02/04/10

NPRE-421

Assignment

Read chapter 4 : Confinement

HW - 3.2, 3.4, 3.5, 3.6

From last time →

Reaction Rate = $n_a n_b \langle \sigma v \rangle_{ab}$
- → nuclear physics
- → quantum mechanical tunneling
- → Average distribution function

$\frac{E}{\text{Volume}}$ = (Reaction rate) · (E_f)

↓ DT = 17 MeV

$\sigma_{scattering} >> \sigma_{fusion}$ → probability of ~~et~~ particles to fuse together is very less.

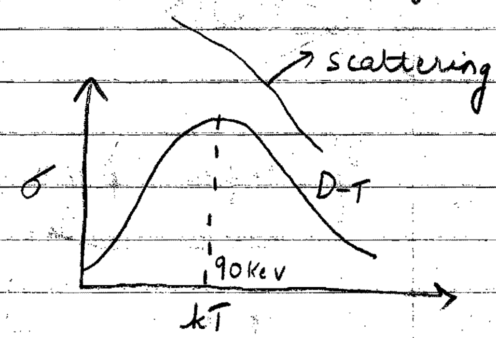
↓

i - i

e - e

e - i

i = ion
e = electron



Importance of scattering

→ loss of ions to fusion and loss of their energy. //need "confinement" to avoid this//

Electrons → Major scattering →
- → Radiation loss (Bremstrahlung) } Energy loss
- → Transfer energy to and from ions (Thermalize plasma)
- → Use RF, laser λ, to couple energy into electrons
- → Allow ohmic heating (IR^2)

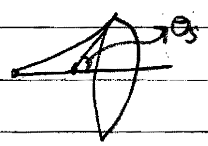
σ scattering

F coulombic

Transfer to center of mass system to do conservation equations

$$\theta_c \xrightleftharpoons{3.9a} \theta_{lab}$$

3.9 a) $\cot(\theta_L) = \frac{m_b}{m_a}\csc(\theta_c) + \cot(\theta_c)$



$$\int_\Omega \frac{d\sigma(\Omega)}{d\Omega}\, d\phi\, d\Omega^*$$

3.4

$$\int_\Omega \frac{d\sigma(\theta_s)}{d\theta_c} d\Omega \longrightarrow d\theta_c\, d\Omega^*$$

$F \propto \frac{1}{r^2}$

If impact parameter $r_0 = 0$, we are having a hard collision $\longleftrightarrow$

If impact parameter $r_0 = \infty$ then $\sigma_s \to 0$

$r_{max} \equiv \lambda_{Debye}$

↓

shielding distance

In typical debye sphere, $n \sim 10^{14}\ cm^{-3}$ and $10^9 e^-$

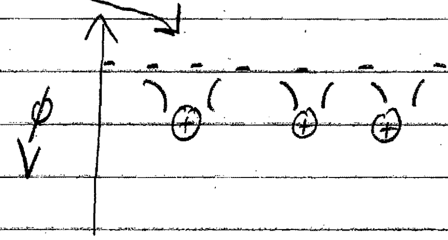
$\lambda_{Debye} \lesssim 1\,mm$

$$\sigma_s = \int_{\theta_c = \theta_{max} \to \theta_{min}}^{\theta_c = \pi} \sigma(\theta_c)\, d\Omega^*$$

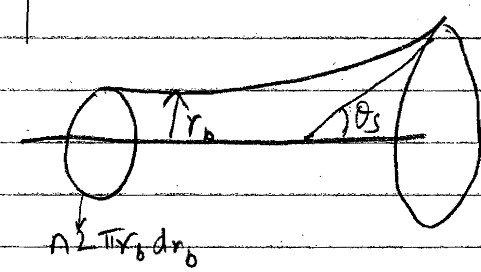
Define: fully ionized plasma

globally neutral $\sum_i q_i n_i = e n_e$

Note: near an ion ≠ neutral



$L_{plasma} \gg \lambda_{Debye}$



$$\sigma_s(\theta_c) = \frac{r_a}{\sin\theta_c}\left|\frac{dr_\theta}{d\theta_c}\right|$$

$\frac{dr_\theta}{d\theta_c}$ is given from 3.9c

Finally, we get eq → 3.15

$$\sigma_s(\theta_c) = \frac{k^2}{4\sin^4(\theta_c/2)} = \frac{1}{4}\left(\frac{q_a q_b}{4\pi\epsilon_0 m_r v_r^2}\right)^2 \frac{1}{\sin^4(\theta_c/2)}$$

Calculated first by Rutherford, when experimenting with α-particle scattering.

$n_i = \text{constant} = n_i(\infty)$

$n_e = n_e(\infty)\exp\left(-\frac{q_e \phi}{kT_e}\right)$

$$-\nabla^2\phi = \frac{e(n_e - n_i)}{\epsilon_0}$$