

Parametric dependence of beam-ion-driven modes in NSTX and NSTX-U

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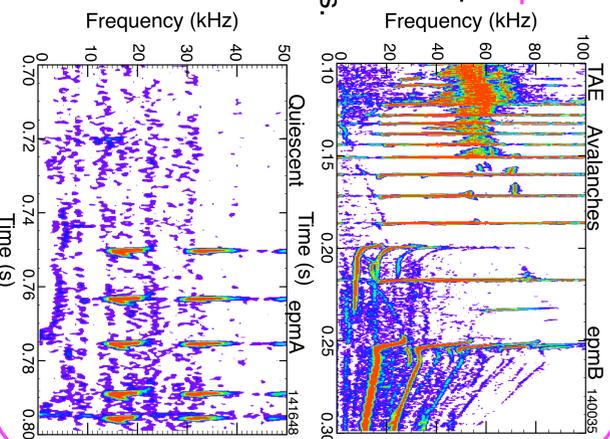
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Morphological classification of beam-driven modes based on spectrograms

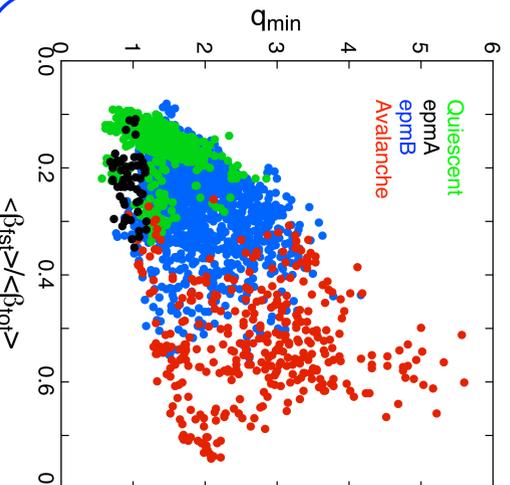
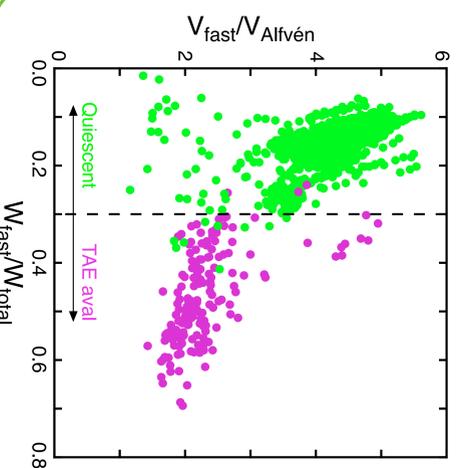
- Goal is to classify different types of beam-driven instabilities, and develop parametric scalings for their stability threshold.
- The scaling can provide guidance for experiments, and also potentially predictions for future experiments.
- Instabilities classified include TAE, TAE avalanches, epmA (f.b.) and epmB (LLM?).
- The initial database found a threshold for TAE avalanches for the parameter $\langle \beta_{fast} \rangle / \langle \beta_{total} \rangle \approx 0.3$.
- The database is being extended to include information on the rotation and q-profiles, and data from NSTX-U at higher field.



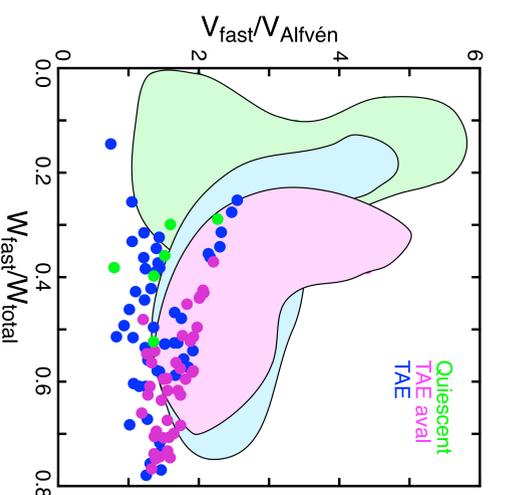
The empirical parametrical database has been extended to include q and rotation data, higher field data from NSTX-U

q_{min} separates epmA and epmB

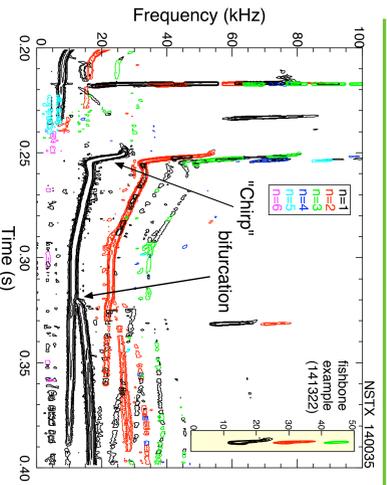
- epmB or LLMs tend to appear with elevated q_{min} .



