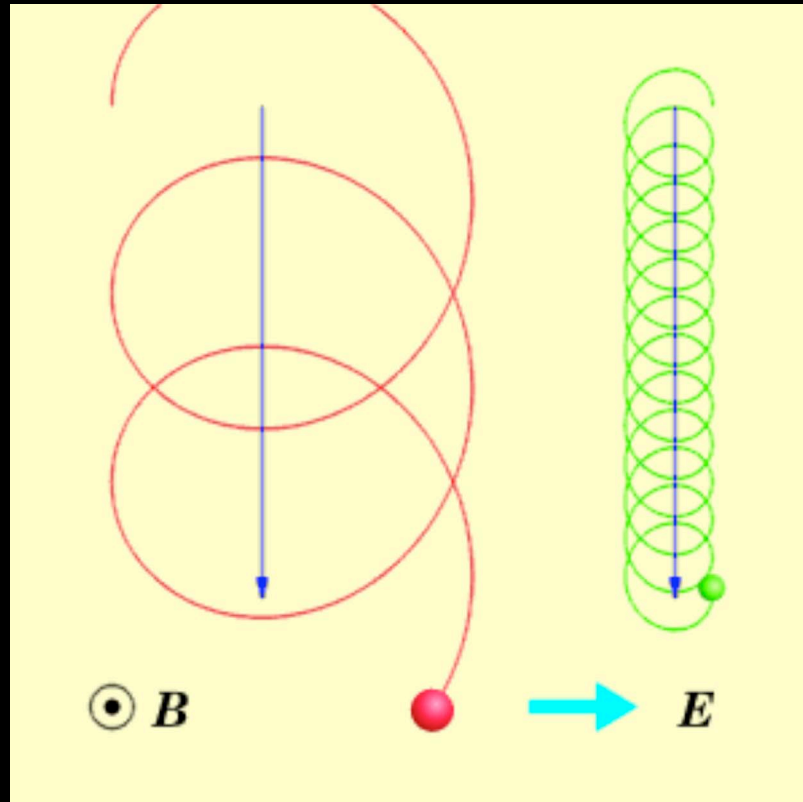


## 4. Interaction with electric field and magnetic field



$B_{\perp}$ -plane

Diagram illustrating the interaction of a particle with electric and magnetic fields. The diagram shows a particle (ion or electron) moving in a helical path around a vertical axis. The magnetic field  $B$  is directed out of the page (indicated by a dot in a circle). The electric field  $E$  is directed to the right. The diagram shows the particle's motion in the  $B_{\perp}$ -plane and the resulting drift velocity  $v_{E \times B}$ .

Equations of motion:

$$\frac{dv_{\parallel}}{dt} = \frac{q}{m} E_{\parallel}$$

$$\frac{dv_{\perp}}{dt} = \frac{q}{m} (E_{\perp} + v_{\perp} \times B)$$

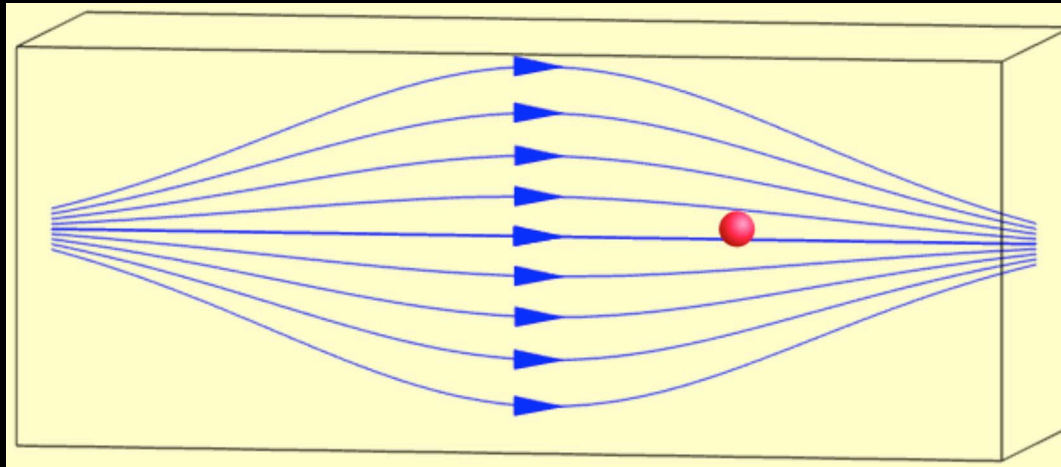
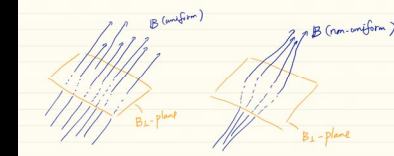
$$v_{\perp} = v_g + v_{E \times B}$$

