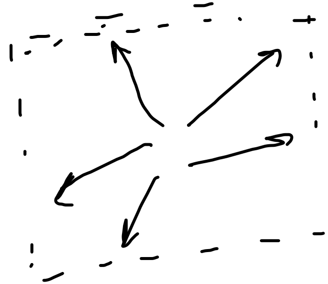
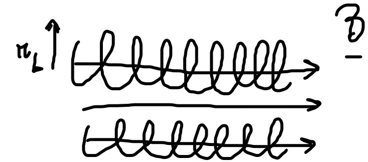
Ogni carica del plasma è "schermata" da tutte le altre

$\underline{B} = \underline{0}$



$\underline{B} \neq \underline{0}$



$$\underline{v} = \frac{d\underline{x}}{dt}$$

$$\underline{v} \cdot m \frac{d\underline{v}}{dt} = \underbrace{q\,(\underline{v} \times \underline{B}) \cdot \underline{v}}_{0}$$

$$\frac{d}{dt}\left(\frac{1}{2} m v^2\right) = 0 \Rightarrow \frac{1}{2} m v^2 = \text{cost}$$

Se $\underline{B} = \overrightarrow{\text{cost}}$ Dir. // a $\underline{B}$

moto rett uniforme

Dir. $\perp$ a $\underline{B}$

moto circolare uniforme

$$r_L = \frac{m v_\perp}{qB} \qquad \omega_L = \frac{qB}{m}$$

Aggiungo $\underline{F} = \overrightarrow{\text{cost}}$ non troppo intensa

$$m \frac{d\underline{v}}{dt} = \underbrace{q(\underline{v} \times \underline{B})}_{\perp} + \underbrace{\underline{F}}_{//,\ \perp}$$

moto rett.

// $\quad m \frac{dv_{//}}{dt} = F_{//}$ unif. accelerato

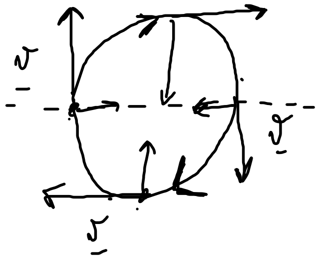
$\perp$ $\quad m \frac{d\underline{v}_\perp}{dt} = q(\underline{v}_\perp \times \underline{B}) + \underline{F}_\perp$

$\underline{E} = \underline{0}$

$\underline{B}$

Jone

$q > 0$

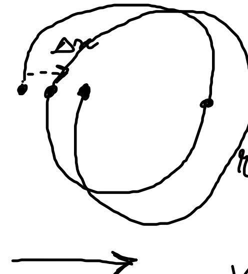


$\underline{E}$

$\underline{E} \neq \underline{0}$

$\underline{B}$

$r_L = \frac{m v_\perp}{qB}$



$r'_L > r_L$

$r'_L < r_L$

$\underline{v}_D$

Velocità di deriva

(drift)

$$\left\langle m \frac{d\underline{v}_\perp}{dt} = q(\underline{v}_\perp \times \underline{B}) + \underline{F}_\perp \right\rangle$$

Cerco una soluzione: $\underline{v}_\perp = \underline{v}_L + \underline{v}_D$

$$\underbrace{\left\langle m\left(\cancel{\frac{d\underline{v}_L}{dt}} + \cancel{\frac{d\underline{v}_D}{dt}}\right)\right\rangle}_{=0} = \underbrace{q\langle \underline{v}_L\rangle \times \underline{B}}_{0} + q\langle \underline{v}_D\rangle \times \underline{B} + \underline{F}_\perp$$

$\underline{v}_D = \vec{\text{const}}$

$\langle \underline{v}_L \rangle = 0$ $\quad \langle \underline{v}_D \rangle = \underline{v}_D$

media su un T_L

$$\underline{0} = q\,\underline{v}_D \times \underline{B} + \underline{F}_\perp$$

$$\underline{0} \times \underline{B} = q(\underline{v}_D \times \underline{B}) \times \underline{B} + \underline{F}_\perp \times \underline{B}$$

