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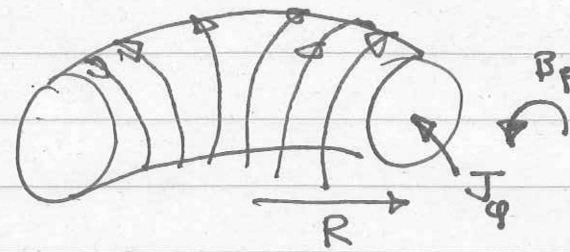
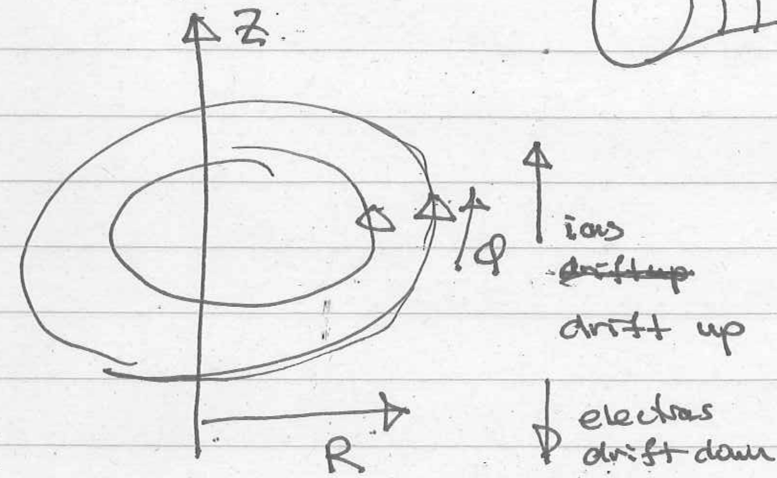
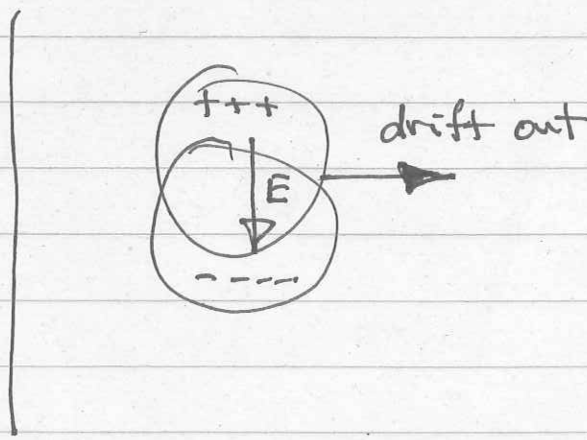
* Particle Orbits in Toroi~~d~~dal Geometry



