{E_0}$,
where $\mathbf{E_0}$ is the self field of the electron .
At the angle α_0 : $\mathbf{fe^0} = \mathbf{G}$ (in magnitude) .

In the previous article [(1)] [see foot note (1)] we have come to two Figs. 5 & 6 which visualize the radiation of the electron in the constant electric field **E** .

Let us examine two Figs. 5 & 6 which are drawn for the case $\varepsilon < 1$ (when the particle behaves like an electron) . Fig.5 shows electric forces **fe** developed on all surface dipoles of the electron : **fe** are centrifugal on the upper hemisphere and centripetal on the lower hemisphere . Fig.6 shows , in addition to the electric forces **fe** , the cohesive forces **G** which attract all surface dipoles to the core and the force **F'** (produced on the core) which accelerates the electron downwards.

On the upper hemisphere, while **fe** are centrifugal , cohesive forces **G** are centripetal ; when the magnitude of **fe** is greater than that of **G** (**fe > G**) , these surface dipoles can be emitted from the surface of the electron ; that is, the electron radiates these photons outwards while it is moving downwards by the force **F'**. So , the condition for the electron to radiate is that the force **fe** that acts on this dipole is greater than the cohesive force **G** :

$$\mathbf{fe} > \mathbf{G} \qquad \text{(in magnitude)} \qquad (2)$$

Meanwhile , on the lower hemisphere, since both **fe** and **G** are centripetal , these surface dipoles cannot break free from the surface of the electron ; i.e., there is no radiation from the lower hemisphere.

Fig.6 shows the radiant zone , which does not cover the entire upper hemisphere of the electron , but only a limited zone around the north pole , defined by the angle α_o where

$$\mathbf{fe^0} = \mathbf{G} \qquad \text{(in magnitude)} \qquad (3)$$

Now let's try to determine this angle α_o . Let us recall that the magnitude of **fe** produced on a surface dipole M of the upper hemisphere has been calculated as :

$$\text{fe} = \left(\frac{1}{\varepsilon} - 1\right) q\, E \cos\alpha \quad , \quad \text{where} \quad \varepsilon < 1 \quad \text{and} \quad 0 < \alpha < \pi/2 \qquad (4)$$

fe is centrifugal and depends on the angular position α of the surface dipole M .

Since α_0 is assumed to be the value of the angle α at which $\mathbf{fe^0} = \mathbf{G}$ (in magnitude)
then the condition for the radiation to occur $\mathbf{fe} > \mathbf{G}$ (in magnitude)
is rewritten as $\mathbf{fe} > \mathbf{fe^0}$ (in magnitude)

or $$\left(\frac{1}{\varepsilon} - 1\right) q\, E \cos\alpha > \left(\frac{1}{\varepsilon} - 1\right) q\, E \cos\alpha_0 \qquad (5)$$

or $$\cos\alpha > \cos\alpha_0 \qquad (6)$$

or $$\alpha < \alpha_0 \qquad (7)$$

Fig.6 shows *the radiant zone* on the upper hemisphere , restricted in a zone around the north pole of the electron , limited by the angle α_0 which is defined by the relation (3).

All radiating rays emitted from the radiant zone are contained inside a radiation cone of solid angle $2\alpha_0$ at the vertex O . So , the existence of the angle α_0 means the existence of the radiation cone .
Now let us determine the condition for the existence of the angle α_0 . From (3) we have

$$\left(\frac{1}{\varepsilon} - 1\right) q\, E \cos\alpha_0 = G \qquad (8)$$

In the article **" A proposed extended model for the electron "** , the magnitude of **G** has been calculated to be equal to

$$G = \left(\frac{1}{\varepsilon} - 1\right) q E_0 \quad , \text{ where } \mathbf{E_0} \text{ is the self field of the electron} \qquad (9)$$

Hence $$\left(\frac{1}{\varepsilon} - 1\right) q E \cos\alpha_0 = \left(\frac{1}{\varepsilon} - 1\right) q E_0 \quad \text{or} \quad \boxed{\cos\alpha_0 = E_0 / E < 1} \qquad (10)$$

