Section 5: Collisions

AE435

Spring 2018

3 Electron-Ion Collisions (Coulomb Collisions)

Very different from electron-atom collisions.

Long-range forces are one characteristic distinguishing plasmas from neutral gases. Since electromagnetic interactions have a much longer reach than atomic interactions, electron-ion cross-sections tend to be much larger than electron-neutral cross-sections. As a corollary, the electron-ion collision frequency exceeds electron-neutral collision frequency, when the ionization fraction is above a few tenths of a percent.

Contents

3.1 Elastic

The long-range "collision" process between electrons-ions is really a continuous process:

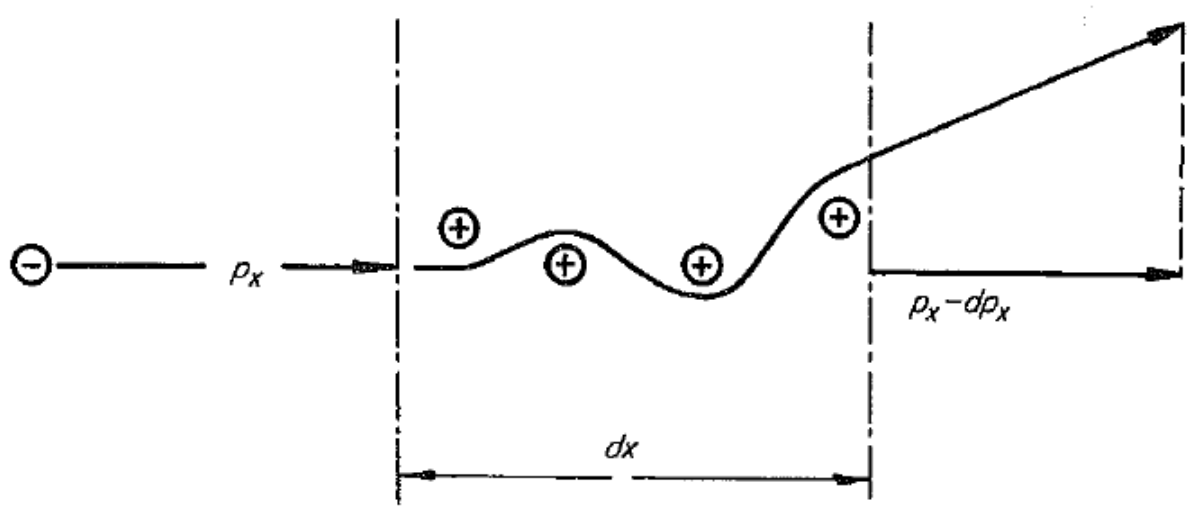

Fig. 4-8 Momentum transfer in electron-ion collisions.

Define the momentum transfer cross section , where x-momentum varies as

Then:

Where is the relative KE before the collision is an empirical cutoff distance for the effective range of the Coulomb force

Best choice for works out to be the Debye Length:

Combine logarithmic terms into the Coulomb Logarithm:

For a broad range of typical plasma parameters, we can simplify :

So the approximate momentum-transfer cross section is:

where Qo

3.2 Inelastic

It's similar to an electron-atom collision because the electron has to penetrate into the ion core to remove another electron.

3.3 Radiation

Charged particles deflected by Coulomb forces can radiate energy away as photons (bremsstrahlung).

But the energies/temperatures in EP plasmas are rarely high enough for this to be important.