Plasma I

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Exercise 1

Compare the momentum transfer cross-section for the electron-ion collisions with small deflection angles with the cross-section for the electron-ion collisions with a deflection angle larger than 90^o. What can you say for a deuterium plasma with $T_e = T_i = 1\,\mathrm{keV}$ and $n = 10^{20}\,\mathrm{m}^{-3}$?

Suggestion: for electron-ion collisions at $T_e = T_i = 1$ keV , the Coulomb logarithm is (NRL Plasma Formulary, page 34)

$$\ln\Lambda = 24 - \ln\left(\frac{\sqrt{n_e\ [\mathrm{cm}^{-3}]}}{T\ [\mathrm{eV}]}\right)$$

Exercise 2

Consider the total momentum lost by a population of electrons colliding with a population of ions, in the three-dimensional space. Demonstrate that for a Maxwellian distribution of electrons with a drift velocity v_d ($v_d << v_{the}$) in the x direction, the average of the collision frequency is given by:

$$\bar{\nu}_p^{e/i} = \frac{1}{3}\sqrt{\frac{2}{\pi}}\nu_p^{e/i}(v_{the}) \simeq 0.26 \cdot \nu_p^{e/i}(v_{the})$$

where $\nu_p^{e/i}(v_{the})$ is the collision frequency for the momentum transfer between electrons and ions at the electron velocity v_{the}.

Indications:

- consider the physical meaning of the effective collision frequency to determine which is the physical quantity that has to be averaged.
- suppose $\ln\Lambda = \mathrm{const}$, independent of the velocity and equal for electrons and ions.

Exercise 3

Consider the relaxation process of *alpha* particles (α's) at 3.5 MeV created by fusion reactions in a deuterium-tritium plasma (50 : 50 D-T). Evaluate the time-scale for the energy loss of α's in a plasma with $n_e = 10^{20}\,\mathrm{m}^{-3}$. Consider the collisions between three plasma species, assuming $T_e = T_D = T_T = 10$ keV.

a.) Which species is the most important in the α's thermalisation process?

b.) Which species is heated more by α's particles?

Suggestion: start with a thermal energy for the α's of 3.5 MeV and then consider the different regimes corresponding to the different energies of the α's during the thermalisation.
