

# Gyrokinetic studies of electromagnetic turbulence reveal challenges for confinement at finite $\beta$

Microturbulence at finite  $\beta$  subject to surprising new effects

- Stable tearing parity fluctuations excited by ITG => electron heat transport
- Magnetic fluctuations can disable zonal flows => much higher transport
- New instabilities arise (microtearing, kinetic ballooning mode)
- Shorter magnetic scale lengths push these effects to higher gradients, beta

Saturation of microturbulence at finite  $\beta$  involves complex feedback loops, especially with zonal flows and magnetic fluctuations (both stable and unstable)

Issues:

- Understand interplay between instability, nonlinearly excited stable modes, zonal (variation of  $\beta$  changes balances to reveal physics)
- Understand how physics plays out in different configurations