The condition for the radiation to occur is thus $$\boxed{E > E_0} \qquad (11)$$

Therefore : **i)** if $E < E_0$, $\cos\alpha_0 > 1$; α_0 does not exist : no radiation emits from the electron while it is accelerated in **E** ; this also implies that in free space (**E** = 0) the electron cannot radiate .

ii) if $E = E_0$, $\cos\alpha_0 = 1$, $\alpha_0 = 0$: the radiation cone reduces to a beam of light emitted from the north pole of the electron . In other words , the electron can radiate only at its north pole ($\alpha_0 = 0$) .

iii) if $E > E_0$, $\cos\alpha_0 < 1$, $0 < \alpha_0 < \pi/2$: radiation occurs around the north pole of the electron and expands towards the equator as the magnitude of **E** increases : the radiation cone emitted in the direction of the electric field **E** as shown in Fig.6 .

iv) if $E \to \infty$, $\cos\alpha_0 \to 0$, $\alpha_0 \to \pi/2$: the radiant zone expands to cover entirely the upper hemisphere (this case is only theoretical because **E** cannot tend to infinity) .

Conclusion : the condition for the existence of the angle $\boldsymbol{\alpha_0}$ (which is also the condition for the emission of radiation) is thus $\mathbf{E > E_0}$. So, while it is accelerated in **E** , the extended electron <u>whether or not radiates</u> depending on the strength of the applied field **E** compared to that of the self field $\mathbf{E_0}$, regardless of its motion in the field **E** . In other words , the radiation of the extended electron in *constant electric field* depends on the strength of the centrifugal electric forces **fe** which are showed in two Figs.5 & 6.

But if the electric field **E** is a *time-varying electric field* , <u>then additional forces **fm** will emerge to reinforce or restrain these centrifugal forces **fe**</u> **,** and create new conditions for the radiation , as we will discuss in the next section .

4. Visualizing the radiation of the electron in the time-varying electric field .

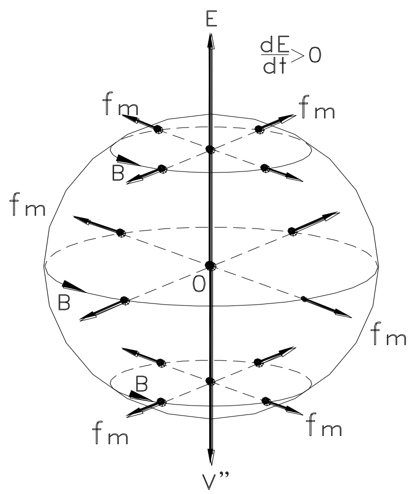

Fig.7 : the magnetic forces **fm** produced on all surface dipoles are radial from centers lying along the axis **OE** .

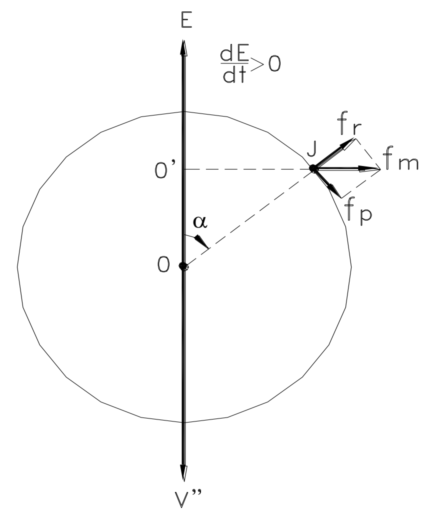

Fig.8 : the force **fm** can be decomposed into two components : **fr** and **fp :** **fr** is radial from O ; **fp** is tangent to the surface of the electron .

When an electron moves obliquely through a time-varying electric field **E**, its velocity **V** has two components : **V'** perpendicular to **E** and **V''** parallel (or anti-parallel) to **E** **.**
In the previous section we investigated the action of the induced magnetic field **B** on the perpendicular component **V'** : the spinning forces $\mathbf{f_S}$ are produced and spin the electron .

Now , in this section we will consider the action of the induced magnetic field **B** on the component **V''** parallel (or anti- parallel) to **E**

The result is the induced magnetic field **B** acting on **V''** gives rise to magnetic forces **fm** which are radial from centers lying on the axis **OE** , as shown in Fig.7 .

