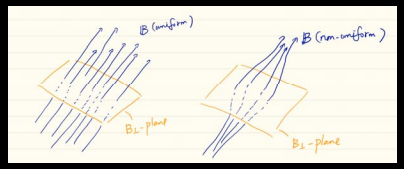
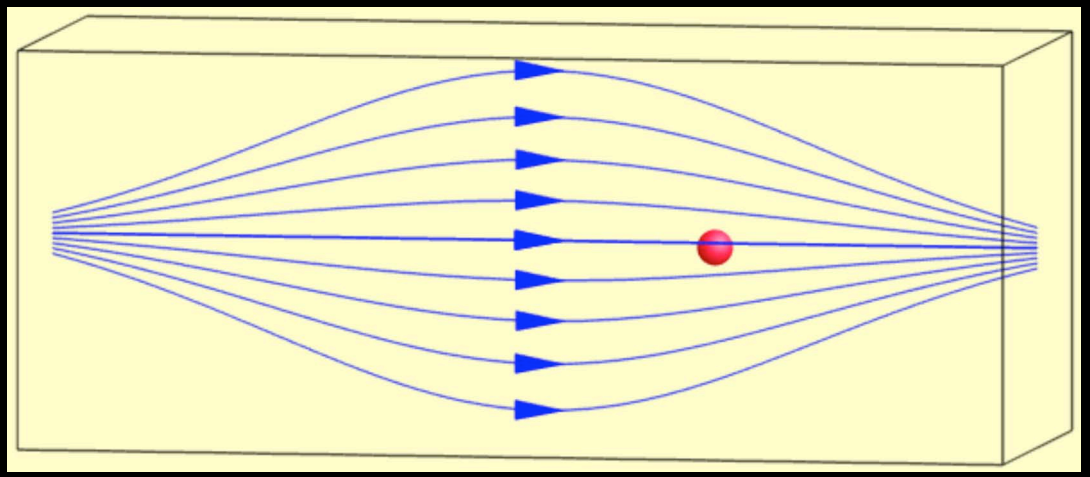
5. Interaction with non-uniform magnetic field

in global scale (1 ~ 4... local scale)





$$v_{tot}^2 = v_{//}^2 + v_{\perp}^2 = const.$$

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*

($\rho_c \sim 0$ when local charge neutrality is satisfied)

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

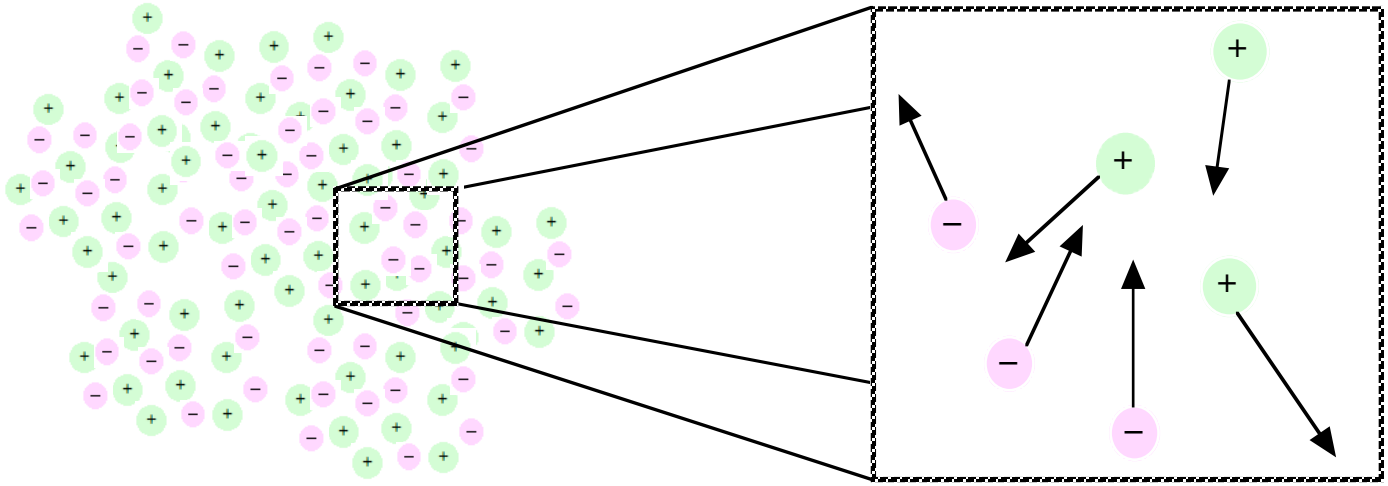
ExB drift ⟶ average flow in $B_\perp$-plane

Two approaches to plasma physics

Plasma... composed of many particles

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 element (=> typical size $L_{FE} >> l_{mfp}, r_G$)

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