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KBM Stability in NSTX Pedestals

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While pedestal models such as EPED have been successful in predicting pedestal pressure profiles for most tokamaks[1], their predictions for NSTX deviate significantly from experiment[2]. We focus on two of the hypothesized reasons for this discrepancy: (1) kinetic corrections to ideal infinite-n ballooning modes, and (2) other transport channels that could constrain pedestal pressure gradients before kinetic ballooning mode (KBM) onset.

We present a new framework that augments existing pedestal models by using gyrokinetic simulations to determine a stability boundary analogous to the ballooning critical pedestal (BCP) constraint in an EPED-like approach. By incorporating the critical linear temperature and density gradients for dominant micro instabilities, we find a new pedestal pressure gradient constraint — the gyrokinetic critical pedestal (GCP) constraint — for NSTX discharges. Local, linear gyrokinetic stability analysis is performed by varying the experimental equilibrium self-consistently, which is then used to predict pedestal width and height. This self-consistent equilibrium calculation rescales temperature and density gradients starting from the experimental point. Since our model distinguishes between density and temperature profiles, we characterise how stability thresholds — and therefore pedestal evolution — are affected by varying temperature and density profiles. This analysis is performed at multiple time intervals in the inter-ELM buildup, which shows how transport channels evolve during the pedestal ELM cycle.

Calculating the GCP constraint not only provides stability information about KBMs — which are similar to the ballooning modes captured by the BCP — but also shows other microstabilities present during the pedestal evolution. Therefore, our model captures both stability and transport properties as the pedestal evolves.

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3. Candy, J., Belli, E. A. & Bravenec, R. V. A high-accuracy Eulerian gyrokinetic solver for collisional plasmas. J. Comput. Phys. 324, (2016).

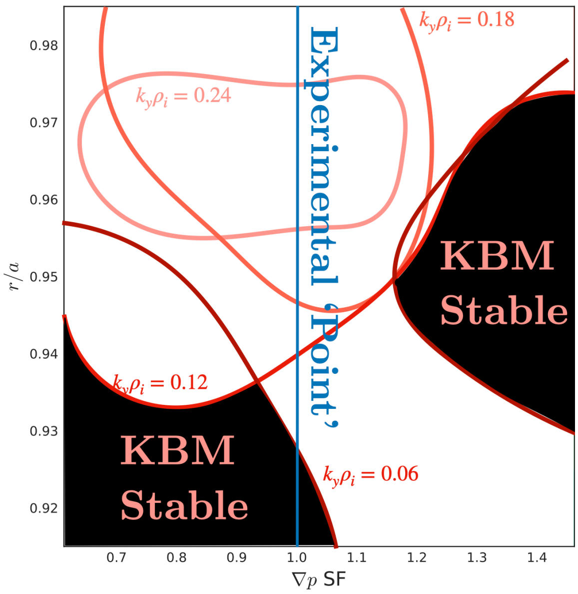

Figure: Contour plot of KBM stable and unstable regions for NSTX discharge #132543, plotted versus pressure gradient scaling factor ∇p (x-axis) and minor radius r/a (y-axis) for four binormal wavenumbers $k_y\varrho_i$. Each stability contour is generated from linear CGYRO[3] simulations. The pressure gradient scaling factor rescales the experimental pedestal equilibrium by a scalar value; the equilibrium is also computed self-consistently.