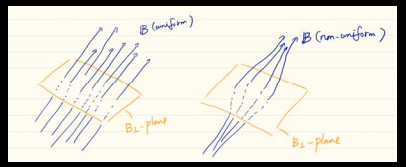
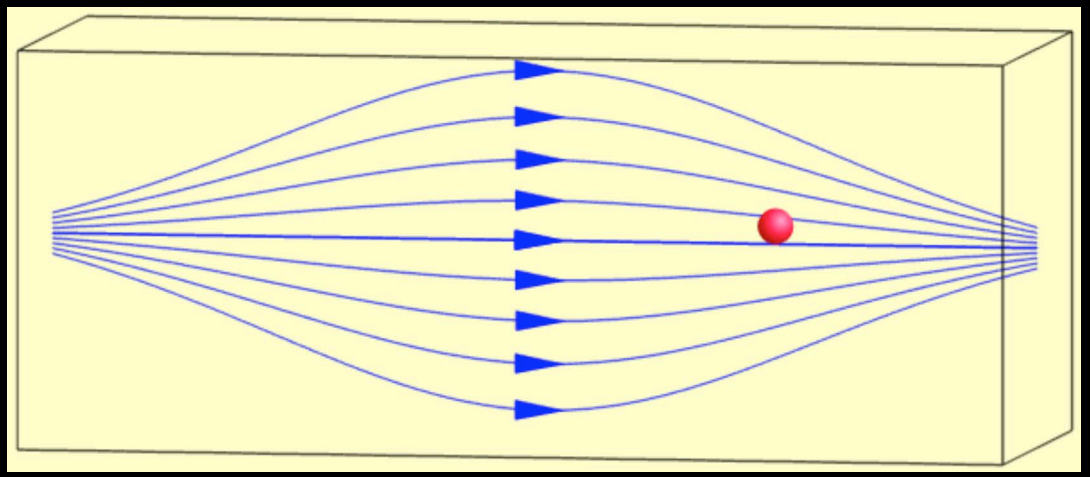
5. Interaction with non-uniform magnetic field





Mirror effect

Relatively low-energy charged particles are reflected at a region where magnetic field becomes strong.

This may cause particle acceleration when the region moves against an incident particle.

From a single particle to a plasma composed of many particles

Coulomb force

$\boldsymbol{F}_C = q\,\boldsymbol{E}$ ⟶ $\boldsymbol{f}_C = \rho_c\,\boldsymbol{E}$ (force per unit volume)

ρ_c: *charge density*, $\rho_c \sim 0$ (local charge neutrality)

One-directional acceleration ⟶ current in $B_{//}$-direction (field-aligned current FAC)

Lorentz force

$\boldsymbol{F}_L = q\,\boldsymbol{v} \times \boldsymbol{B}$ ⟶ $\boldsymbol{f}_L = \boldsymbol{j} \times \boldsymbol{B}$ (force per unit volume)

$\boldsymbol{j}$: *current density*

Gyration ⟶ current in $B_\perp$-plane when **nonuniformity** exists

Coulomb force + Lorentz force

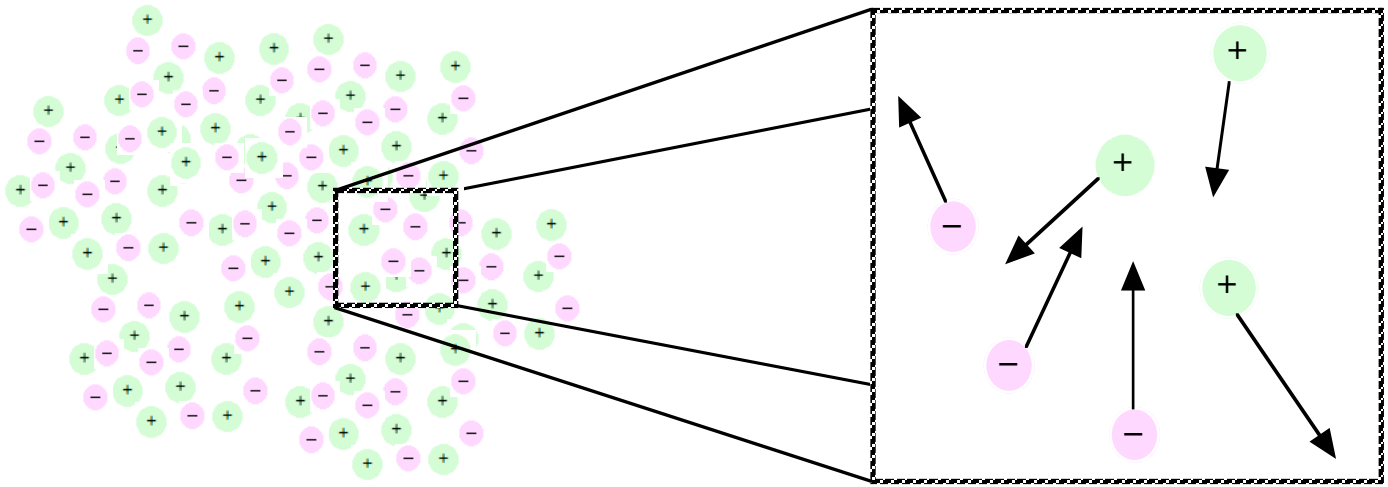
ExB drift ⟶ average flow in $B_\perp$-plane

Two approaches to plasma physics

Plasma... composed of <u>many particles</u>

Focus on a selected local region → **Kinetic approach**

Focus on the whole region → **Fluid approach**

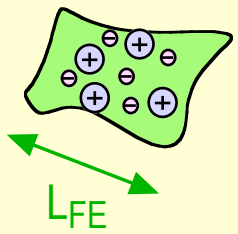


Fluid approach

Kinetic approach

Kinetic approach → study microscale processes,
the behavior of particles

Fluid approach → study macroscale processes,
the behavior of fluid elements*



*fluid element... a virtual object containing a number of particles;
most of the particles keep staying inside the
object (=> typical size $L_{FE} >> l_{mfp}, r_G$)

l_{mfp}: mean free path r_G: gyration radius