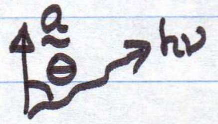
Thomson Scattering by free electrons (MKS units)

EM theory → power radiated by accelerated charge

$$\frac{dP(\theta)}{d\Omega} = \frac{q^2 a^2 \sin^2\theta}{16\pi^2 \epsilon_0 c^3} \quad \text{watts/steradian}$$



$$P = \int_{4\pi} dP(\theta)\, d\Omega = \frac{q^2 a^2}{6\pi\epsilon_0 c^3} \quad \text{watts}$$ (LARMOR'S FORMULA)

Consider free electron exposed to incident $\underset{\sim}{E}$-field from em wave

$|B| = \frac{1}{c}|E|$ so $\underset{\sim}{v} \times \underset{\sim}{B} \sim \frac{v}{c}|E|$ can be neglected for $v \ll c$

acceleration $a = qE/m$. Take $h\nu \ll m_0 c^2$ so wave approx. o.k.

So scattered power $\langle P \rangle = \dfrac{q^4 \langle E^2 \rangle}{6\pi\epsilon_0 m^2 c^3}$ watts $\quad \langle\,\rangle$ - time average

If average power density (w/m^2) in incident wave is $\langle I \rangle$ then

$$\langle I \rangle = \epsilon_0 c \langle E^2 \rangle$$

Define σ — scattering cross-section of free electron — as area of incident rad^n containing scattered power, i.e.

$$\langle P \rangle = \sigma \langle I \rangle$$

then

$$\sigma = \sigma_T = \frac{q^4}{6\pi\epsilon_0^2 m^2 c^4}$$

$$\sigma_T = \frac{8\pi}{3} r_0^2$$

THOMSON CROSS-SECTION FOR ELECTRON-"PHOTON" SCATTERING

$6.652 \times 10^{-29}\ m^2$

where r_0 is "classical electron radius" defined by $mc^2 = \dfrac{q^2}{4\pi\epsilon_0 r_0}$