The magnitude of **fm** is $\quad fm = (\mu - 1)\, q\, V''B \quad (12)$

The magnetic force **fm** can be decomposed into two components **fr** and **fp** with **fr** radial from the core O and **fp** tangent to the spherical surface of the electron as shown in Fig.8.

The direction of **fm** depends on the directions of **V''** and **B** , where **V''** can be parallel or anti-parallel to **E** , while the direction of **B** (see Figs. 1 & 2) depends on the time rate of change (d**E** / dt) of **E** , which can be positive or negative . We therefore have four different situations :

1. **V''** ↓↑ **E** , d**E** / dt > 0 : electron is accelerated by an increased **E** : Fig.9

2. **V''** ↓↑ **E** , d**E** / dt < 0 : electron is accelerated by a decreased **E** : Fig.10

3. **V''** ↑↑ **E** , d**E** / dt > 0 : electron is decelerated by an increased **E** : Fig.11

4. **V''** ↑↑ **E** , d**E** / dt < 0 : electron is decelerated by a decreased **E** : Fig.12

The radial forces **fr** in these four situations create <u>contractive /</u> <u>expansive effects</u> on the electron , we call them **pulsating forces** .

We notice that in two Figs. 9 and 12 the magnetic forces **fm** point out of the electron , and the radial components **fr** are centrifugal , they thus enhance the radiation process of the electron in the electric field . On the other hand , in two Figs.10 and 11 , since the radial components **fr** are centripetal , they restrain the radiating capability of the electron in the electric field as we see below .

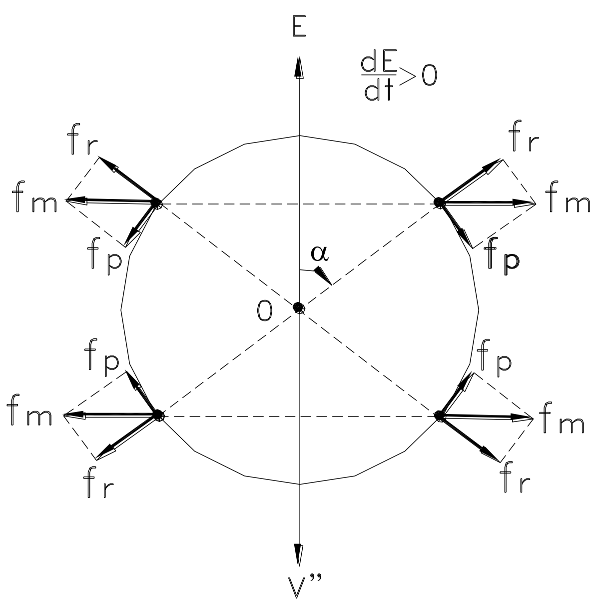

Fig.9 : When **V''** ↓↑ **E** , and d**E** / dt > 0 : all components **fr** are centrifugal .

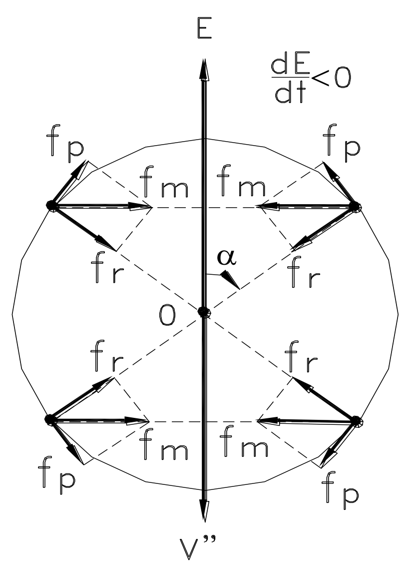

Fig.10 : When **V''** ↓↑ **E** , and d**E** / dt < 0 : all components **fr** are centripetal .

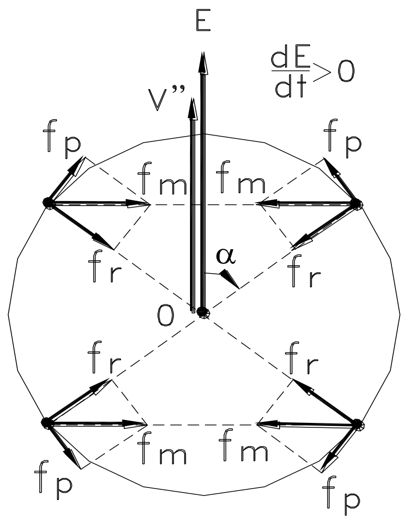

Fig. 11 : When **V''** ↑↑ **E** , and d**E** / dt > 0 :
all components **fr** are centripetal .

