2004 Part II Q1 A,C GPP I

A. ratio of ion-ion collision frequency to electron-electron collision frequency:

$$\nu = n\sigma v_{rel} \qquad \sigma \cong b_0^2 \cong \left(\frac{q_1 q_2}{T}\right)^2$$

For $T_i = T_e$, $\sigma_{ii} = \sigma_{ee}$

For ee collision, $v_{rel} \sim v_{Te} \sim \sqrt{\frac{1}{m_e}}$

For ii collision, $v_{rel} \sim v_{Ti} \sim \sqrt{\frac{1}{m_i}}$

$$\Rightarrow \frac{\nu_{ii}}{\nu_{ee}} \sim \sqrt{\frac{m_e}{m_i}}$$

ratio of the electron-ion energy exchange rate to the electron-electron collision frequency

• Consider an electron colliding head on with a stationary ion

$$\Delta\vec{p}_e = -2m_e\vec{v}_e \Rightarrow \Delta\vec{p}_i = 2m_e\vec{v}_e \longrightarrow \vec{v}_i = 2\frac{m_e}{m_i}\vec{v}_e$$

The energy transferred to the ion is $\frac{1}{2}m_i v_i^2 = 4\frac{m_e}{m_i}\frac{m_e v_e^2}{2}$

It takes $\sim \frac{m_i}{m_e}$ such collisions for the electron to transfer all its energy to the ions. In such a collision, the electron's momentum changes on order of the incoming momentum, so

$$\frac{\nu_{Eei}}{\nu_{ei}} \sim \frac{\nu_{Eei}}{\nu_{ee}} \sim \frac{m_e}{m_i}$$

C. thermal energy density = pressure

$P = nT$

After compression, density increases by $\left(\frac{a_0}{a_1}\right)^2$

"Compression"? So ambiguous... does B and hence $W_\perp$ increase?