**ExB drift** of gyration center:

$$v_{E \times B} \equiv \frac{E \times B}{B^2}$$

... 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.

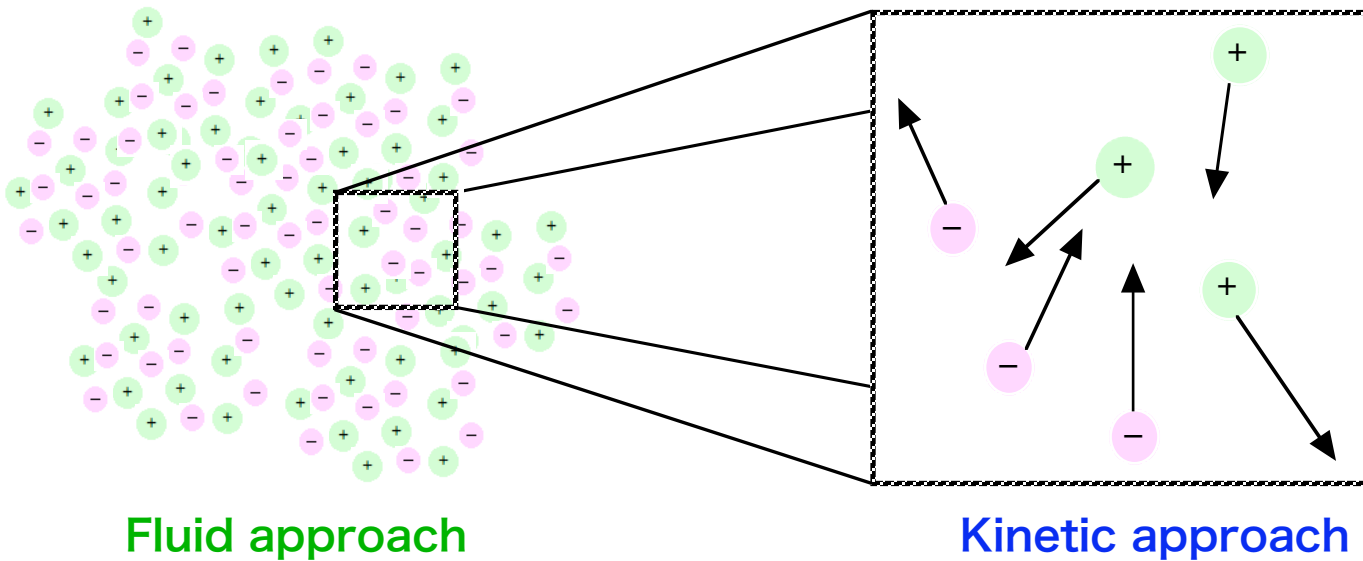
(This may cause particle acceleration when the region moves against an incident particle.)

## Two approaches to plasma physics

*Plasma... composed of many particles*

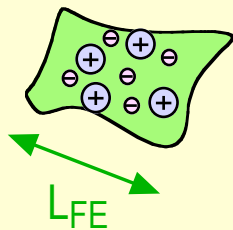
Focus on a selected **local region** → **Kinetic approach**

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