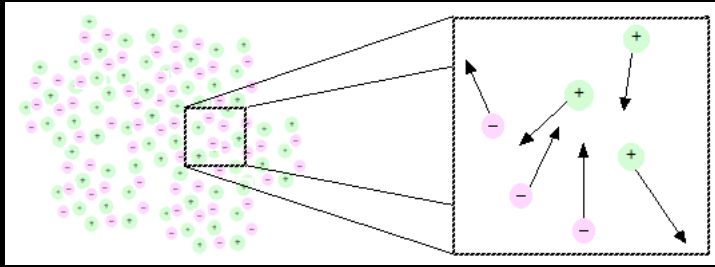


## 1. Local charge neutrality

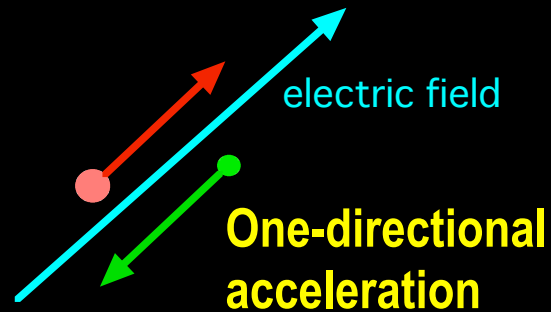


The numbers of positive charges and negative charges **are almost the same** in every local region.

## 2. Interaction with electric field (**Coulomb force: $F_C = q E$** )

Red... ion (+)

Green... electron (-)

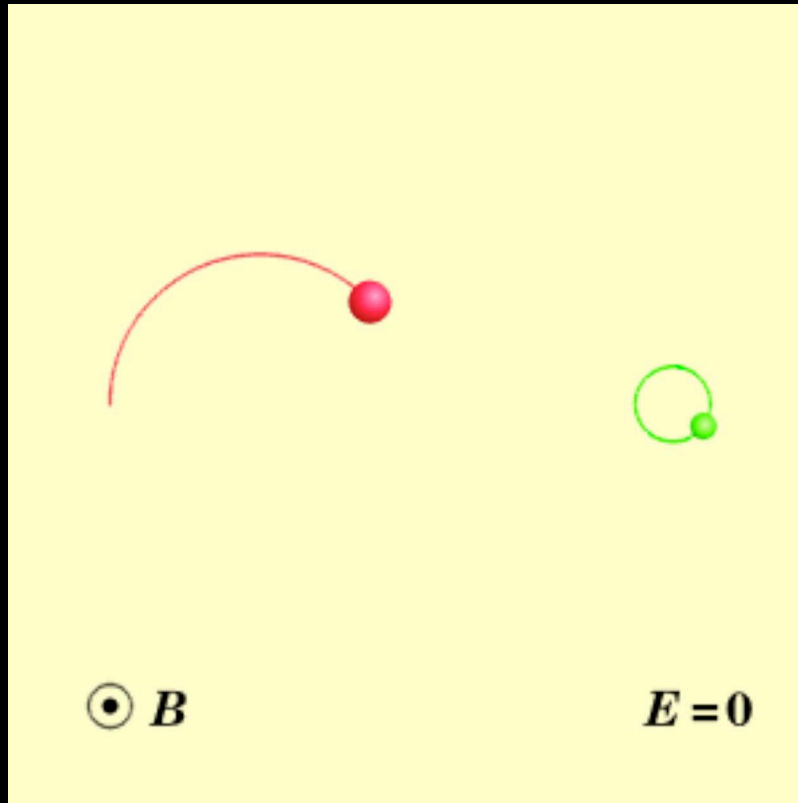


Charged particles are **accelerated** along electric field.

$$\frac{d\mathbf{v}}{dt} = \frac{q}{m} \mathbf{E}$$

**Magnitude of  $v$  is changed.**

### 3. Interaction with magnetic field (**Lorentz force:** $F_L = q \mathbf{v} \times \mathbf{B}$ )

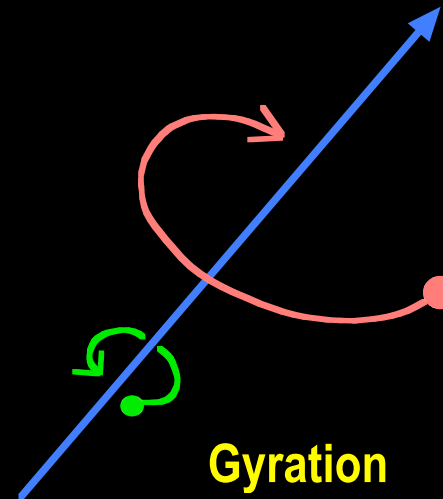


$B_{\perp}$ -plane

Red... ion (+)

Green... electron (−)

magnetic field

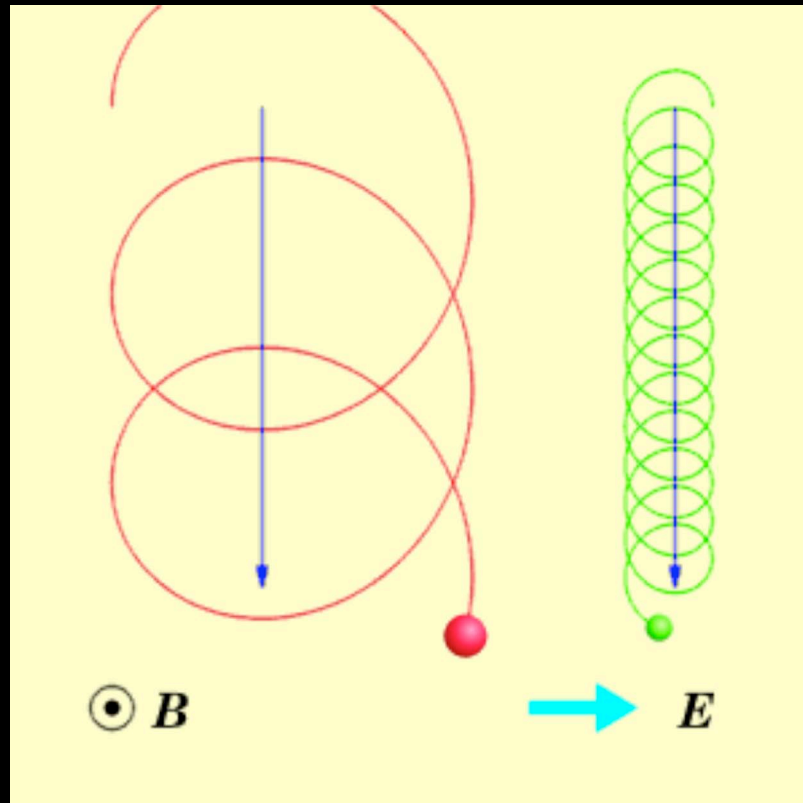


Charged particles gyrate around magnetic field.

**Direction of  $\mathbf{v}$  is changed.**

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

## 4. Interaction with electric field and magnetic field



$B_{\perp}$ -plane

Diagram illustrating the motion of an ion (red dot) and an electron (green dot) in a magnetic field (blue arrow) and an electric field (cyan arrow). The ion's gyration radius is labeled "small  $r_g$ " and the electron's is labeled "large  $r_g$ ". The vector  $E \times B$  is shown as a yellow arrow pointing in the direction of drift.

Equations for the motion of a particle with charge  $q$  and mass  $m$ :

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

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

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

**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