- The colored points are data from NSTX for a variety of fast-ion instabilities.
- Database shows parameter range of existence of TAE avalanches (red), epmB (blue), epmA (black) and quiescent plasmas (green) in NSTX.
- Figure on right shows approximate parameter range expected for NSTX-U.
- TAE avalanches on NSTX-U (red) are seen with $V_{fast} V_{Alfvén} < 1$.
- Quiescent plasmas found at higher $\langle \beta_{fast} \rangle / \langle \beta_{tot} \rangle$ at $V_{fast} V_{Alfvén} \approx 1$.

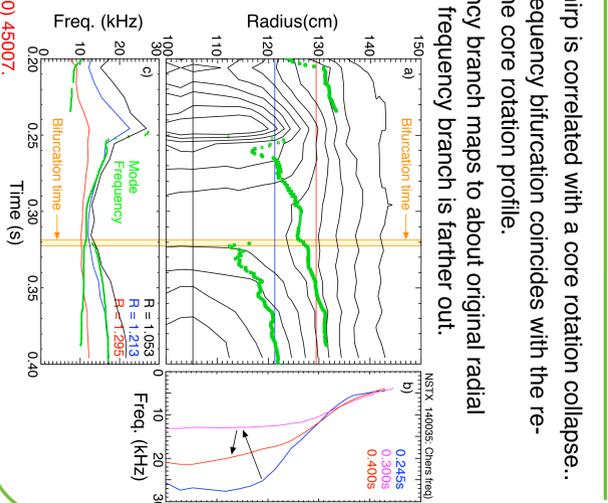


epmB bear many similarities to the Long-lived mode*

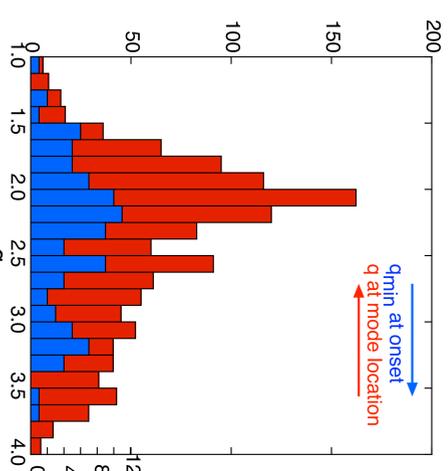


- Mode starts with a strong frequency chirp, similar in extent to the chirp of a fishbone, but somewhat slower.
- The mode saturates as a kink-type instability, with 'harmonics' that in some cases appear to be independent.
- Sometimes the kink later bifurcates into two or more separate modes..

*Chapman, et al., NF 50 (2010) 45007.

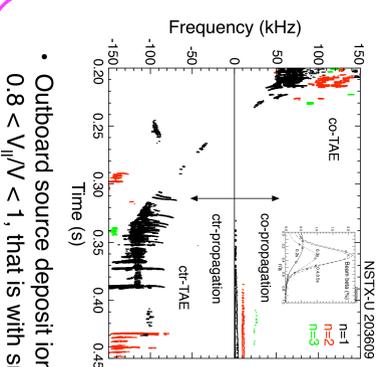


Mode weakly correlated with 'local' q

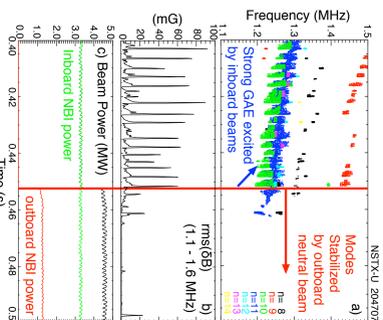
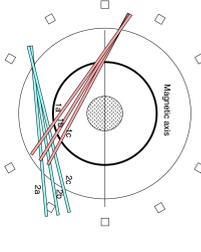


- Blue histogram shows q_{min} at mode onset.
- Red histogram shows local q at mode location determined by matching mode frequency to toroidal rotation.

NSTX-U will provide further constraints on fast-ion distribution function



- Beam sources shifting fast ion distribution to higher pitch suppress GAE instabilities.
- Far off-axis neutral beam sources excite new energetic particle-driven instabilities.



Summary of observations

- An empirical parametric database approach is being developed to identify stability limits for various beam-driven modes.
- Fishbones (epmA) are correlated with $q_{min} \approx 1$.
- Onset of epmB (llm) are only loosely correlated with q-evolution.
- Kinks can bifurcate, allowing re-peaking of core rotation.
- Far off-axis beam can excite new branch of ctr-propagating TAE – fast-ion parameters should be added to database.
- New off-axis, tangential beam sources can be strongly stabilizing for ctr-propagating Global Alfvén Eigenmodes.