Geometry in a tokamak → passing part.
↳ trapp. part.

Neoclassical transport theory: collisions + orbits
(geometry)

$$D \sim \frac{(\Delta r)^2}{\tau} \qquad \cancel{r_L} \longrightarrow > r_L$$

<u>Passing particles</u> $\Delta r \sim 2 q r_L$ q: safety factor

$q > 1$

q up to 4-5

$$(\Delta r)^2 \sim 4 q^2 r_L^2$$

$$D_{(NC)} \sim 4 q^2 \underbrace{r_{Le}^2 \cdot \nu_{ei}} \sim 4 q^2 D_{(c)} \qquad 4q^2 > 10$$

Diffusitivities

$$\chi_{ii}^{(NC)} \sim 4q^2 \chi_{ii}^{(c)} \qquad \chi_{ee}^{(NC)} \sim 4q^2 \chi_{ee}^{(c)}$$

Trapped particles

$$\Delta r \sim \frac{q}{\sqrt{\varepsilon}} r_L \qquad \varepsilon = \frac{r}{R_0} \qquad \varepsilon \ll 1$$

$$D_{tr}^{(NC)} \sim \cancel{(\Delta r)^2 \cdot \nu_{ei}} \qquad \tau_{eff} = \varepsilon \cdot \tau_{ei}$$

$$\nu_{eff} = \varepsilon^{-1} \nu_{ei}$$

$$D_{tr}^{(NC)} \sim \frac{(\Delta r)^2 \cdot \nu_{ei}}{\varepsilon} \cdot \left(\text{fraction of trapped part.}\right)_{\sqrt{\varepsilon}} \sim \frac{q^2}{\varepsilon} r_{Le}^2 \cdot \frac{\nu_{ei}}{\varepsilon} \cdot \varepsilon^{\frac{1}{2}}$$

$$\sim \frac{q^2}{\varepsilon^{3/2}} : D^{(c)}$$

$D_{tr}^{(nc)} \simeq 100\, D^{(c)}$ $\qquad D \sim 10^{-3}\, m^2/s$

$\chi_i^{(nc)} \sim 100\, \chi_i^{(c)}$ $\qquad \chi_e^{(nc)} \sim 100\, \chi_e^{(c)}$

$\chi_i^{(c)} \gg \chi_e^{(nc)}$ $\qquad \chi \sim 0.1\, m^2/s$

$\tau \sim a^2/D$ $\qquad \tau_E \sim a^2/\chi$

Bootstrap current $\qquad j \simeq (\qquad)\left(\frac{R_0}{r}\right)^{\frac{1}{2}} \frac{T}{B_0}\left[\frac{\partial n}{\partial r} + 0.04\, \frac{n}{T} \frac{\partial T}{\partial r}\right]$