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Formulas for Energy Radiation from Accelerated Charged Particles

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1 Abraham-Lorentz Formula

Abraham-Lorentz formula of classical electrodynamics [1] gives the radiation reaction force $\boldsymbol{R}_f$ due to a particle of charge q as a vector proportional to the rate of change of acceleration $\boldsymbol{a}$ at time t, thus:

$$\mathbf{R}_f = \frac{q^2}{6\pi\varepsilon_o c^3}\frac{d\mathbf{a}}{dt} \tag{1}$$

where c is the speed of light in a vacuum and ε_o is the permittivity of a vacuum.

2 Larmor Formula

Larmor formula of classical electrodynamics [1] gives the radiation power R_p of a particle of charge q as a scalar proportional to the square of acceleration a, thus:

$$R_p = \frac{q^2 a^2}{6\pi\varepsilon_o c^3} \tag{2}$$

These formulas of classical electrodynamics, equations (1) and (2), are incompatible with one another as radiation power must always be equal to the scalar product of radiation reaction force and velocity.

3 Lienard Formula

To the best of the author's knowledge, there is no formula for radiation reaction force in relativistic electrodynamics. However, special relativity adopted Larmor formula to gives Lienard formula [1] for radiation power as.

$$R_p = \frac{q^2 a^2 \gamma^4}{6\pi\varepsilon_o c^3} \tag{3}$$

where the relativistic factor $\gamma = \dfrac{1}{\sqrt{1-\dfrac{v^2}{c^2}}}$

4 Alternative Formula

The author [2] shows that radiation reaction force $\boldsymbol{R}_f$ due to a particle of charge q moving with velocity $\boldsymbol{v}$ in the direction of an electric field of intensity $\boldsymbol{E}$ and magnitude E is given, as:

$$\mathbf{R}_f = -qE\frac{\mathbf{v}}{c} = -\frac{qv}{c}\mathbf{E} \tag{4}$$

The radiation power R_p, in rectilinear motion, is the scalar product $-\boldsymbol{v}.\ \boldsymbol{R}_f$ given by:

$$R_p = -\mathbf{v}, \mathbf{R}_f = qE\frac{v^2}{c} \tag{5}$$

Where the velocity $\boldsymbol{v}$ is perpendicular to the radiation reaction force $\boldsymbol{R}_f$, as in circular motion of an electron round a positively charged nucleaus (velocity $\boldsymbol{v}$ in the circumferential direction and radiation reaction force $\boldsymbol{R}_f$ in the radial direction), the radiation power is zero (0).

5 Stability of Rutherford's Nuclear Model of the Hydrogen Atom

Larmor formula, an erroneous equation, is most unfortunate as it misled physics early in the 20th century taking it into the quagmire of quantum mechanics. According to this formula, the Rutherford's nuclear model of the hydrogen atom [3] should be unstable as the revolving electron would radiate energy and spiral inwards to collide with the nucleus thereby leading to the collapse of the atom. But atoms are the most stable entities known in nature. It required Bohr's brilliant hypotheses [4], invoking quantum mechanics, to prevent the atom from emitting radiation and collapsing.

Actually, Rutherford's model is inherently stable outside quantum mechanics. The author [2, 5] shows that circular motion of an electron round a positively charged nucleus is without radiation and inherently stable. Radiation takes place only if a revolving electron is dislodged from the stable circular orbit. An excited electron revolves in an elliptic orbit with emission of radiation, at the frequency of revolution, before reverting back (after many cycles of revolutions) into the stable circular orbit

6 References

1 D.J. Griffith; *Introduction to Electrodynamics*, Prentice Hall, Englewood Cliff, New Jersey (1981), pp 375-378

2 "An Alternative Electrodynamics to the Theory of Special Relativity" http://www.musada.net/Papers/Paper1.pdf

3 E. Rutherford; Phil. Mag., 21 (1911), 669

4 N. Bohr; Phil. Mag., 26 (1913), 476

5 "A Nuclear Model of the Hydrogen Atom Outside quantum Mechanics", http://www.musada.net/Papers/Paper3.pdf