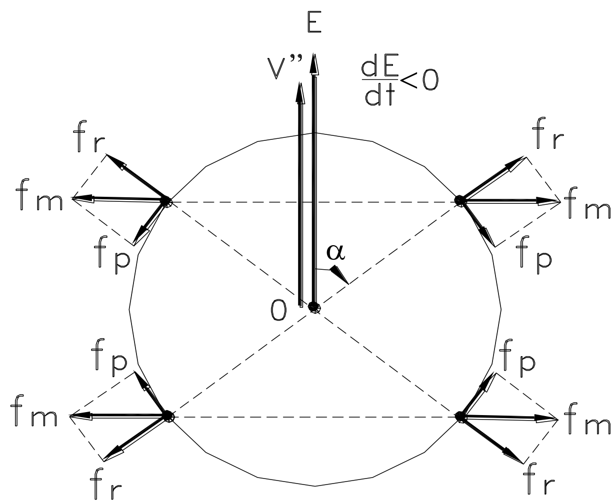

Fig.12 : When **V''** ↑↑ **E** , and d**E** / dt < 0
all components **fr** are centrifugal .

In the section 3 we have seen that the electric forces **fe** produced on surface dipoles are centrifugal on the upper hemisphere and centripetal on the lower hemisphere as shown in Fig.5 & 6 .

When **fe > G** in magnitude , **fe** cause the electron to radiate from a restricted zone around the north pole as shown in Fig.6 and there is no radiation on the lower hemisphere .

Now , if the electric field **E** is time-varying , in two cases of Figs.9 & 12 , the centrifugal forces **fr** reinforce **fe** on the upper hemisphere, and enhance the radiating ability , hence the radiant zone expands .

On the other hand , in two cases of Figs.10&11 , the centripetal forces **fr** oppose and weaken **fe** on the upper hemisphere , and hence reduce the radiating ability of the electron .

Therefore , in a time-varying electric field **E** , both electric forces **fe** and magnetic pulsating forces **fr** contribute to the radiation process of the electron .

Conclusion :

Electric field can affect the electron by two different ways :
The external electric field **E** produces the electric forces **fe** which are the main forces that cause the electron to radiate in the direction of the field **E** , no matter how the electron moves in the field *. In the meantime , if the electric field is a time-varying field , it produces the induced magnetic field **B** which gives rise to **spinning forces fs** due to the normal component **V' (⊥E)** and **pulsating forces fr** due to the parallel component **V" (// E)** of the velocity **V** . The pulsating forces **fr** create contracting or expansive effects on the electron , contributing to the radiation process and determining the radiation pattern when the electron radiates .
All illustrations in this article help us visualize these features of the electron in an electric field .

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* According to the Lorentz 's forces equation $\mathbf{F_L} = q\ (\mathbf{E} + \mathbf{V} \times \mathbf{B})$: the electric force $\mathbf{Fe} = q\mathbf{E}$ is independent of the velocity , while the magnetic force $\mathbf{Fm} = q\ \mathbf{V} \times \mathbf{B}$ depends on **V** .

Appendices :

We are going to discuss two topics :

1. **Mechanisms of Bremsstrahlung and Cerenkov Radiation**

2. Emission & Absorption of photons

Discussion 1 : Mechanisms of Bremsstrahlung and Cerenkov Radiation .

The visualizations of radiation of the electron by the electric field can be used to explain the mechanism of Bremsstrahlung and Cerenkov Radiation .

In the literature , Bremsstrahlung (or braking radiation) is described as radiation due to the deceleration of a charged particle when it is deflected in the electric field of an atomic nucleus . And Cerenkov radiation is emitted when a charged particle (e.g., electron) passes through a dielectric medium at a speed greater than the phase velocity of light in that medium . (Wikipedia)

By these descriptions , physicists only tell us WHEN these radiations occur , not WHY they happen . They cannot elaborate the physical reasons that cause the electron to radiate because they view the electron as a point charged particle and thus they cannot figure out **why** it can emit radiation (photons) .

