# ITG instability

Ref: ITG-like Instability in the Two-Fluid Model in Slab Geometry D.D.Schnack et al. 2011

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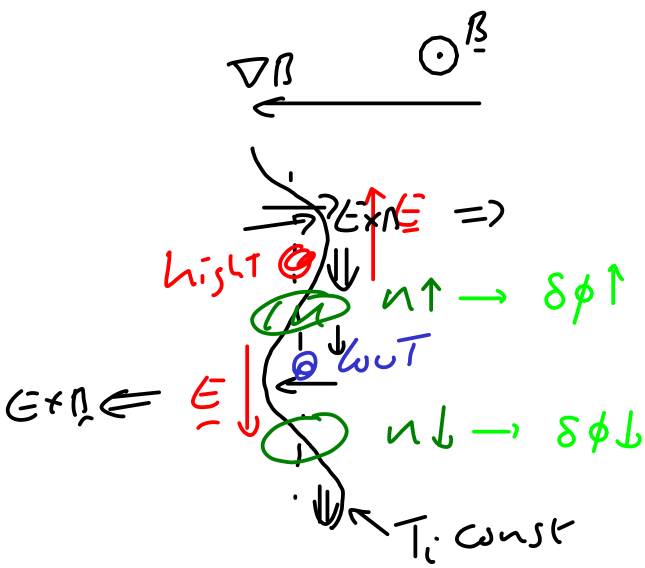
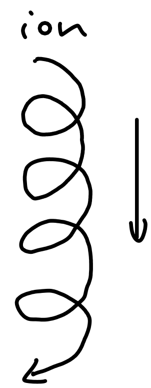
## Particle picture




$$V_D \simeq \frac{1}{R\Omega_i}\Big(\underbrace{\frac{v_\perp^2}{2}}_{\nabla B} + \underbrace{v_\parallel^2}_{\text{Curvature}}\Big)$$

$$\propto T_i$$

electron Boltzmann response

$$\frac{\delta n}{n} = \frac{\delta\phi}{T_e}$$

$\underline{E}\times\underline{B}$ drifts enhance perturbation

$\Rightarrow$ instability

## Fluid model

$$\frac{\partial n}{\partial t} = -\nabla\cdot(n\underline{u})$$

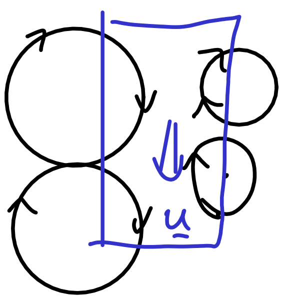
$$\frac{d}{dt} = \frac{\partial}{\partial t} + \underline{u}\cdot\nabla$$

$$m_i n \frac{d\underline{u}}{dt} = \underline{J}\times\underline{B} - \nabla p - \nabla\cdot\Pi$$

Finite Larmor Radius (FLR) effects needed

$$\frac{dp_i}{dt} = -\gamma p_i \nabla\cdot\underline{u} - (\gamma-1)\nabla\cdot\underline{q}_i \qquad \gamma = 5/3$$

$$\frac{dp_e}{dt} = -\gamma p_e \nabla\cdot u_e$$




$u_{i*}$ diamagnetic flow

$$\frac{\underline{b}\times\nabla p_i}{enB}$$

$\Pi_{gv}$ gyroviscous stress

$$m_i n\,\underline{u}_{i*}\cdot\nabla\underline{u} + \nabla\cdot\Pi_{gv} \simeq 0$$

gyroviscous cancellation

$$\frac{5}{3}\frac{p_i}{n}\underline{u}_{i*}\cdot\nabla n = \frac{2}{3}\nabla\cdot\underline{q}_{gv}$$

<u>Dispersion relation</u>

frequency

$$(\omega^2 - \omega_{s*}^2)\omega - \omega_{se}^2\,\omega_{*Ti} = 0$$

sound wave $k_\parallel c_s$

$$\frac{k_\perp}{eB}\frac{dT_i}{dr}$$

if $\frac{dT_i}{dr}$ small $\Rightarrow \omega^2 = \omega_{s*}^2$ sound wave if $\omega \gg \omega_{s*}$

$$\omega^3 = \frac{k_\perp k_\parallel^2 T_e}{e B m_i} \underbrace{\frac{dT_i}{dr}}_{\eta_i T_i}$$

$\gamma \sim \eta_i^{1/3}$ "$\eta_i$ mode"