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Parallel Impurity Spreading During Massive Gas Injection.[1]

V.A. IZZO, University of California

Extended-MHD simulations of disruption mitigation in DIII-D demonstrate that both pre-existing islands (locked-modes) and plasma rotation can significantly influence toroidal spreading of impurities following massive gas injection (MGI). Given the importance of successful disruption mitigation in ITER and the large disparity in device parameters, empirical demonstrations of disruption mitigation strategies in present tokamaks are insufficient to inspire unreserved confidence for ITER. Here, MHD simulations elucidate how impurities injected as a localized jet spread toroidally and poloidally. Simulations with large pre-existing islands at the q=2 surface reveal that the magnetic topology strongly influences the rate of impurity spreading parallel to the field lines. Parallel spreading is largely driven by rapid parallel heat conduction, and is much faster at low order rational surfaces, where a short parallel connection length leads to faster thermal equilibration. Consequently, the presence of large islands, which alter the connection length, can slow impurity transport; but the simulations also show that the appearance of a 4/2 harmonic of the 2/1 mode, which breaks up the large islands, can increase the rate of spreading. This effect is seen both for simulations with spontaneously growing and directly imposed 4/2 modes. Given the prevalence of locked-modes as a cause of disruptions, understanding the effect of large islands is of particular importance. Simulations with and without islands also show that rotation can alter impurity spreading, even reversing the predominant direction of spreading, which is toward the high-field-side in the absence of rotation. Given expected differences in rotation for ITER vs. DIII-D, rotation effects are another important consideration when extrapolating experimental results.

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