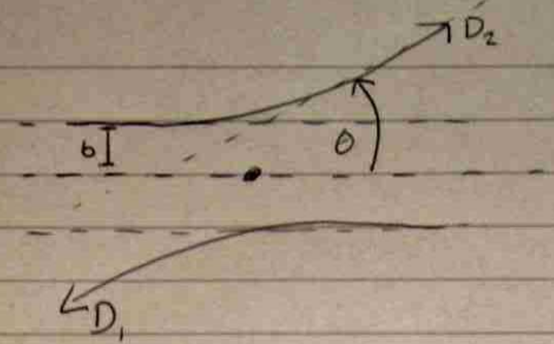


b = lateral displacement from C of M

$$b = \frac{z_1 z_2 k e^2}{2.E} \cdot \cot\frac{\theta}{2}$$

let $s = \dfrac{z_1 z_2 k e^2}{2E}$

for an inertial frame with D_1 stationary:

relative energy loss $= K = \sin^2\frac{\theta}{2}$

so $\sin\frac{\theta}{2} = \sqrt{K}$, $\cos\frac{\theta}{2} = \sqrt{1-k}$

$$b = s\frac{\sqrt{1-k}}{\sqrt{k}} \Rightarrow b^2 = s^2\frac{1-k}{k} \Rightarrow b^2 + s^2 = \frac{s^2}{k} \Rightarrow k = \frac{s^2}{b^2+s^2}$$

now sum relative energy losses for b to radius R and for all angles about axis parallel to projectile motion throught C of M.

$$\text{sum of energy losses} = \int_0^{2\pi}\int_0^R k.db.b.d\theta = 2\pi s^2 \int_0^R \frac{\cancel{2}b}{b^2+s^2}\,db$$

$$= \pi s^2\left[\ln|R^2+s^2| - \ln|\cancel{b}s^2|\right]$$

$$= \pi s^2 . \ln\left|\frac{R^2+s^2}{s^2}\right|$$

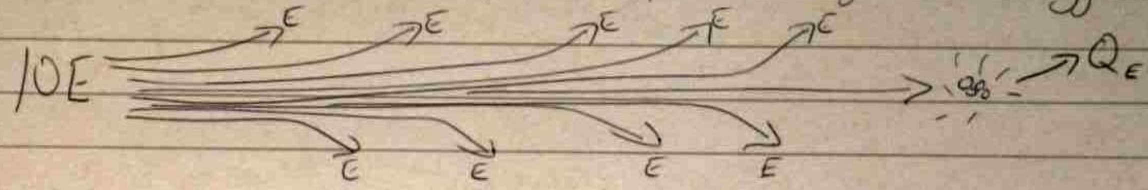
this sum is with respect to a cross-section of beam of D_2 to radius R such that it is over an area of πR^2

so average energy loss $= \bar{k} = \dfrac{s^2 . \ln\left|\frac{R^2+s^2}{s^2}\right|}{R^2}$

therefore the beam cross-section can be written:

$$\pi R^2 = \frac{\pi . s^2 . \ln\left|\frac{R^2+s^2}{s^2}\right|}{\bar{k}} \qquad (1)$$

Consider a 'beam-type' fusion process such that (by example) a target particle fuses one time out of ten; and the particles begin with energy E



Here, an input of $10E$ looses $9E$ before releasing Q_E of energy

so to release as much energy as put in:

$$\frac{P_f}{P_s} * = \frac{\text{probability of fusing}}{\text{probability of scattering}} = \frac{1}{9} > \frac{E}{Q_E}$$

we define a scattering cross-section, σ_c, and compare it with a fusion cross-section, σ_f, such that:

$$P_f = \frac{\sigma_f}{\sigma_f + \sigma_c} \quad \text{and} \quad P_s = \frac{\sigma_c}{\sigma_f + \sigma_c}$$

so that for over-unity energy out:

$$\frac{\sigma_f}{\sigma_c} > \frac{E}{Q_E}$$

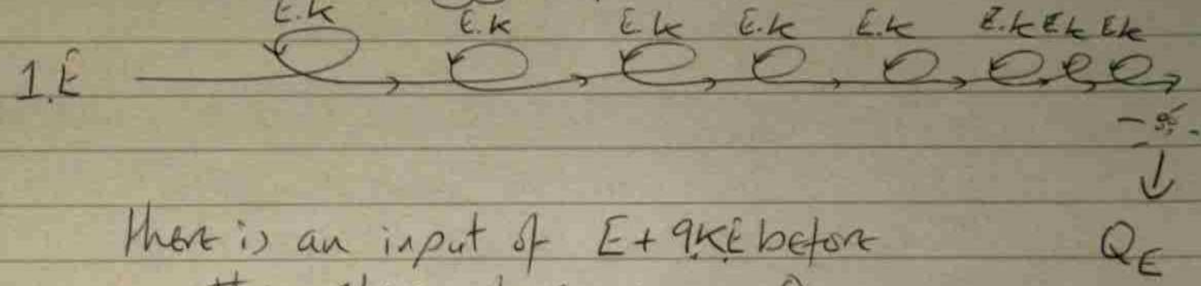
When this $\sigma_c >> \sigma_f$ we can say the cross-section of 1 will contain mostly particles that will scatter, i.e. $\sigma_c = \pi R^2$

So for over unity energy out:

(2) $$\frac{\sigma_f . \bar{k}}{\pi . s^2 . \ln\left|\frac{R^2+s^2}{s^2}\right|} > \frac{E}{Q_E} \Rightarrow \sigma_f > \frac{\pi . E . s^2 . \ln\left|\frac{R^2+s^2}{s^2}\right|}{\bar{K} . Q_E}$$

THIS CAN BE PROOVED FALSE AS $\bar{K}$ WILL TEND TO ZERO FOR VERY LARGE R SO RHS BECOMES INFINITELY LARGE.

Consider an alternative fusion process in which scattered particles are recycled, such that the energy input is the scattered loss; k;



there is an input of $E + 9kE$ before the release of energy, Q_E

[Here, we recognise that in reality there will be several thousand scattering events for each fusion such that the result would tend to $9k$.]

So to release as much energy as put in

$$\frac{P_f}{P_s} = \frac{1}{9} > \frac{E.k}{Q_E}$$

and (2) can be re-written:

$$\frac{\sigma_f . \bar{k}}{\pi . s^2 . \ln\left|\frac{R^2+s^2}{s^2}\right|} > \frac{E.\bar{k}}{Q_E} \Rightarrow \sigma_f > \frac{\pi . E . s^2 . \ln\left|\frac{R^2+s^2}{s^2}\right|}{Q_E}$$

note that this form neglects the input 'E' for the initial energy of the recycled particle. This can be re-inserted into the equation by treating the 'net output energy'; $Q_E - E$

So for over-unity energy:

(3) $$\sigma_f > \frac{\pi . E . s^2 . \ln\left|\frac{R^2+s^2}{s^2}\right|}{Q_E - E}$$