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Gas Jet Disruption Mitigation Studies on Alcator C-Mod[1]

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Disruptions are a major concern for C-Mod, ITER, and future tokamak reactors. Damage can come from several different effects, including high instantaneous thermal loads on material surfaces, electromagnetic loads on conducting structures due to halo and toroidal eddy currents, and highly localized damage from relativistic runaway electron impact. Reliable mitigation of these problems using techniques benign to tokamak operation are key to meeting the scientific and technological goals of these experiments. High pressure noble gas jet injection is a mitigation technique which potentially satisfies the operational requirements of fast response time and reliability, while still being benign to subsequent discharges. Previous gas jet injection experiments on DIII-D have shown good success at reducing the deleterious effects of disruptions. However, many questions remain about the effectiveness of this approach on high energy density, high pressure plasmas in high field devices such as C-Mod and ITER. Disruption mitigation experiments using an optimized gas jet injection system are being carried out on C-Mod to study the physics of gas jet penetration into high pressure plasmas, the ability of the gas jet to convert plasma energy into radiation on timescales consistent with C-Mod's fast quench times, and the reduction of halo currents with C-Mod's high current density. The dependence of impurity penetration and effectiveness on noble gas species (He, Ne, Ar), gas pressure, and plasma pressure/energy density will also be discussed. 3-D MHD modeling of the disruption physics with NIMROD, incorporating data from temperature profiles taken during the disruption quench, as well as high-speed images of the plasma cross-section in the gas nozzle region, show that edge cooling of the plasma triggers the growth of tearing modes, producing a stochastic region in the core of the plasma and rapid loss of core thermal energy. This may explain the apparent effectiveness of the gas jet despite its limited penetration.

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