

ITG modes

Some characteristics:

- ignore trapped particles

$$\omega \ll \omega_B, \text{ i.e.}$$

- $k_{\parallel} v_{Te} \gg \omega \gg k_{\parallel} v_{Ti}$

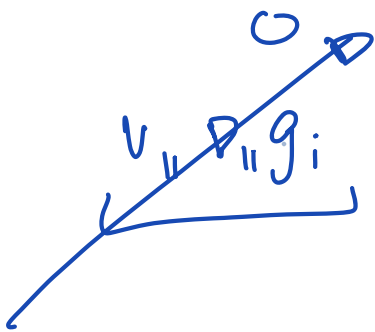
ions are moving slowly along field.

e^- moving rapidly \Rightarrow

$$g_e = 0$$

- also assume small drift

$$\omega \gg \omega_{di}$$



$$-i(\omega - \omega_{di}) g_i = -\frac{ie_i}{T_i} J_0 \phi (\omega - \omega_{*i}^T) f_{i0}$$

$$g_i = \frac{e_i \phi (\omega - \omega_{*i}^T)}{T_i (\omega - \omega_{di})} J_0 f_{i0}$$

quasi-neutrality

$$\sum_a \frac{n_a e_a}{T_a} \phi = \sum_a \overbrace{e_a}^{\text{only ions}} \int g_a J_0 d^3v$$

$$n_e = n_i$$

$$T_e = T_i$$

$$\frac{2 n_e e^2}{T} \phi = \frac{e^2 \phi}{T} \int \frac{\omega - \omega_{*i}^T}{\omega - \omega_{di}} J_0 f_{i0} d^3v$$

~~$$(T = T_e = T_i)$$~~

$$\text{low } \omega_{di} \ll \omega \quad \frac{1}{\omega - \omega_{di}} \approx \frac{1}{\omega} \left(1 - \frac{\omega_{di}}{\omega}\right)$$

$$\approx \frac{e^2 \phi}{T} \int \frac{(\omega - \omega_{*i}^T)}{\omega} \left(1 - \frac{\omega_{di}}{\omega}\right) J_0 \left(\frac{k_{\perp} v_{\perp}}{v_e}\right) f_{i0} d^3v$$

$$\omega_{*i}^T = \omega_{*i} \left(1 + \gamma \left(\frac{v_{\perp}^2}{T} - \frac{3}{2}\right)\right)$$

$$E \propto v^2$$

$$\propto (v_{\parallel}^2 + v_{\perp}^2)$$

$$\omega_{di} \approx \tilde{\omega}_{di} \left[\frac{v_{\perp}^2}{2} + v_{\parallel}^2 \right]$$

$$2\pi$$

$$d^3v = d\theta v_{\perp} dv_{\perp} dv_{\parallel}$$

• Normalised velocity to thermal velocity v_T

$$x_{\parallel} = \frac{v_{\parallel}}{v_T}, \quad x_{\perp} = \frac{v_{\perp}}{v_T}, \quad v_T = \sqrt{\frac{2T}{m}}$$

Trapped-electron modes (trapped-particle modes)

• important characteristics

• $g_e \neq 0$

• $\omega_{be} \gg \omega$

g_a , GK equation

$$\underbrace{V_{||} \mathcal{D}_{||} g_a}_{\text{dominant}} - i(\omega - \omega_{da}) g_a = -\frac{ie_a}{T_a} J_0 \phi (\omega - \omega_{*a}^T) f_{a0}$$

expand $g_a = g_{a0} + g_{a1} + \dots$ $g_{a1} \ll g_{a0}$

1st lowest order

$$V_{||} \mathcal{D}_{||} g_{a0} = 0$$

$$g_{a0} = f(l)$$

↑
along the
field
("z")

next order

$$V_{||} \mathcal{D}_{||} g_{a1} - i(\omega - \omega_{da}) g_{a0} = -\frac{ie_a}{T_a} J_0 \phi (\omega - \omega_{*a}^T) f_{a0}$$

now, take field line average

$$\overline{(\dots)} = \frac{\oint \dots \frac{dl}{v_{||}}}{\oint \frac{dl}{v_{||}}} \quad \text{line average}$$

first term $\oint v_{||} \nabla_{||} g_{a0} \frac{dl}{|v_{||}|} = \oint \nabla_{||} g_{a0} dl = 0$

because $g_{a0} \neq f(l)$

$$- \Gamma (\omega - \overline{\omega_{da}}) g_{a0} = - \frac{ie_a}{T_a} \overline{J_0 \phi} (\omega - \omega_{*a}^+) f_{a0}$$

$$g_{a0} = \frac{e_a}{T_a} \frac{\omega - \omega_{*a}^+}{\omega - \overline{\omega_{da}}} \overline{J_0 \phi} f_{a0}$$

$J_0 \approx 1$ always for e^-