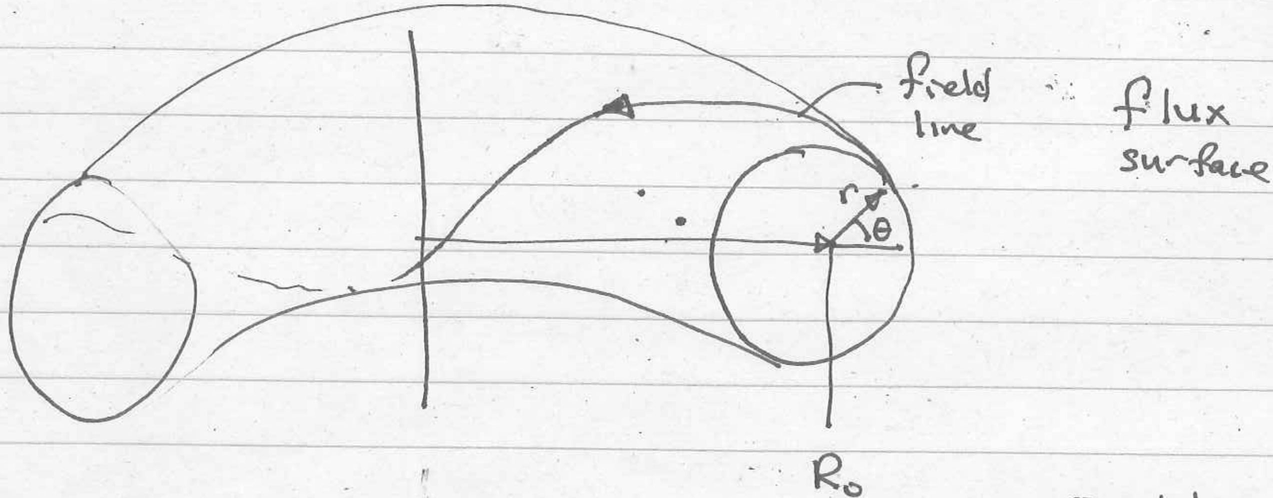


$$B_\varphi = \frac{\text{const}}{R}$$

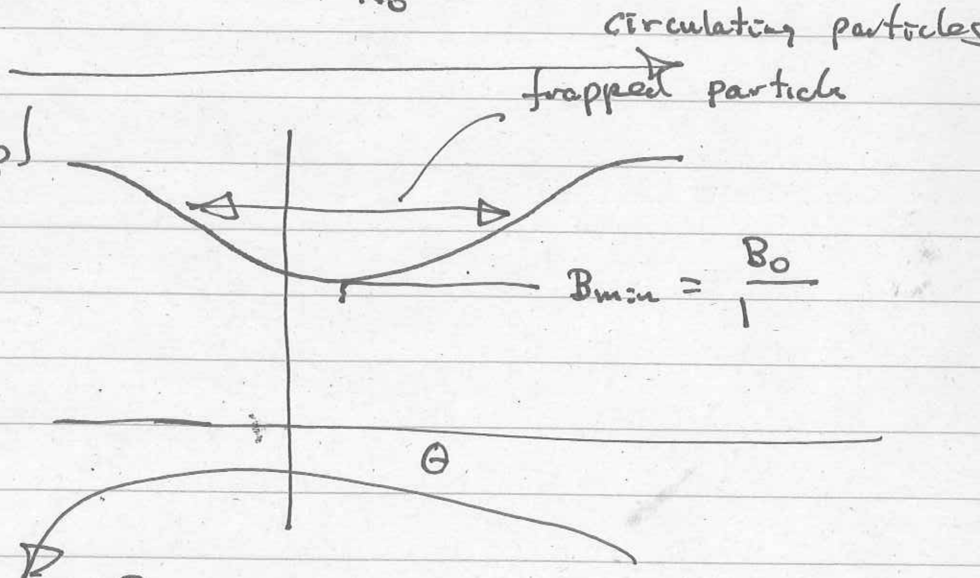


Particles
not confined

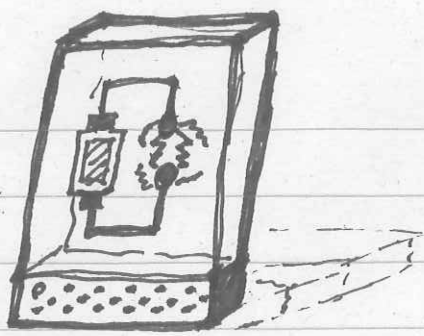
Add Poloidal field



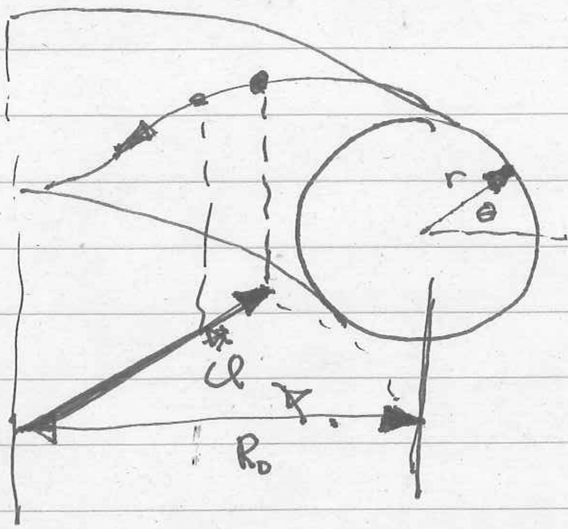
& if $B_\varphi \gg |B_p|$



$$|B| = \frac{B_0}{\left(1 + \frac{r}{R}\cos\theta\right)} \sim \frac{\text{const}}{R}$$



