HYM simulations of sub-cyclotron frequency modes: effects on fast ions and electron transport

E. Belova, N. Gorelenkov, E. Fredrickson, H. Berk

- HYM equilibrium solver has been modified to improve the equilibrium fit to the TRANSP and EFIT profiles.
- HYM simulations of GAEs show good agreement with experimental results for both NSTX L-mode and H-mode shots, in terms of the most unstable toroidal mode numbers, frequency and the mode structure.
- HYM simulations for L-mode shots show good agreement in terms of the amplitude, and estimated growth rate.
- Linearized and nonlinear simulations have been performed in order to study in detail resonant wave-particle interaction in order to understand the nonlinear evolution of the instability. It has been shown that most resonant particles have stagnant orbits, and poloidal structure of the unstable mode is relatively coincident with location of the resonant orbits.
- Self-consistent kinetic description for the electrons has been implemented in the HYM code, where the electrons are described as delta-f drift-kinetic particles. This version of the code will be used to study the effects of GAE modes on the electron transport.

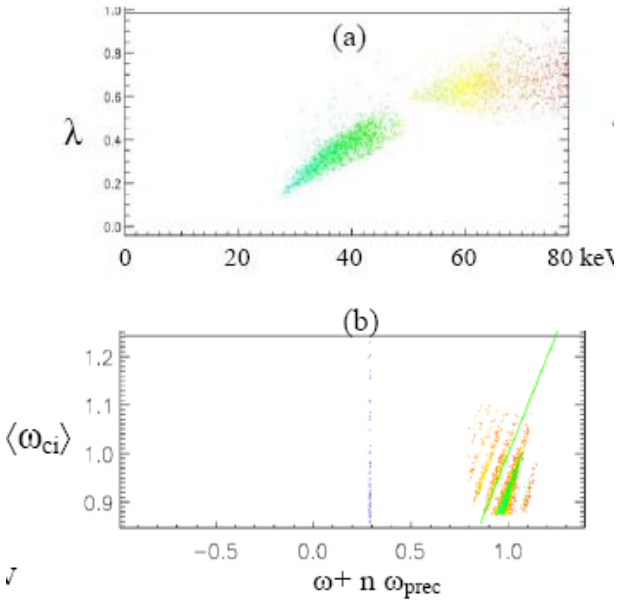


Figure 1. (a) Location of resonant particles in phase space, $\lambda=\mu B_0/\varepsilon$ vs energy, (b) resonant particles shown with orbit-averaged cyclotron and precession frequencies, both normalized to the ion cyclotron frequency at the axis, ω_{ci0}. From HYM simulations for NSTX shot #135419, $\omega=0.29\omega_{ci0}$, $\gamma=0.01\omega_{ci0}$, (n=9, m=1). Particle color corresponds to different energies: from E=0 (purple) to E=80keV (red).

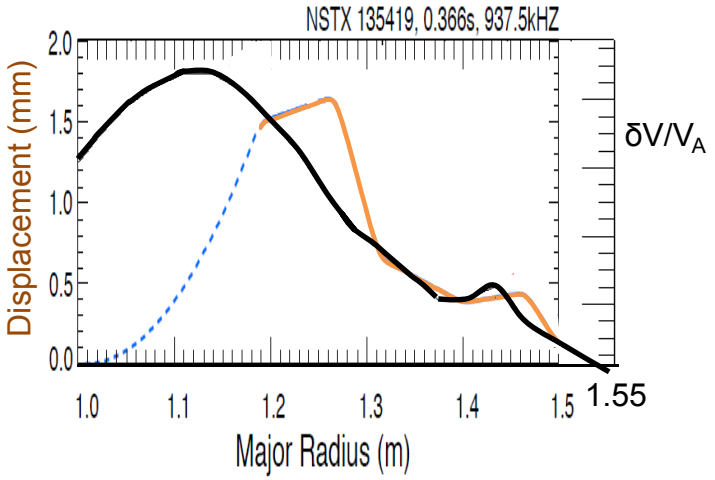
Effects of GAE and CAE modes on fast ion distribution function and electron transport

Effects on fast ions:

- Detailed numerical diagnostics are implemented in HYM to study resonant particle behavior.
- Improved resolution of resonant regions, particle sources and sinks will be implemented in HYM simulations to study the nonlinear evolution of the fast ion distribution.

Effects on the electron transport

- Correlation between strong GAE activity and enhanced electron transport has been observed in NSTX. [Stutman, PRL 2009]
- HYM code with drift-kinetic electrons can be used to study the effects of GAEs on electron transport (test-particle and self-consistent simulations).
- Damping due to thermal electrons (linearized simulations).
- Additional physics can be implemented, including generalized Ohm's law with the Hall effects and parallel electric field.



Mode amplitude profile - displacement NSTX#135419 [E. Fredrickson, IAEA 2010].
Mode structure from HYM simulations GAE n=9.

Improved measurements of fast ion distribution function, and its evolution are needed for accurate modeling of GAE and CAE modes.