# Impurity Mixing, Radiation Asymmetry, and Runaway Electron Confinement in MGI Simulations of DIII-D and ITER*

V.A. Izzo, University of California San Diego

Massive gas injection (MGI) is one candidate for the ITER disruption mitigation system (DMS), due to its proven effectiveness for mitigating heat loads and halo currents. The number and locations of the DMS ports will soon be chosen with the goals of maximizing assimilation of impurities into the core and keeping radiated power asymmetry low. Macroscopic MHD instabilities help redistribute impurities from the edge to the core during an MGI shutdown [1]. We present DIII-D and ITER simulations performed with the extended-MHD code NIMROD, in which the effects of an impurity species—including radiation cooling and mixing with the main ion species—are incorporated. The impurity source is localized to the edge, based on the observation that MGI doesn't penetrate deeply into tokamak plasmas. We find that n>1 MHD modes moderately increase impurity transport, while the n=1/m=1 mode dramatically enhances mixing. Because n>0 modes are responsible for impurity transport, we find that even with a toroidally symmetric source at the edge, radiated power from the core can vary by a factor of two toroidally; this may imply a hard lower bound in achievable radiation symmetry. Impurity assimilation for localized sources is also compared, such as high-field- vs low-field-side injection. Successful MGI suppression of runaway electrons (REs) in ITER will require additional loss mechanisms beyond the collisional suppression assumed by the theoretical (but hard to reach) "Rosenbluth density," such as MHD-induced losses. A test-particle RE confinement model in NIMROD has been benchmarked against a range of Ar-pellet injection shots in DIII-D. MGI simulations find higher amplitude and longer lived fluctuations that can increase RE losses compared with deeply penetrating impurities.

[1] V.A. Izzo, et al., Nucl. Fusion **51** (2011) 063032.

*Supported by the US DOE under DE-FG02-95ER54309.