Linear stability analysis of high frequency Alfvén eigenmodes in MAST and predictions for MAST-U

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Neutral-beam-driven, high frequency ($\omega \lesssim \omega_{ci}$) compressional (CAE) and global (GAE) Alfvén eigenmodes have been linked to anomalous electron temperature flattening at high beam power in NSTX [1]. While these modes are routinely excited in spherical tokamaks such as NSTX(-U) and MAST, and have also been observed in conventional tokamaks including DIII-D, AUG, and JT-60U, distinguishing between them with experimental measurements alone is often challenging. Nonetheless, classifying which type of mode is present in an experiment is essential for investigating (and eventually predicting) their potential influence on plasma confinement. To this end, linear stability theory represents an additional tool to aid their experimental identification, which is applied in this work to MAST and MAST-U plasmas.

By calculating the fast ion drive for CAEs and GAEs for specific discharges, the interpretation of previously published MAST observations [2] is clarified and extended beyond the original experimental analysis. Specifically, for the cntr-propagating modes observed at high field (B = 0.5 T), the strongest drive occurs for GAEs excited at mid-radius, with frequencies in good agreement with the measurements. The co-propagating modes excited at reduced field strength (B = 0.4 and 0.34 T) are likely a combination of GAEs and CAEs driven by the direct resonance, as opposed to the anomalous cyclotron resonance considered in the original analysis. Predictions are made for MAST-U, finding that the new off-axis beam sources can destabilize a wide range of co-propagating modes, while they are capable of suppressing the cntr-GAEs driven by the pre-existing on-axis beams, similar to previous observations on NSTX-U [3].

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References

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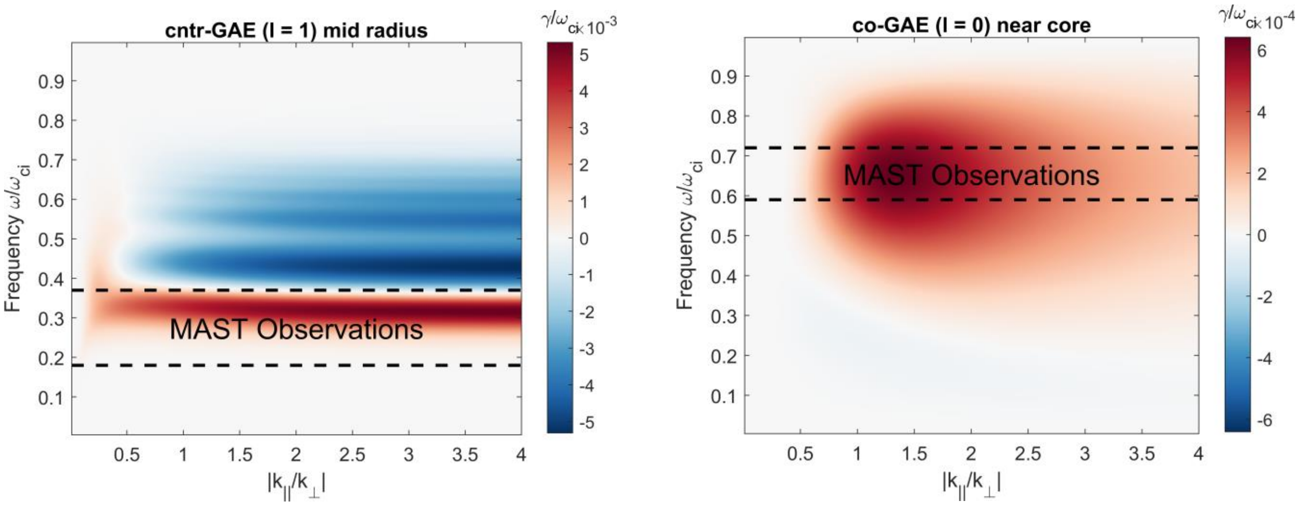

Figure 1. Calculated linear growth rate for GAEs as a function of wave vector direction $|k_\parallel/k_\perp|$ and frequency ω/ω_{ci} for the on-axis neutral beam parameters in two MAST discharges. Left: B = 0.5 T, cntr-propagating modes driven by the ordinary Doppler-shifted cyclotron resonance. Right: B = 0.4 T, co-propagating modes driven by the direct/Landau resonance. Horizontal dashed lines indicate the frequency range of experimental observations. Color scales have different magnitudes for the two plots.