Plasma Physics I

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Exercise 1

Consider a non-magnetized plasma ($\mathbf{B_0} = 0$) described by the Vlasov model. The equilibrium distribution is a Maxwellian. Suppose to insert at $t = 0$ a test particle with charge q_T, $\mathbf{x}_0 = 0$ and with initial velocity $\mathbf{v}_0 = 0$. Assume that the equilibrium perturbation produced by the charge is small, consequently that the equations can be linearized.

From the Vlasov-Poisson model, use Fourier transform to describe the space evolution and Laplace transform to analyze the time variation of the main quantities. Evaluate the electrostatic potential produced by the test particle in stationary conditions as a function of the radial distance from the test particle r. Show that the result coincides with the Debye shielding formalism discussed in the first lecture.

Suggestions:

- Solving the inverse Laplace transform problem, we can consider only the pole $p = 0$ (corresponding to $t \to \infty$).
- To evaluate the integral from the inverse Fourier transform, use spherical coordinates and the method of residues.