2013 II Q1 JH

Part 1: a) $\frac{\nu_{eff}}{\omega_b} < 1$ Many bounces before a collision

$$\omega_b^{-1} = \tau_b = \int \frac{ds}{V_{\parallel}} \simeq \frac{R_0 q}{\varepsilon^{1/2} V_t}$$

$ds = R_0 q \, d\theta$ • connection length

$V_{\parallel} \sim \varepsilon^{1/2} V_t$ • Trapping condition

$$\frac{\nu_{ei} R_0 q}{\varepsilon^{3/2} V_t} < 1$$

$\nu_{eff} \sim \frac{\nu_{ei}^{90°}}{(\Delta\theta)^2}$ $\Delta\theta \sim \varepsilon^{1/2}$ Trapping condition

b) You should know how to do this from your notes.

- Justify $V_{\parallel} \sim \varepsilon^{1/2} V_t$
- Either get $\Lambda \sim \frac{(V_D)_r}{\omega_b}$ or conserve $P_S = mV_S R - eRA_S$
- $\langle j_{\parallel} - j_S \rangle = -e\Lambda \frac{dn}{dr} V_{\parallel}$ ← $\sim V_{th}$ for untrapped.

c) Exercise for the reader

d) Collisional equilibrium w/ untrapped particles imprints momentum ~~an~~anisotropy in trapped particles due to density gradient and drives a current in the untrapped particles.

e) $I_p \Rightarrow B_\theta$ rotational transform averages out drifts.
Could drive I_p w/ RF, NBI but BS is cheaper.

Part II : a) $$1 - \frac{\omega_{*e}}{\omega} + b_s \phi - \frac{k_\parallel^2 c_s^2}{2\omega^2}\left(1 - \frac{\omega_{pi}^*}{\omega}\right) = 0$$

$$\omega_{pi}^* = \omega_i^*\left[1 + \eta_i\right] \qquad \eta_i \text{ large, } \quad 1 - \frac{\omega_{pi}^*}{\omega} = 1 - \frac{\omega_i^*[1+\eta_i]}{\omega}$$

$$\simeq -\frac{\omega_i^* \eta_i}{\omega}$$

Drop all other terms but 1:
(See Bill Tang's notes)
$$\frac{k_\parallel^2 c_s^2 \omega_i^* \eta_i}{2\omega^3} + 1 = 0$$

$$\omega^3 = -\frac{k_\parallel^2 c_s^2 \omega_i^* \eta_i}{2}$$

ω^3 has three roots, one real, one damped, one growing.

b) QN: $\frac{\delta n_e}{n_e} \sim \frac{\delta n_i}{n_i}$ use low frequency assumption of drift waves, gives $\frac{\omega}{k} = V_p \ll c$ electrons can easily flow along field lines to neutralise.