Now if we view the electron as an extended particle with a structured configuration , composed of a core ($-q_0$) surrounded by a cloud of electric dipoles (-q , +q) (photons), then we can visualize the physical reason (the mechanism) for the radiation of the electron in external electric field .

In Bremsstrahlung : the electron is first decelerated in the (primary) electric field **E** , thus it radiates by electric forces **fe** as shown in Figs. 5 & 6 (regardless of its orbital motion) . Secondly , since it moves through an inhomogeneous (non-uniform) electric field : this is equivalent to a time-varying electric field , hence it is also subject to a (secondary) induced magnetic field **B** which creates radial forces **fr** that reinforce or restrained the radiation capability of the electron as shown in four Figs 9 ,10 , 11 , 12 **.** In short **,** Bremsstrahlung is caused by the main electric forces **fe** which are reinforced (or restrained) by radial forces **fr.**

In Cerenkov radiation : the electron is forced to traverse a medium like water (or heavy water in a nuclear reactor) : it glows a bluish light while accelerating or decelerating through the electric fields of atoms of the medium . Like in Bremsstrahlung , the main forces that cause the Cerenkov radiation is the electric forces **fe** which are reinforced (or restrained) by radial forces **fr** while the electron moves through the medium **.** Four Figs.9 ,10 ,11 ,12 delineate four possible situations of the electron when it is accelerated or decelerated through the varying electric field of the medium .

Discussion 2 : Emission & Absorption of photons .

In this discussion we will use mathematical expressions , which have been derived from the extended electron , to demonstrate two following statements (assertions) of the mainstream physics 's theory of radiation :

- **when an electron emits (radiates) photons : it loses (kinetic) energy and slows down** , (13)
- **when an electron absorbs photons (by irradiation) : it gains energy and speeds up** . (14)

The reasoning will go through two steps :

1. First , we prove that the **emission and absorption** of photons of the electron are linked to the **physical factor 'a'** , which represents the *physical structure of the extended electron* .

2. Next , we prove that this **factor 'a'** has mathematical relation with the **velocity** of the electron . And as a result , we come to a full agreement with two statements (13) and (14) .

First , let us recall the results we have obtained from calculations on the extended electron when it is subject to an external electric field **E** [(1)] (see foot note 1) : Two electric forces **F** and **F'** are produced on the electron :

- $\mathbf{F} = \sum \mathbf{fe} = (\frac{1}{\varepsilon} - 1)\, q\, \mathbf{E} \sum_i^n \cos^2 \alpha_i$ is the resultant force of all forces **fe** developed on n surface dipoles of the electron .

- $\mathbf{F}' = -\frac{1}{\varepsilon}\, q_0\, \mathbf{E}$ is the electric force developed on the core $-q_0$ of the electron .

Hence , the net force developed on the electron is **Fe = F + F '**

$$\mathbf{Fe} = (\frac{1}{\varepsilon} - 1)\, q\, \mathbf{E} \sum_i^n \cos^2 \alpha_i - \frac{1}{\varepsilon}\, q_0\, \mathbf{E}$$

by factoring we get $$\mathbf{Fe} = \left[(\frac{1}{\varepsilon} - 1)\, (q / q_0) \sum_i^n \cos^2 \alpha_i - \frac{1}{\varepsilon} \right] q_0\, \mathbf{E}$$

Let's set $$\boxed{a \equiv (q / q_0) \sum_i^n \cos^2 \alpha_i} \qquad (15)$$

we get $$\mathbf{Fe} = (\frac{a-1}{\varepsilon} - a)\, q_0\, \mathbf{E} \qquad (16)$$

'a' is a dimensionless positive number since q , q_0 and $\sum_i^n \cos^2 \alpha_i$ are positive numbers ; it represents the *physical structure of the extended electron* and depends on the number **n** of surface dipoles .

From Eq.(15) we get the following relationship between **emission & absorption** and **'a'** :

When the electron radiates , it loses its surface dipoles ; i.e., **n** decreases and hence **'a'** decreases accordingly , because $\sum_i^n \cos^2 \alpha_i$ is the sum of **n** positive terms $\cos^2 \alpha_i$.

