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Some Constraints on Generation of Poloidal Shear Flow.

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Electrons:

\[ \omega = \omega_k + \delta \omega_{NL}, \]

\[ \omega_k = \omega_p + \frac{3}{2} k^2 \frac{T_e}{m}, \]

\[ \delta \omega_{NL} = \frac{1}{2} \omega_p \frac{\delta n}{n}, \]

Ions:

\[ \Omega^2 = k^2 \frac{T_e}{M} + \delta_{NL}, \]

Nonlinearity is coming from \((V_e \nabla)V_e\) in electron equations of motion (and taking \(V_e = \frac{eE}{m \omega}\) while \(\omega = \omega_p\)) and can be reduced to a kind of additional pressure:

\[ \delta \Omega_{NL}^2 = \frac{E^2}{8 \pi n M}. \]
\[(\omega - \omega_p)\delta E = \frac{1}{2} \omega_p E \frac{\delta n}{n},\]

\[\left(\frac{\partial^2}{\partial t^2} - \frac{T_e}{M}\right)\delta n = \frac{1}{8\pi M} \frac{\partial^2}{\partial x^2} E \delta E\]

\[\omega = \omega_p + i\nu, \quad \Omega = \Omega_s + i\nu,\]

\[\nu^2 = \frac{1}{16} \frac{\omega_p \omega_s E^2}{4\pi n T}\]
\[
\left( \frac{\partial^2}{\partial t^2} - \frac{T}{M} \right) \delta n = \frac{1}{8\pi M} \frac{\partial^2}{\partial x^2} E \delta E,
\]

\[
\omega = \omega_p + i\nu, \quad \Omega = \Omega_x + i\nu,
\]

\[
\nu^3 = \left( \frac{1}{16\pi nM} \omega_p E^2 \right)^{\frac{1}{3}}
\]
\[ \omega_d \Rightarrow \dot{\omega}_d + \omega_{c.c.}, \]

1. \( \omega_{c.c.} \) small compared to \( \omega_d \)

2. Dissipation brings imaginary part greater than 3 - wave resonance mismatch

*Arbitrary strong dissipation but only in one mode (e.g. in drift mode) does not eliminate instability, only reduces its growth rate.*
Poloidal zonal (Shear) flow is a particular case of Convective Cells (c.c.)

\[ k_y = 0, \; k_x \neq 0 \]

\[ x \leftrightarrow r \text{ (in cylindrical geometry)} \]

If poloidal shear flow suppresses drift mode microturbulence, is there a mechanism to switch it on and off?
Standart Theory:

Parametric generation of poloidal shear flow by Drift mode is unstoppable,

Thus the “Predator-Pray” scenario is unavoidable with improved confinement.

Experiment:

There are regimes of improved confinement but not universal; within the same regimes there might be zones of significantly lower microturbulence (areas of “Transport Barriers”)

Computational:

See both cases
Suggested Model
(Dissipation in both resulting modes)

Drift Mode:
• Consider scenario of Non-linearly Saturated Drift Microturbulence (as starting point before it start interacting with zonal flow)
• Imaginary part of damping is of the order of real part

Zonal Flow mode:
• Include “primordial” damping due to turbulent viscosity provided by Initial Drift Mode Turbulence