Charged Particle in Uniform Magnetic & Electric Field

Course: MPHYEC-01I Plasma Physics (M.Sc. IV Sem)

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Lecture 3: Unit-I

Charged Particle in Uniform Static Magnetic Field

- For a particle of charge q and mass m, moving with velocity v in magnetic field **B**, the equation of motion is:

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

- Decomposing **v** in components parallel ($\mathbf{v}_{||}$) and perpendicular ($\mathbf{v}_{\perp}$) to the magnetic field $\mathbf{v} = \mathbf{v}_{\parallel} + \mathbf{v}_{\perp}$

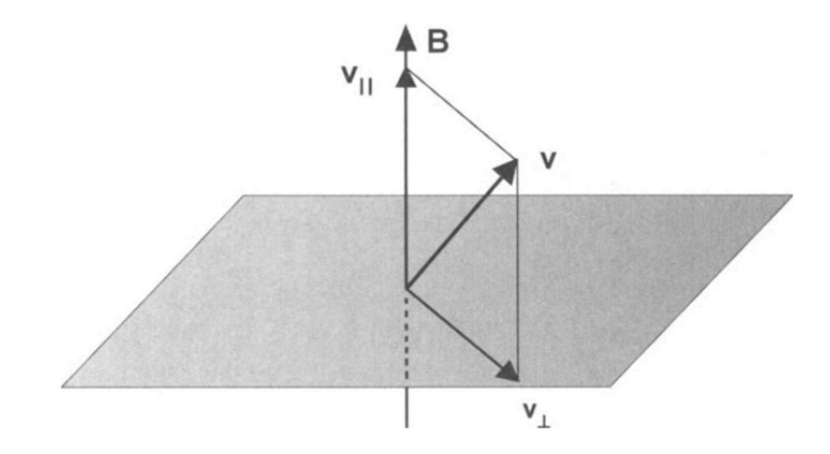


Figure is taken from “Fundaments of Plasma Physics” by Bittencourt

- Then the equation of motion in the components form is

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

- Consiquently, the equations corresponding to the parallel component is $\frac{d\mathbf{v}_{\parallel}}{dt} = 0$

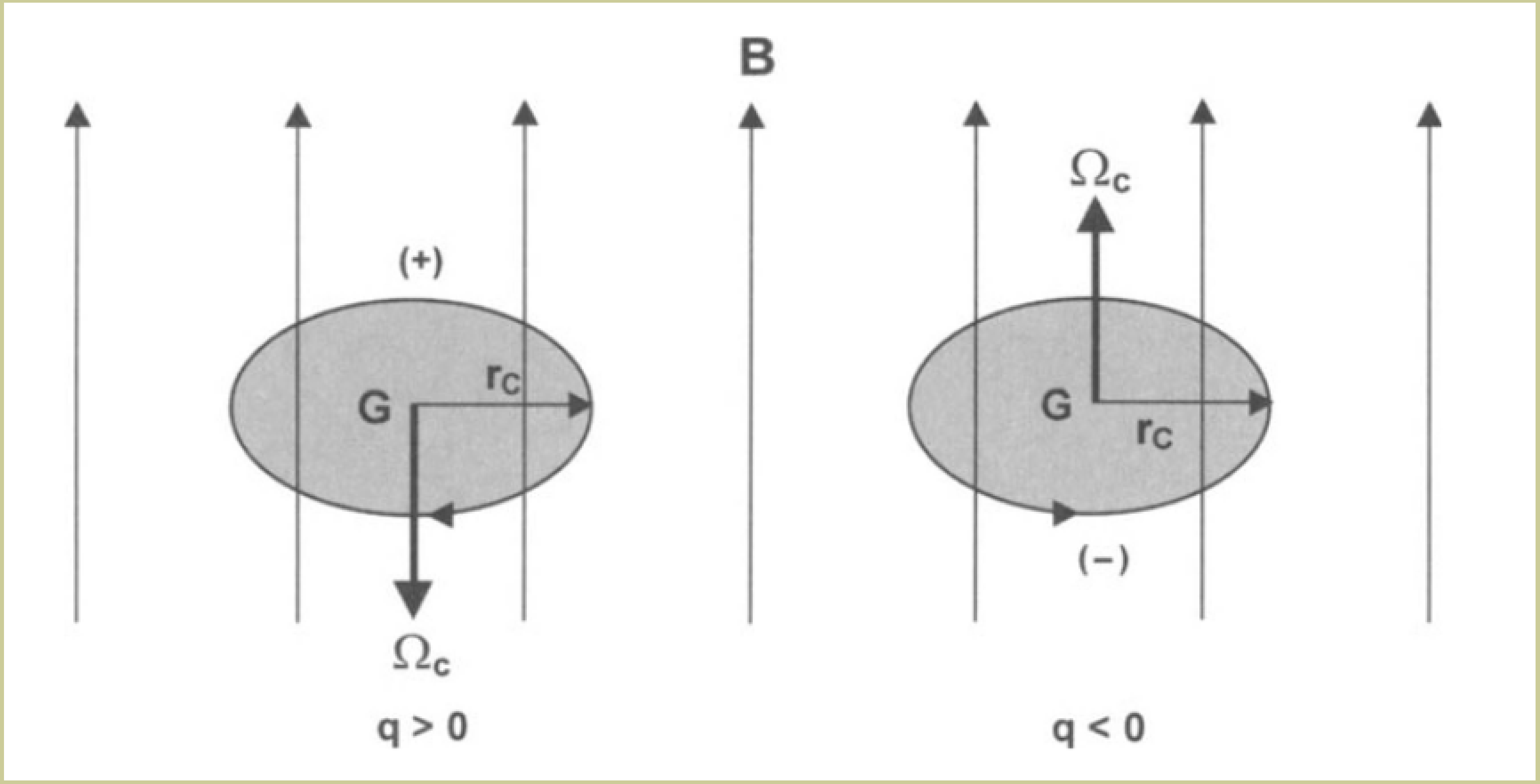
and the perpendicular component is $\frac{d\mathbf{v}_{\perp}}{dt} = \frac{q}{m}(\mathbf{v}_{\perp} \times \mathbf{B})$

