Vodivost (conductivity)

$$j = e(Zn_i\vec{v}_i - n_e\vec{v}_e) = en(\vec{v}_i - \vec{v}_e)$$

$$n = n_e = Zn_i$$

stationary (without B_0)

$$0 = -ne\vec{E} - n_e\nu_{ei}(\vec{v}_e - \vec{v}_i)m_e$$

$$n\nu_{ei}(\vec{v}_i - \vec{v}_e) = ne\vec{E}$$

(Drude relat.)

$$\Rightarrow \quad \vec{j} = \underbrace{\frac{ne^2}{m_e\nu_{ei}}}_{\sigma}\vec{E}$$

Resistivity

$$\eta = \frac{1}{\sigma} = \frac{m_e\nu_{ei}}{ne^2} \qquad \nu_{ei} = \frac{ne^2}{m_e}\eta$$

P_{ei} – momentum ions give to electrons

$$\vec{P}_{ei} = m_e n(\vec{v}_i - \vec{v}_e)\nu_{ei} = \eta e^2 n^2(\vec{v}_i - \vec{v}_e) =$$

$$= en\eta\vec{j} = \frac{m_e\nu_{ei}}{e}\vec{j}$$

Axisymmetric cylindrical plasma z ~~1~~ D2

$\vec{E} = \hat{r} E$ $\quad \vec{B} = B\hat{z}$ $\quad \nabla p_{e,i} = \frac{\partial p_{e,i}}{\partial r} \cdot \hat{r}$

neglect $(\vec{v}\nabla)\vec{v}$ (centrifugal force)

steady state

1) Show $v_{ir} = v_{er}$

2) compute $v_{De,i}$

3) Show that v_{ir} does not depend on $\vec{E}$

Steady state

$$en(\vec{E} + \vec{v}_i \times \vec{B}) - \nabla p_i - e^2 n^2 \eta (\vec{v}_i - \vec{v}_e) = 0$$

$$-en(\vec{E} + \vec{v}_e \times \vec{B}) - \nabla p_e - e^2 n^2 \eta (\vec{v}_e - \vec{v}_i) = 0$$

φ component $\quad (r, \varphi, z)$

$$-en v_{ir} B_z - e^2 n^2 \eta (v_{i\varphi} - v_{e\varphi}) = 0$$

$$en v_{er} B_z + e^2 n^2 \eta (v_{i\varphi} - v_{e\varphi}) = 0$$

$$\Rightarrow \underline{\underline{v_{er} = v_{ir}}}$$

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r component ions

$$en(E_r + v_\varphi B_z) - \frac{\partial p_i}{\partial r} - e^2 n^2 \eta \underbrace{(v_{ir} - v_{er})}_{0} = 0$$

$$v_{i\varphi} = -\frac{E_r}{B_z} + \frac{1}{enB_z}\frac{\partial p_i}{\partial r} = \left(\frac{\vec{E}\times\vec{B}}{B^2} - \frac{\nabla p_i \times \vec{B}}{en}\right)_\varphi$$

D3

analogically for $v_{e\varphi}$

$$v_{i\varphi} - v_{e\varphi} = \frac{1}{enB_z}\frac{\partial p_i}{\partial r} + \frac{1}{enB_z}\frac{\partial p_e}{\partial r} = \frac{1}{enB}\frac{\partial p}{\partial r}$$

$$\Rightarrow \quad v_{ir} = -\frac{en}{B_z}\eta\,\frac{1}{enB_z}\frac{\partial p}{\partial r} = -\frac{\eta}{B_z}\frac{\partial p}{\partial r}$$

$$v_{er} = v_{ir}$$

Diffusion does not depend on $\vec{E}$