Force of Cherenkov radiation

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Abstract : The new mathematical model allows us to calculate force of electromagnetic radiation (Cherenkov radiation) . It is shown that the equation for the calculation of force of Cherenkov radiation radiation accounts for angular frequency of electromagnetic radiation and refractive index of the medium . The energy of Cherenkov radiation ,force of electromagnetic radiation (Cherenkov radiation) and refractive index of the medium are brought togather in one frame of reference to explain the phenomenon of Cherenkov radiation.The above expressions was developed based on the basic concepts of electromagnetic radiation and quantum mechanics.The fundamental universal constants like planck's constant (h),speed of light(C) are included in the paper to explain the Cherenkov effect. [Academia Arena, 2010;2(5):44-48] (ISSN 1553-992X).

Key words : Force of electromagnetic radiation (Cherenkov radiation) , Speed of light , Frequency of electromagnetic radiation, Wavelength of Cherenkov radiation, velocity of electromagnetic radiation.

Cherenkov radiation is the electromagnetic radiation emitted when a charged particle (such as an electron) passes through an insulator at a constant speed greater than the speed of light in that medium . Light produced by charged particles when they pass through an optically transparent medium at speeds greater than the speed of light in that medium. For example, when electrons from a nuclear reactor travel through shielding water, they do so at a speed greater than that of light through water and they displace some electrons from the atoms in their path. This causes emission of electromagnetic radiation that appears as a weak bluish-white glow. The radiation is emitted in a cone whose half angle is greater for faster particles and media with higher refractive indices. Radiation occurs mainly in the visible and near UV (especially blue) region of the spectrum.

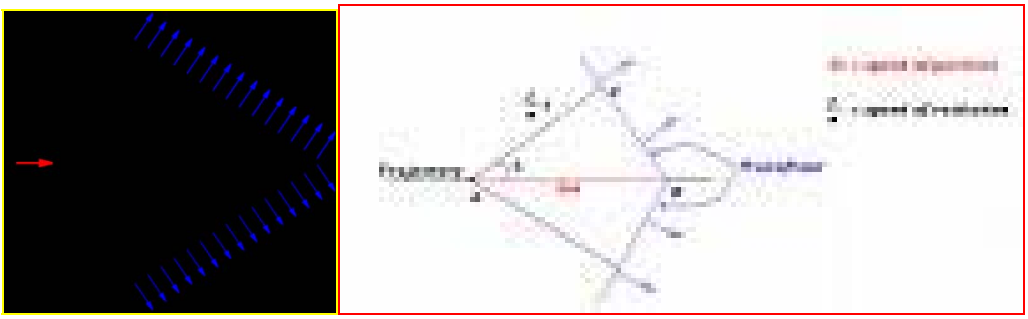

Figure-1: The geometry of the Cherenkov radiation

Force of electromagnetic radiation (Cherenkov radiation) is given by

$$\mathbf{F}_{em} = \mathbf{E}_{em} / \boldsymbol{\lambda}_{em} \text{ .....(1)}$$

Here $\mathbf{F}_{em}$ = Force of electromagnetic radiation (Cherenkov radiation), $\mathbf{E}_{em}$=Energy of Cherenkov radiation , $\boldsymbol{\lambda}_{em}$= Wavelength of Cherenkov radiation .

According to Max planck's law of radiation

Energy associated with the electromagnetic radiation (Cherenkov radiation) is given by

$$\mathbf{E}_{em} = \mathbf{h}\boldsymbol{f}_{em} \text{ .....(2)}$$

Here **h**=Plancks constant($6.625*10^{-34}$Js) , $\boldsymbol{f}_{em}$=Frequency of electromagnetic radiation(Cherenkov radiation) .

Thus (1)becomes $\mathbf{F}_{em} = \mathbf{h}\boldsymbol{f}_{em} / \boldsymbol{\lambda}_{em}$ .....(3)

Frequency of electromagnetic radiation is given by

$$\boldsymbol{f}_{em} = \boldsymbol{V}_{em} / \boldsymbol{\lambda}_{em}$$

Here $\boldsymbol{V}_{em}$= velocity of electromagnetic radiation(Cherenkov radiation) , $\boldsymbol{\lambda}_{em}$= Wavelength of Cherenkov radiation.

$$\boldsymbol{\lambda}_{em} = \boldsymbol{V}_{em} / \boldsymbol{f}_{em} \text{.....(4)}$$

Figure-2:The characteristic blue glow of nuclear reactors is due to Cherenkov radiation.