Therefore , **'a' decreases in the emission of photons .** (17)

Conversely , when the electron absorbs photons , it gains more surface dipoles ; i.e., **n** increases and hence **' a '** increases accordingly .

Therefore , **'a' increases in the absorption of photons .** (18)

<u>This is the first step of reasoning</u> : we linked the **physical factor 'a'** to the **emission and absorption of photons of the electron .**

Now , in the second step we relate the factor **'a'** to **the velocity** of the electron .
From Eq.(16) we can deduce the effective electric charge Q of the electron (since **Fe =** Q **E)** :

$$\boxed{Q = \left(\frac{a-1}{\varepsilon} - a \right) q_0} \qquad \text{where} \quad a > 1 \quad , \quad \varepsilon < 1 \tag{19}$$

Let us recall that in a previous article , entitled **" A foundational problem in physics : Mass vs Electric charge "** we have obtained the general expression for the effective electric charge of the electron when it is subject to an external field :

$$\boxed{Q = -(1 - v^2/c^2)^{N/2} q_0} \tag{20}$$

where $N \geq 0$ is a real number representing the applying field , and the minus sign on the right side indicates the negative charge Q of the electron .
From (19) and (20) we get

$$\frac{a-1}{\varepsilon} - a = -(1 - v^2/c^2)^{N/2} \tag{21}$$

Now , let us extract (v^2/c^2) from Eq.(21) :

$$v^2/c^2 = 1 - [\, a - (a-1)/\varepsilon \,]^{2/N} \tag{22}$$

In the expression (22) , v^2/c^2 is a function of **'a'** while ε and N remain unchanged in the emission and absorption of photons .

Note : From the discussion in a previous article , we knew that ε varies in a very narrow interval (1-1/a , 1) . Since **'a'** is assumed to be a large number ; so this interval becomes (1- , 1) , or **ε ≈** 1- (infinitesimally less than 1) ; so it is approximately constant . The real number $N \geq 0$ represents the applying field , it is supposed to be constant . So , approximately speaking , ε and N remain unchanged in the emission and absorption of photons .

Therefore , from Eq.(22) we can take derivative of (v^2/c^2) with respect to **'a'** , we get

$$d(v^2/c^2)/da = (2/N)(1/\varepsilon - 1)[\, a - (a-1)/\varepsilon \,]^{(2/N)-1} \tag{23}$$

Since $N > 0$, $a > 1$ and **ε ≈** 1- we have

$$(2/N) > 0 \quad , \quad (1/\varepsilon - 1) > 0 \quad \text{and} \quad [\, a - (a-1)/\varepsilon \,]^{(2/N)-1} > 0\,^* \tag{24}$$

hence from Eq.(23) we get

$$\boxed{\mathbf{d(v^2/c^2)/da > 0}} \tag{25}$$

Expression (25) allows us to conclude that **(v^2 / c^2) is monotonic increasing with respect to the factor 'a'** which represents the physical structure of the extended electron .

<u>This is the result of the second step of reasoning</u> . Now by combining these two steps , we get :

- When the electron **emits photons** : **'a'** decreases (first step) , hence **(v^2 / c^2)** also decreases (second step) ; that is , the electron slows down , or it loses its (kinetic) energy .

- When the electron **absorbs photons** : **'a'** increases (first step) , hence **(v^2 / c^2)** increases as well (second step) ; that is , the electron speeds up , or it gains energy .

Therefore , by using expressions from (15) to (25) , which belong to the extended electron , we can demonstrate two established statements (13) and (14) of the mainstream physics .
This proves that the extended model of the electron is eligible for the explanation of the emission and absorption of photons of the electron .

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* From Eq.(16) : since the electric force **Fe** is a negative force , (it points in the opposite direction to the electric field **E**) , the factor $\left(\frac{a-1}{\varepsilon} - a \right)$ is negative , and hence in (24) $[\ a - (a-1) / \varepsilon\ ]$ is positive and $[\ a - (a-1) / \varepsilon\ ]^{(2/N)-1} > 0$ for all values of the exponent (2 / N) - 1 .