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Electron Cyclotron Heating Modification of Alfvén Eigenmode Activity in DIII-D

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Localized electron cyclotron heating (ECH) can have a dramatic impact on neutral beam driven Alfvén eigenmode (AE) activity in DIII-D plasmas. The most common effect, which is explained here for the first time, is a shift in the dominant observed modes from a mix of reversed shear Alfvén eigenmodes (RSAEs) and toroidicity induced Alfvén eigenmodes (TAEs) to a spectrum of weaker TAEs when ECH is deposited near the shear reversal point, q_min. Discharges with weaker RSAE activity also have reduced fast ion transport. A recent experiment to understand the physical mechanisms responsible for this shift in AE stability included variations of ECH steering, power, and timing as well as current ramp rate, beam injection geometry, and beam power. All variations were observed to change the impact of ECH on AE activity significantly. In some cases, RSAE activity was enhanced with ECH near q_min as opposed to near the axis, in contrast to the original DIII-D experiments [1]. It is found that during intervals when the geodesic acoustic mode (GAM) frequency at q_min is elevated and the calculated RSAE minimum frequency is very near or above the nominal TAE frequency (f_TAE), RSAE activity is not observed or RSAEs with a much reduced frequency sweep range are found. This condition is primarily brought about by ECH modification of the local electron temperature (T_e) which can raise both the local T_e at q_min as well as its gradient. A q-evolution model that incorporates this reduction in RSAE frequency sweep range is in agreement with the observed spectra and appears to capture the relative balance of TAE or RSAE-like modes throughout the current ramp phase of over 38 DIII D discharges. Detailed ideal MHD calculations using the NOVA code show both modification of plasma pressure and pressure gradient at q_min play an important role in modifying the RSAE activity. Analysis of a case with ECH near q_min, and no observable RSAE activity, shows the traditional RSAE is no longer an eigenmode of the system. Calculations with the non-perturbative gyro fluid code TAEFL confirms this change in RSAE activity and also shows a large drop in the resultant mode growth rates.
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[1] M.A. Van Zeeland, et.al PPCF 50 (2008) 035009

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