Thus(3)becomes $\mathbf{F}_{em}\ \boldsymbol{V}_{em} = \mathbf{h}\boldsymbol{f}_{em}^{\ 2}$.....(5)

n is the refractive index of the medium and so the emitted electromagnetic radition(Cherenkov radiation) travel at speed

$$\boldsymbol{V}_{em} = \mathbf{C}/\boldsymbol{n} \text{ .....(6)}$$

Here **C** = Speed of light in vaccum($3*10^8$m/s) , V_{em} = velocity of electromagnetic radition(Cherenkov radiation) .

Thus (5)becomes

$F_{em}\, C/n = hf_{em}^2$.....(7)

Let us multiply the equation(7) by$4\pi^2$

$4\pi^2 F_{em} = (4\pi^2 hf_{em}^2)\, n / C$ .....(8)

Angular frequency of electromagnetic radiation is given by

$\omega_{em} = 2\pi f_{em}$.....(9)

Thus the equation (8) becomes $F_{em} = h\,\omega_{em}^2\, n /4\pi^2 C$ .....(10)

Let $k = h/4\pi^2 C$

Here k=proportionality constant

$F_{em} = k\,\omega_{em}^2\, n$ .....(11)

Here ω_{em} =Angular frequency of electromagnetic radiation ,k = proportionality constant ,n=Refractive index of the medium , F_{em}= Force of electromagnetic radiation (Cherenkov radiation).

Energy of electromagnetic radiation is given by

$E_{em} = h\,\omega_{em}/2\pi$.....(12)

$\omega_{em}^2 = 4\pi^2\, E_{em}^2/h$.....(13)

Thus the equation (11) becomes $F_{em} = k4\pi^2\, n\, E_{em}^2/h$ .....(14)

Let $k_1 = k4\pi^2/h$

Here k_1 = proportionality constant .

$F_{em} = k_1\, n\, E_{em}^2$ .....(15)

$E_{em} = (F_{em}/k_1\, n)^{1/2}$.....(16)

Here, k_1 = proportionality constant, E_{em} =Energy of electromagnetic radiation, F_{em}= Force of electromagnetic radiation (Cherenkov radiation), n is the refractive index of the medium

Result:

1) Force of electromagnetic radiation (Cherenkov radiation) is given by $F_{em} = k\,\omega_{em}^2\,n$
[ω_{em} =Angular frequency of electromagnetic radiation ,k = proportionality constant ,n=Refractive index of the medium , F_{em}= Force of electromagnetic radiation (Cherenkov radiation)] .

2) Energy of electromagnetic radiation (Cherenkov radiation) is given by $E_{em} = (F_{em}/\,k_1\,n)^{1/2}$
[k_1 = proportionality constant, E_{em} =Energy of electromagnetic radiation, F_{em}= Force of electromagnetic radiation (Cherenkov radiation), n is the refractive index of the medium].

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References :

1) Cherenkov radiation (From Wikipedia,the free encyclopedia).

2) Angular frequency(From Wikipedia,the free encyclopedia).

3) Frequency (From Wikipedia,the free encyclopedia).

4) Planck's law(From Wikipedia, the free encyclopedia).

5) Determination of the Photon Force and Pressure Reissig, Sergej (Google search).

Conclusion : The mathematical determination of force of Cherenkov radiation according to formula(11) which take into account the refractive index of the medium in which the charged particle travels at speed' V_{em}' such that $V_{em} > C$ and angular frequency of electromagnetic radiation . The energy of the electromagnetic radiation can be calculated by knowing the value of ω_{em} and n with the application of formula(16). The angular frequency of electromagnetic radiation ,refractive index of the medium ,force of electromagnetic radiation (Cherenkov radiation)and energy of Cherenkov radiationare related to each other in one or other way to explain the phenomenon of Cherenkov radiation.This mathematical theory predicts a new method for determination of force and energy of Cherenkov radiation.

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