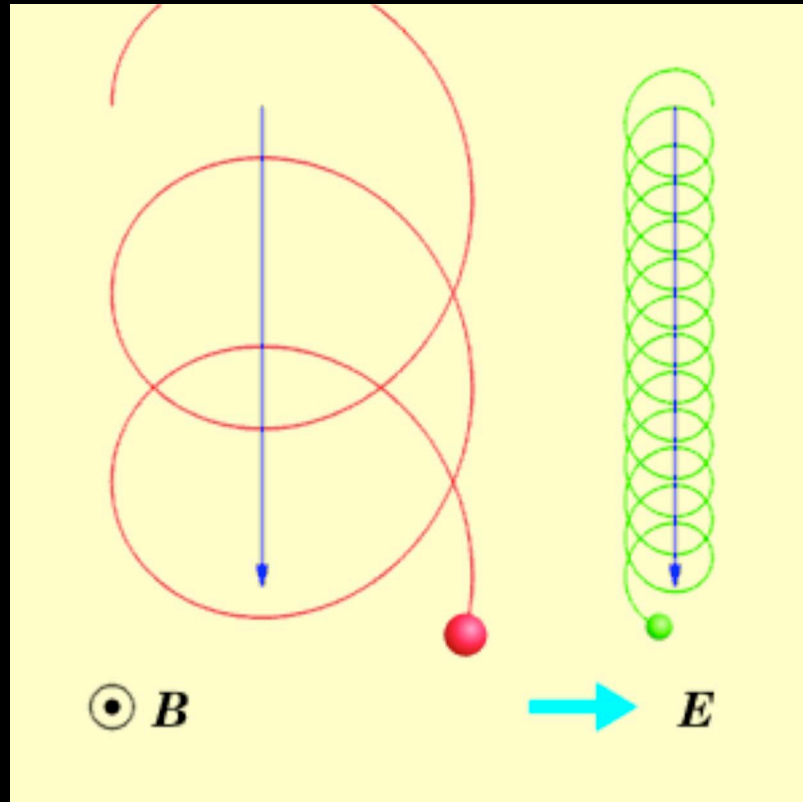


4. Interaction with electric field and magnetic field



B_{\perp} -plane

Diagram illustrating the motion of a particle (ion or electron) in a magnetic field B and an electric field E . The magnetic field is represented by a blue arrow pointing upwards, and the electric field is represented by a red arrow pointing downwards. The particle's velocity vector \mathbf{v} is shown as a yellow arrow, and the resulting drift velocity $\mathbf{v}_{E \times B}$ is shown as a green arrow.

Equations of motion:

$$\frac{d\mathbf{v}_{\parallel}}{dt} = \frac{q}{m} E_{\parallel}$$

$$\frac{d\mathbf{v}_{\perp}}{dt} = \frac{q}{m} (\mathbf{E}_{\perp} + \mathbf{v}_{\perp} \times \mathbf{B})$$

$$\mathbf{v}_{\perp} = \mathbf{v}_g + \mathbf{v}_{E \times B}$$

Labels in the diagram:

- magnetic field
- electric field
- ion
- electron
- $E \times B$

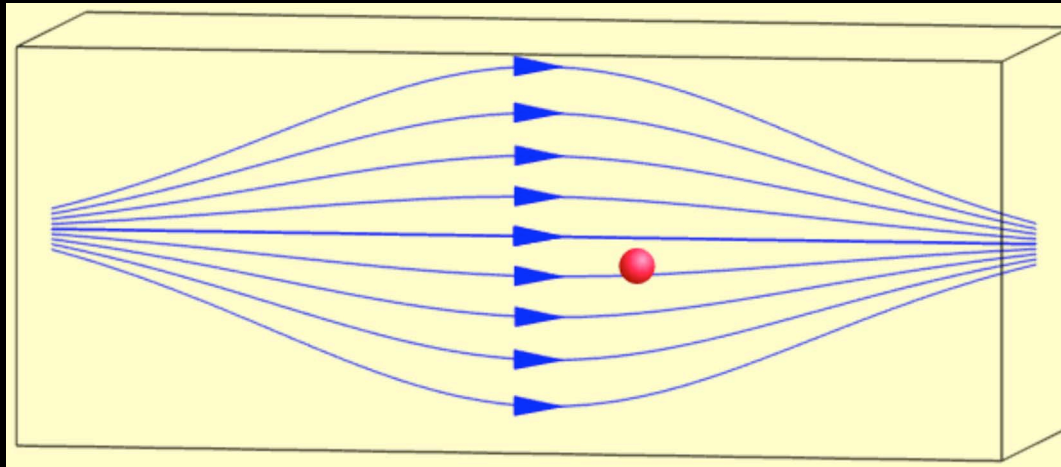
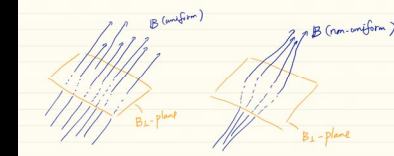
$E \times B$ drift of gyration center:

$$\mathbf{v}_{E \times B} \equiv \frac{\mathbf{E} \times \mathbf{B}}{B^2}$$

... perpendicular to both electric field and magnetic field

... does not depend on mass & charge of a particle \Rightarrow keep local charge neutrality

5. Interaction with non-uniform magnetic field



Mirror effect

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

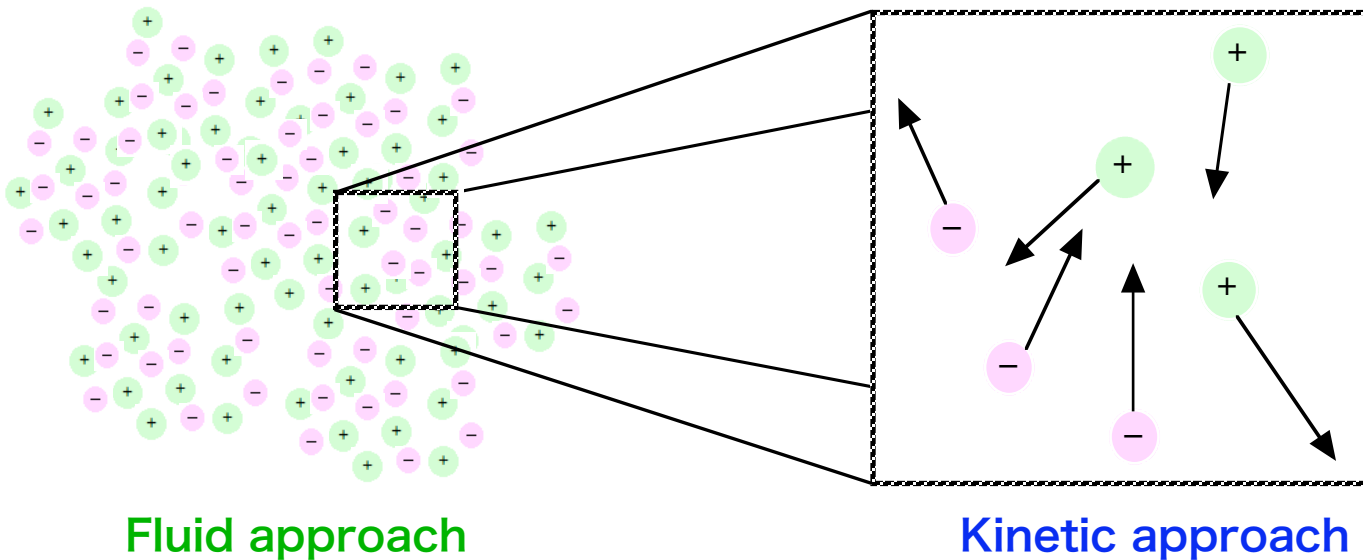
(This may cause particle acceleration when the region moves against an incident particle.)

Two approaches to plasma physics

Plasma... composed of many particles

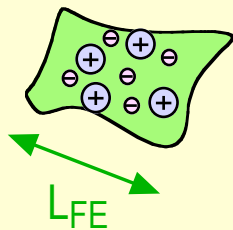
Focus on a selected **local region** → **Kinetic approach**

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



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 this
object (\Rightarrow typical size $L_{FE} \gg l_{mfp}, r_G$)

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