$$\frac{qvB}{c} \sim \frac{mv^2}{r}$$

$$\frac{qB}{mc} \sim \frac{v}{r} \sim \Omega$$

2012 Neoclassical

1. a. $\nu_* = \frac{\nu_{eff}}{\omega_B} < 1$ banana.

$\nu_{eff} \sim \frac{\nu_{ei}}{\Delta\theta^2} \sim \frac{\nu_{ei}}{\epsilon}$ from trapped fraction

$$\tau_B \sim \frac{2\pi}{\omega_B} \sim 2\int_{\theta_0}^{\theta_1} \frac{ds}{v_{\parallel}} \sim \frac{R_0 q}{v_{th}\epsilon^{1/2}}$$

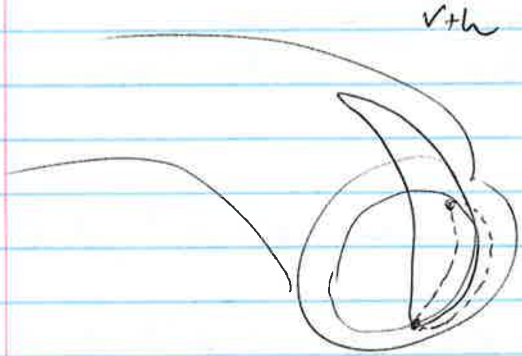
connection length $ds = \hat{n}\cdot d\vec{x} \sim (\hat{\varphi} + \frac{B_p}{B_T}\hat{\theta})\cdot(R\,d\varphi\,\hat{\varphi} + r\,d\theta\,\hat{\theta})$

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

$$ds \sim R\,d\theta\left(\frac{d\varphi}{d\theta} + \frac{r}{R}\frac{B_p}{B_T}\right) \sim Rq\,d\theta$$

$$\nu_* \sim \nu_{ei}\frac{R_0 q}{v_{th}}\frac{1}{\epsilon^{3/2}} < 1$$

b.



2. a. $\sigma_{\parallel}$ reduced by $\sqrt{\epsilon}$ since trapped particles do not contribute.
Also there is a new current J_{boot} from ∇P.

b. $$\begin{pmatrix}\Gamma_e \\ J_{neo}\end{pmatrix} \sim \begin{pmatrix}\frac{1}{T}D_{ban} & \text{Ware coeff} \\ \text{Boot coeff} & \sigma_{\parallel}\epsilon^{1/2}\end{pmatrix}\begin{pmatrix}-\nabla P \\ -n_0 E_{\parallel}\end{pmatrix}$$

Get the Ware coeff, use Onsager symmetry:

~~$V_W \sim V$~~ $\quad C_W \sim \epsilon^{1/2}\frac{V_W}{E_{\parallel}}$

$$V_W \sim V_{D,r}\,\Delta\theta \sim V_{D,r}\frac{\Delta v_{\parallel}}{v_{\parallel}}$$

$$V_{D,r} \sim \frac{1}{\Omega}\hat{n}\times(\mu\nabla B + W_{\parallel}\hat{n}\cdot\nabla\hat{n}) \sim \frac{\mu}{\Omega}(\hat{n}\times\nabla B)_r \sim \frac{\mu}{\Omega}\frac{B}{R}$$

$$\sim \frac{v_{th}^2}{\Omega}\frac{1}{R} \sim \rho\frac{v_{th}}{R}.$$

$\frac{\Delta v_{\parallel}}{\Delta t} \sim \frac{e}{m}E_{\parallel}$, $\Delta v_{\parallel} \sim \frac{e}{m}E_{\parallel}\frac{1}{\omega_B}$ and $v_{\parallel} \sim \epsilon^{1/2}v_{th}$ from trapped condition

$$C_W \sim \frac{\cancel{\epsilon^{1/2}}}{\cancel{E_{\parallel}}}\left(\rho\frac{v_{th}}{\cancel{R_0}}\right)\left(\frac{e}{m}\frac{\cancel{E_{\parallel}}\,\cancel{R_0}q}{\cancel{v_{th}\epsilon^{1/2}}}\right)\frac{1}{v_{th}\epsilon^{1/2}} \sim \frac{e\rho q}{m v_{th}\epsilon^{1/2}}$$

$$\sim \frac{eB_T}{mc\,v_{th}}\frac{\rho\,\epsilon\, c}{B_p\,\epsilon^{1/2}} \sim \frac{c\,\epsilon^{1/2}}{B_p}$$

$$J_{neo} \sim \frac{c}{B_p}\epsilon^{1/2}\nabla P + \sigma_{\parallel}\epsilon^{1/2}n_0E_{\parallel}$$

2. b. (continued) also, $J_{boot} \sim$ # passing $\cdot\, e v_{th}$

$$\sim \Delta \frac{dP}{dr}\, e v_{th} \sim \frac{v_{Dr}}{\omega_B} \sim$$ will work out the same.

3. Need D_{banana} now $= f_{tr}\, \Delta^2\, \omega_B\, \nu_{eff}$

Calculate Δ alternate way since already did $v_{D,r}$, ω_B:

$$P_\phi = mRv_\phi + eRA_\phi = mRv_\phi - e\psi(r)$$

$$P_\phi(\text{turning}) = -e\psi(r)$$

$$P_\phi(\text{midplane}) = m(R_0 + r + \Delta)v_\phi - e\psi(r+\Delta)$$

$$\psi(r+\Delta) \approx \psi(r) + \Delta\, \hat{n}\cdot\nabla\psi(r) = \psi(r) + \Delta(R_0 + r)B_p$$

$$\rightarrow \quad 0 = m(R_0 + r + \Delta)v_\phi - e\Delta(R_0 + r)B_p$$

$$\Delta \sim \frac{mv_\phi}{eB_p} \sim \frac{mv_{th}\epsilon^{1/2}}{eB_p} \sim \left(\epsilon\frac{B_T}{B_p}\right)\frac{1}{\epsilon B_T}\frac{mv_{th}}{e}\epsilon^{1/2}$$

$$\sim \frac{q\rho}{\epsilon^{1/2}}$$

$$D_{ban} \sim \epsilon^{1/2}\left(\frac{q\rho}{\epsilon^{1/2}}\right)^2\frac{\nu_{ii}}{\epsilon} \sim \nu_{ii}\rho_e^2 q^2 \epsilon^{-3/2}$$

$$\Gamma_{neo} \sim \nu_{ii}\rho_e^2 q^2 \epsilon^{-3/2}\, \nabla n + \frac{c}{B_p}\epsilon^{1/2} n_0 E_{\parallel}.$$