Safety factor



Assume $\frac{r}{R_0} << 1$ Large aspect ratio

$$R = R_0 + r\cos\theta$$

$$B_T \sim \frac{B_0 R_0}{R} \qquad B_p(r)$$

Following a field line

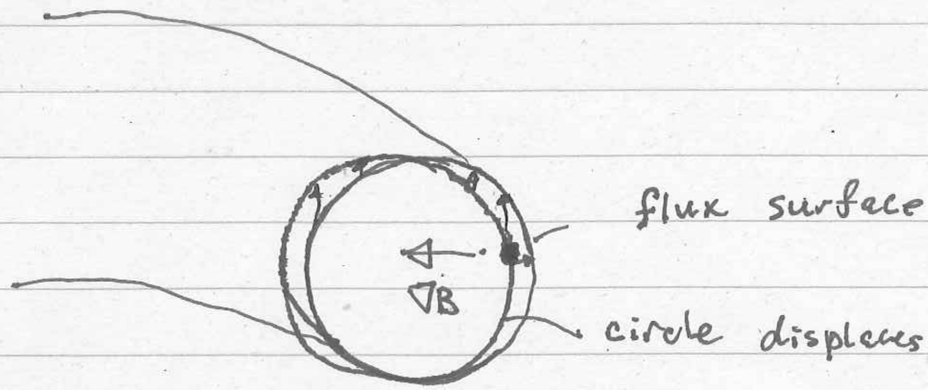
$$\frac{r\,d\theta}{B_p} = \frac{R\,d\varphi}{B_T}$$

$$\frac{d\varphi}{d\theta} = \frac{r B_T}{R B_p} = q(r) \quad \text{safety factor}$$

~~to~~ field line makes q toroidal loops for each poloidal loop.

$q(r) = m/n$ rational surface

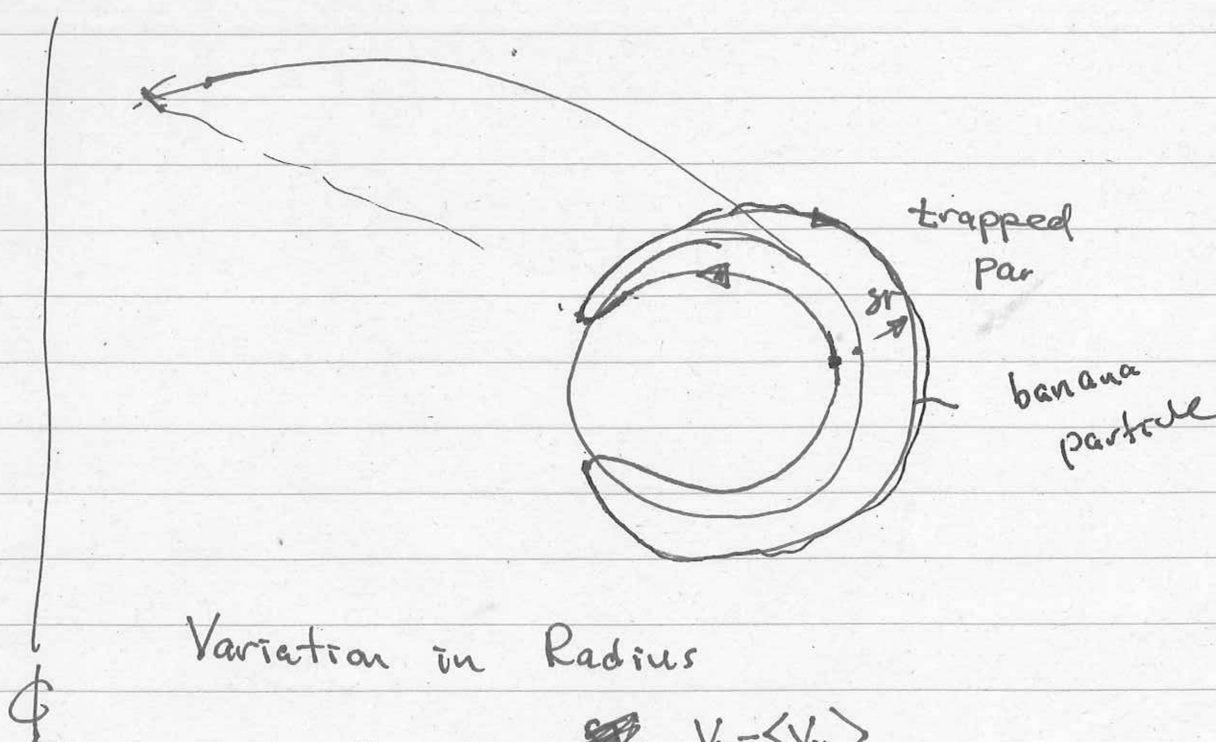
DRIFT ORBITS ARE closed



$$\underset{\sim}{V} = \frac{c}{qB}\, \underset{\sim}{b} \times (\mu B + m v_\parallel^2)\left(\frac{\nabla B}{B}\right) + V_\parallel \underset{\sim}{b}$$

