Diamagnetic current

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from ideal MHD

$$\underset{\sim}{J} \times \underset{\sim}{B} = \nabla P$$

$$\underbrace{\underset{\sim}{B} \times (\underset{\sim}{J} \times \underset{\sim}{B})} = \underset{\sim}{B} \times \nabla P$$

$$\underset{\sim}{J} \underbrace{(\underset{\sim}{B} \cdot \underset{\sim}{B})}_{B^2} - \underset{\sim}{B} \underbrace{(\underset{\sim}{J} \cdot \underset{\sim}{B})}_{B J_{\parallel}}$$

$J_{\parallel}$ parallel to B

$$B^2 \left(\underset{\sim}{J} - \underbrace{\frac{\underset{\sim}{B}}{B}}_{\text{unit vector } \underset{\sim}{\hat{b}}} \underset{\sim}{J} \right) = \underset{\sim}{B} \times \nabla P$$

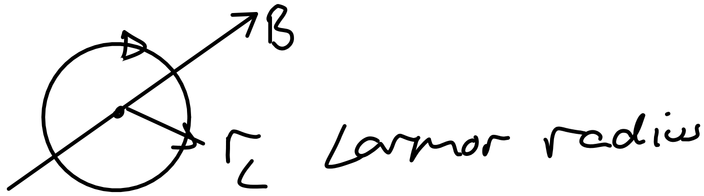
$$B^2 \underset{\sim}{J}_{\perp} = \underset{\sim}{B} \times \nabla P$$

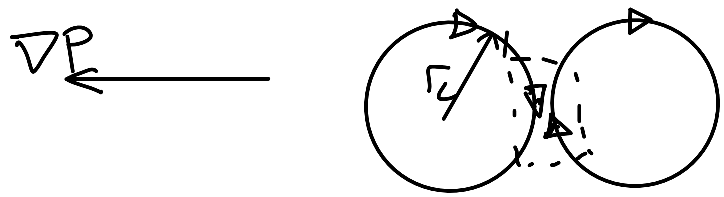
$\underset{\sim}{J}_{\perp}$ perpendicular to $\underset{\sim}{B}$

$$\boxed{\underset{\sim}{J}_{\perp} = \frac{\underset{\sim}{B} \times \nabla P}{B^2}}$$

Diamagnetic current

Origin of Diamagnetic current



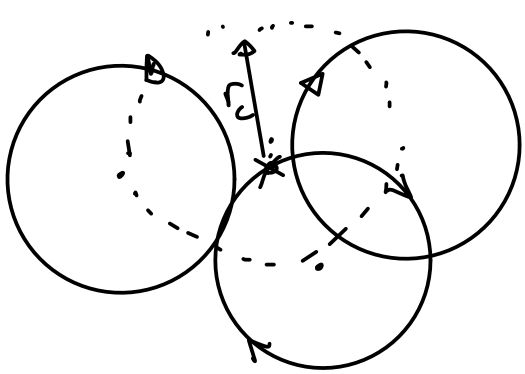


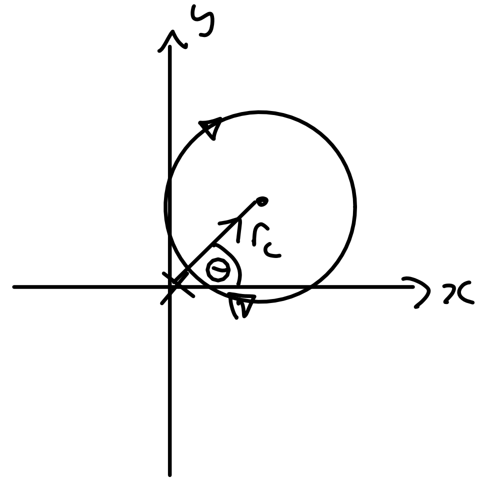
assume T const

orbit frequency $\Omega = \dfrac{qB}{m}$

$\frac{1}{2} m V_\perp^2 = eT$ 2 d.o.f $\frac{1}{2} k_B T \times 2$

$$r_L = \frac{V_\perp}{\Omega}$$





$V_y = V_\perp \cos\theta$
vertical component

$$J_y = \frac{1}{2\pi}\int n(\theta) V_y \, q \, d\theta$$

n varies in x $n(\theta) = n_0 + r_L \frac{\partial n}{\partial x} \cos\theta$

$$J_y = \frac{1}{2\pi} q \int \left(n_0 + r_L \frac{\partial n}{\partial x} \cos\theta\right) V_\perp \cos\theta \, d\theta$$

$$= \frac{1}{2\pi} q r_L V_\perp \underbrace{\int \frac{\partial n}{\partial x} \cos^2\theta \, d\theta}_{\frac{\partial n}{\partial x} \frac{1}{2} \cdot 2\pi}$$

$$= q r_L V_\perp \frac{\partial n}{\partial x} \frac{1}{2}$$

$$r_L = V_\perp / \Omega \qquad V_\perp^2 = \frac{2eT}{m}$$

$$= \cancel{q} \frac{\cancel{2} eT}{\cancel{m}} \frac{\cancel{m}}{\cancel{q} B} \frac{\partial n}{\partial x} \frac{1}{\cancel{2}} = \frac{eT}{B} \frac{\partial n}{\partial x}$$

$$\underline{J_y = \frac{1}{B} \frac{\partial P}{\partial x}} \qquad P = eTn$$

Compare $\qquad \underline{J_\perp = \frac{B \times \nabla P}{B^2}}$ $\qquad$ Diamagnetic current