Comprehensive Study of Excitation of High-Frequency Alfvén Eigenmodes by Beam Ions in NSTX

- Conducted large set of 3D MHD-delta f hybrid linearized and nonlinear simulations to investigate CAE and GAE instability for a wide range of beam parameters ($2<V_b/V_A<6$, $0.3<V_{||}/V_A<0.95$, P_b)
- Detailed understanding of CAE/GAE excitation is vital to predicting (and eventually preventing) their deleterious effects on plasma confinement, e.g. anomalous T_e flattening

SIMULATION RESULTS	EXPERIMENT/THEORY (DIS)AGREEMENT
CAE are stable for $V_b/V_A < 4$	*Prediction*: less CAE will be unstable in NSTX-U
Co-CAE more unstable than cntr-CAE	Experiment observes mostly cntr-CAE. Theory by Belikov (PoP 2003) claims co-CAE more unstable
GAE unstable for lower energy ($V_b/V_A \sim 2.5$), wider range of beam parameters	For |n| > 5, experiments observe mostly GAE
Most unstable co-(cntr-)GAE frequencies increase (decrease) with beam energy	Follows from dispersion + resonance condition
CAE freqs. increase with |n| cntr-GAE freqs. decrease then increase for |n| > 7	Experiment sees cntr-GAE frequency decrease with |n| – disagrees with approximate dispersion
No unstable CAE or GAE for |n| < 3	Agrees with theory: very few resonant particles. Agrees with experiment: most modes have larger |n|
Mode amplitudes scale as $dB \sim P_b$^2	Experimental amplitudes scale with beam power. Agrees with saturation via particle trapping theory
CAE to KAW energy flux depends strongly on beam power ($\sim P_b$^5)	Consistent with experimental T_e flattening most dramatically at large beam power (6 MW). Theory explains $P_{KAW}=\Gamma_{CAE} db$^2 $\sim P_b$^5.

NSTX-U J.B. Lestz, E.V. Belova, N.N. Gorelenkov, E.D. Fredrickson (PPPL) | N.A. Crocker, S. Tang (UCLA)