A Comparison of Alfvén Eigenmode Stability in L- and H-mode†

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Abstract

Persistent Alfvén eigenmodes in the frequency range from 600 kHz to 1.2 MHz are observed during both ELM-free and Enhanced D_α H-mode with high power H minority ICRF heating in Alcator C-Mod. The modes are observed at relatively high density, typically between 1.8×10^{20} m^{-3} < $\overline{n}_e$ < 2.5×10^{20} m^{-3}, but not during the preceding L-mode phase of the discharge, which is at about half the H-mode density with the same input power. This suggests that H-mode profiles are more unstable to TAEs than L-mode profiles.

A comparison of the AE stability of L- and H-mode was made with the NOVA-K code with input from TRANSP/TORIC5 for the fast ion calculations. The results indicate that the L-mode remains stable and the H-mode unstable to TAEs in the measured frequency range. However, the overall damping rate hardly changes between the L- and H-mode times. Instead, the fast particle drive term increases substantially in H-mode relative to L-mode because the calculated fast ion energy does not decrease very much in H-mode despite the doubling of the density. So, the energy density and ICRF power deposition are larger and more peaked in H-mode. The increased ICRF power deposition is perhaps due to increased focusing of the ICRF waves at higher density. The gradient in the fast ion β also increases substantially, which increases the TAE drive term. The radial mode structure also shows some differences between L- and H-mode in that the H-mode profile is much broader with weak continuum interaction in the core while the L-mode profile is narrower and peaked further out radially with larger core continuum interaction.

While the overall calculated drive – damping rate appears to be consistent with the experimental results, the rotation direction expected by theory remains in the ion drift direction, which is opposite to the measured direction of mode rotation. Passing fast ions need to be included in the ICRF distribution in NOVA-K to properly model the drive in the electron direction. The calculated fast ion distribution from TORIC5 is peaked near the axis but calculations with the AORSA/CQL3D code indicate that the fast ion radial profile for lower density conditions are peaked well off-axis, which could provide sufficient drive in the electron direction if the TAE radial eigenfunction were peaked in the region of positive gradient in the fast ion β.

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