Proprietà

$$\underline{A} \times (\underline{B} \times \underline{C}) = (\underline{C} \times \underline{B}) \times \underline{A} = (\underline{A} \cdot \underline{C})\,\underline{B} - (\underline{A} \cdot \underline{B})\,\underline{C}$$

$$0 = \underbrace{\cancel{q(\underline{v}_D \cdot \underline{B})}}_{=0}\,\underline{B} - qB^2\,\underline{v}_D + \underline{F}_\perp \times \underline{B}$$

$$\underline{v}_D = \frac{\underline{F}_\perp \times \underline{B}}{qB^2}$$

$\underline{v}_D \perp$ sia a $\underline{F}_\perp$
sia a $\underline{B}$

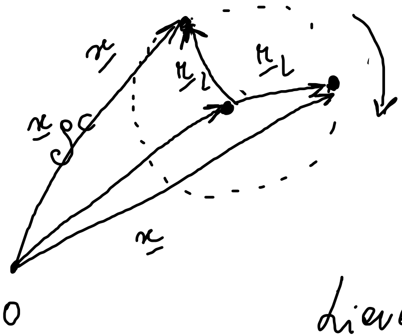
$\underline{v}_D$ dip. da q se $\underline{F}_\perp$ **non** vi dipende

Se $\underline{F}_\perp = m\vec{g}$ $\underline{v}_D$ in direzione opposta per ioni ed elettroni

Se $\underline{F}_\perp \propto q$ (es $\underline{F}_\perp = q\,\underline{E}_\perp$)

$$\underline{v}_D = \frac{\underline{E} \times \underline{B}}{B^2}$$

Moto in $\underline{B}$ e $\underline{E}$ lievemente disuniformi



gc: girocentro

$$\underline{x} = \underline{x}_{gc} + \underline{r}_L$$

$$\underline{v} = \frac{d\underline{x}}{dt} = \frac{d\underline{x}_{gc}}{dt} + \underline{v}_L$$

$\frac{d\underline{x}_{gc}}{dt} \to \underline{v}_D$

Scala spaziale r_L

Scala temporale T_L

Lievemente disuniformi $\Rightarrow$ variazione di $\underline{B}$ ed $\underline{E}$ trascurabile su scale spaziali e temp. $< \underline{r}_L, T_L$

$$m\frac{d\underline{v}}{dt} = q\left[\underline{E}(\underline{x},t) + \underline{v} \times \underline{B}(\underline{x},t)\right]$$

$\frac{d\underline{v}}{dt} \to \frac{d^2\underline{x}}{dt^2}$

Espandere $\underline{E}(\underline{x},\cancel{t})$ $\underline{B}(\underline{x},\cancel{t})$ in serie di Taylor

Centro: $\underline{x}_{gc}$

Parametro di esp: $\underline{x} - \underline{x}_{gc} = \underline{r}_L$

(Δx)

$$\underline{E}(\underline{x}) = \underline{E}(\underline{x}_{gc}) + \left[(\underline{r}_L \cdot \underline{\nabla})\right] \underline{E}(\underline{x})\Big|_{\underline{x}=\underline{x}_{gc}}$$

$$\underline{B}(\underline{x}) = \underline{B}(\underline{x}_{gc}) + \left[(\underline{r}_L \cdot \underline{\nabla})\right] \underline{B}(\underline{x})\Big|_{\underline{x}=\underline{x}_{gc}}$$

$$m\left[\frac{d\underline{v}_{gc}}{dt} + \frac{d\underline{v}_L}{dt}\right] = q\left[\underline{E}(\underline{x}_{gc}) + (\underline{r}_L \cdot \underline{\nabla})\underline{E}(\underline{x}_{gc})\right] + q\,(\underline{v}_{gc} + \underline{v}_L) \times \left[\underline{B}(\underline{x}_{gc}) + (\underline{r}_L \cdot \underline{\nabla})\underline{B}(\underline{x}_{gc})\right]$$

Moto di girazione

$$m \frac{d \underline{v}_L}{dt} = q \left(\underline{v}_L \times \underline{B}(\underline{x}_{gc}) \right)$$

Sottraggo girazione:

$$m \frac{d \underline{v}_{gc}}{dt} = q \left(\underline{E}(\underline{x}_{gc}) + \underbrace{(\underline{r}_L \cdot \underline{\nabla}) \underline{E}(\underline{x}_{gc})} \right) + q\, \underline{v}_L \times (\underline{r}_L \cdot \underline{\nabla}) \underline{B}(\underline{x}_{gc})$$

$$+ q\, \underline{v}_{gc} \times \underline{B}(\underline{x}_{gc}) + q\, \underbrace{\underline{v}_{gc} \times (\underline{r}_L \cdot \underline{\nabla})} \underline{B}(\underline{x}_{gc})$$

$\langle \quad \rangle$: media su T_L

$$m \frac{d \underline{v}_{gc}}{dt} = q\, \underline{E}(\underline{x}_{gc}) + q\, \underline{v}_L \times (\underline{r}_L \cdot \underline{\nabla}) \underline{B}(\underline{x}_{gc}) + q\, \underline{v}_{gc} \times \underline{B}(\underline{x}_{gc})$$