- The parallel velocity component does not change.
- Equation of motion for perpendicular component can be re-written as:

$$\frac{d\mathbf{v}_\perp}{dt} = \boldsymbol{\Omega}_c \times \mathbf{v}_\perp$$

- The acceleration (or force) is always perpendicular to velocity. Therefore, there is circulular motion in the perpendicular plane.

$$\mathbf{v}_\perp = \boldsymbol{\Omega}_c \times \mathbf{r}_c$$



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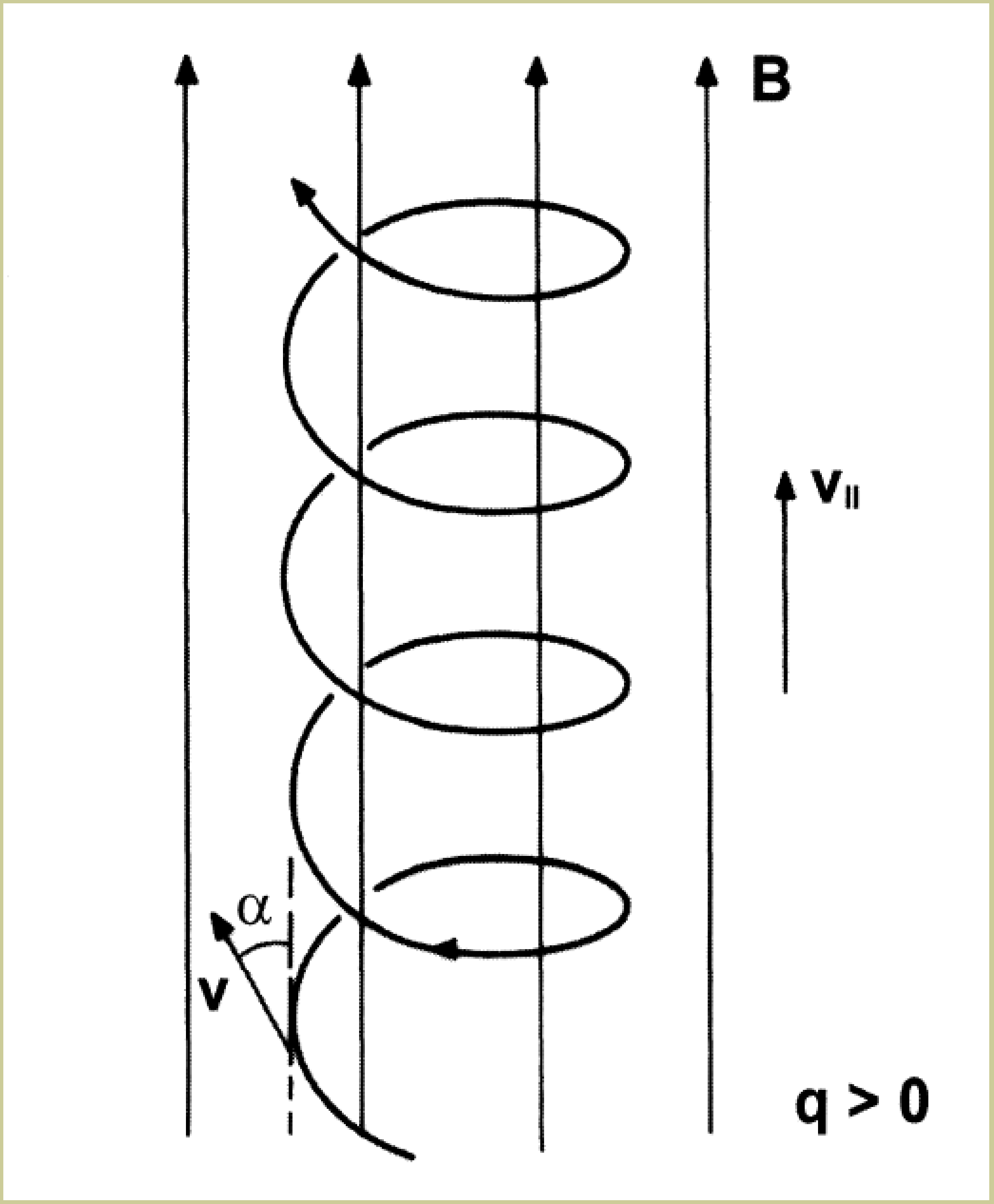

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After superposing perpendicular and parallel components of velocities, we get helical trajectory of the particle. The angle between **v** and **B** is called Pitch angle.

Charged Particle in Uniform Static Electric Field

- Equation of motion of a charged particle q in an static electric field **E:**

$$m\frac{d^2\boldsymbol{r}}{dt^2}=q\boldsymbol{E}$$

$$\boldsymbol{r}=\frac{q\boldsymbol{E}}{m}\frac{t^2}{2}+\boldsymbol{v_0}t+\boldsymbol{r_0}$$

where $\mathbf{v}_0$ and $\mathbf{r}_0$ are constant of integrals which are fixed by initial velocity and position of the particle.

- Motion of the charged particle is parallel to **E** if the q> 0 and anti-parallel to **E** if q<0.

- Acceleration of the particle remains constant.

Thanks!