

PHYS 626 -- Fundamentals of Plasma Physics -- Section 5.5

1. Dispersion relations for small amplitude waves can be derived from the first moment equation with zero magnetic field and isotropic pressure.
2. For high frequency waves above electron plasma frequency, the non propagating cold plasma mode $\omega = \omega_p$ becomes propagating due to thermal effect, such that
$$\omega^2 = \omega_{pe}^2 + \gamma_e C_e^2 k^2 = \omega_{pe}^2 (1 + \gamma_e \lambda_{De}^2 k^2).$$
3. However, these waves are not heavily damped (Landau damping due to kinetic effect not described in moment equations) only when $k\lambda_{De} \ll 1$.
4. Due to high frequency, ion average velocity is much smaller than electron average velocity.
5. For low frequency, a new wave mode exists due to thermal effect. It is called the ion acoustic wave (mode). When $k\lambda_{De} \ll 1$, it has a dispersion relation of
$$\frac{\omega}{k} = \sqrt{\frac{\gamma_e \kappa T_e}{m_i}}.$$
6. The ion acoustic wave is also heavily damped due to Landau damping unless $T_e \gg T_i$.
7. Ions and electrons are having roughly the same average velocity in ion acoustic waves.