Plasma Physics I

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Exercise 1

In the lecture we have neglected the effect of collisions in the two-fluid model used to derive the dispersion relation of a wave in a magnetised plasma.

Consider a cold unmagnetized fluid plasma ($T = 0, \boldsymbol{B_0} = 0$).

a.) Derive the dispersion relation of waves in such plasma keeping the collision term in the momentum equation for the electrons.

b.) Show that in this case longitudinal waves (*Langmuir* waves) are damped.

Exercise 2

An antenna can detect frequencies around $f = 80\,\mathrm{MHz}$ and is used to measure the wave coming from a pulsar producing a broad electromagnetic spectrum.

Due to the dispersion of the group velocity caused by the interstellar plasma, the measured frequency during a pulse drift varies according to $\mathrm{d}f/\mathrm{d}t = -5\,\mathrm{MHz} \cdot \mathrm{s}^{-1}$.

a.) Considering $\omega^2 \gg \omega_p^2$ and neglecting the magnetic field in the interstellar plasma, demonstrate that:

$$\frac{\mathrm{d}f}{\mathrm{d}t} \approx -\frac{c}{x}\frac{f^3}{f_p^2}$$

where $f_p = \omega_p/2\pi$ and x is the distance of the pulsar.

b.) Find the distance of the pulsar in *parsec* ($1\,\mathrm{parsec} = 3 \times 10^{16}\,\mathrm{m}$) considering a mean electron density in space of $2 \times 10^6\,\mathrm{m}^{-3}$.