mainly toroidal

mainly inward



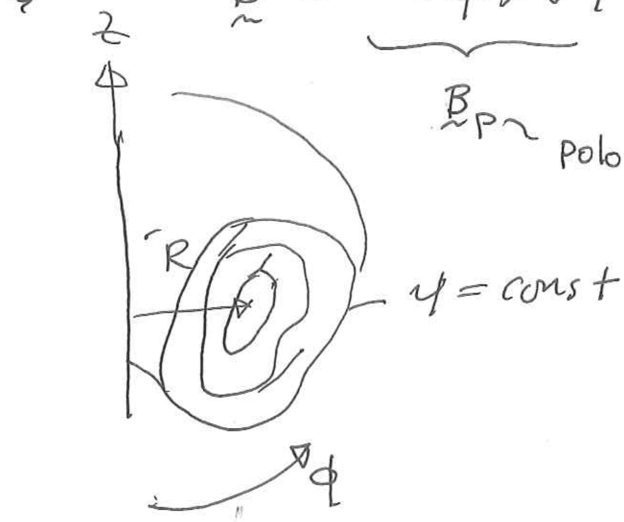
Variation in Radius

$$\delta r = \frac{V_\parallel - \langle V_\parallel \rangle}{(qB_p/mc)}$$

$B_p \ll B$

2D Axisymmetric Field

$$\underset{\sim}{B} = \underbrace{-\nabla\phi \times \nabla\psi}_{\underset{\sim}{B}_p \text{ poloidar}} + \underbrace{I(\psi)\nabla\phi}_{\underset{\sim}{B}_T \text{ toroidal}}$$



$\psi(R,Z)$ — Poloidal flux function

$\underset{\sim}{B}\cdot\nabla\psi = 0$ field lines live in surfa of const ψ

$$\nabla\psi\cdot\underset{\sim}{V}_d = \nabla\psi\cdot\frac{c}{qB}V_\parallel\nabla\times(\underset{\sim}{b}mV_\parallel)$$

$$= \frac{cV_\parallel}{qB}\nabla\cdot(\underset{\sim}{b}mV_\parallel\times\nabla\psi)$$

After some work

$$= -\frac{cIV_\parallel}{q}\,\underset{\sim}{b}\cdot\nabla\left(\frac{V_\parallel}{B}\right)$$

variation in ψ

$$\frac{d\psi}{dt} = -\frac{cI}{q}\frac{d}{dt}\left(\frac{mV_\parallel}{B}\right)$$

$$\psi = \psi(r_0) + \delta r\frac{\partial\psi}{\partial r}$$

$$\delta r = -\frac{cI}{q\,\partial\psi/\partial r}\left(\frac{mV_\parallel}{B}\right)$$

$$\approx -\frac{cB_T\,mV_\parallel}{B_p\,B}$$

~~FOR~~ $$V_\parallel = \sqrt{\frac{2}{m}(\epsilon - \mu B)}$$

$$\simeq \sqrt{\frac{2}{m}\left(\varepsilon - \frac{\mu B_0}{1 - \frac{r}{R_0}\cos\theta}\right)}$$

For circulating

$$V_\parallel - \langle V_\parallel \rangle \sim \left(\frac{r}{R_0}\right) V_\parallel$$

$$\epsilon$$

$$\delta r = \frac{V_\parallel \; r}{R_0 B_p / mc} \sim \rho$$ same size as Larmor radius (not significa

For trapped $\langle V_\parallel \rangle = 0$

$$V_\parallel \sim \left(\frac{r}{R}\right)^{1/2} \sqrt{\frac{2\varepsilon}{m}}$$

~~δr~~

$\delta r \gg \rho$ trapped particles dominate ~~tran~~ classical transport of Heat, momentum,

Neo-Classical Transport

TO AVOID Transport $\underset{\sim}{V}_d \cdot \nabla \psi = 0$ omnigenous