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Disruption mitigation experiments with multiple gas jets on Alcator C-Mod[1]

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Experiments have been conducted on the Alcator C-Mod tokamak to determine the effectiveness of disruption mitigation using multiple, toroidally separated massive gas injections (MGI). This represents the first study of MGI using more than one gas jet simultaneously. The implications are important for ITER, as a toroidal radiation peaking factor greater than approximately 2 could lead to localized melting of the first wall, even in the case of a successful mitigation. A new diagnostic system consisting of a toroidal array of six AXUV photodiodes with wide poloidal view, but narrowly collimated toroidal view, has been fielded, allowing for time-resolved measurements of the toroidal radiation asymmetry during disruptions. Synchronization has been achieved between the two gas jets, allowing for a scan of the "stagger time" Δt, defined as the difference in time between the gas from the two jets arriving at the plasma. In the limit of long stagger time ($\Delta t > 1$ ms), the two-jet system behaves like a single jet, dominated by the jet the fires first. It is found that in the pre-thermal quench phase of the disruption, the radiation is toroidally peaked, and is localized near the gas jet which fires first. In the thermal quench (when most of the plasma stored energy is radiated), the pattern is more complicated, and depends sensitively on physical differences between the gas jets. In the current quench phase, the radiation pattern is toroidally symmetric, as expected from previous single-jet experiments. Disruption parameters such as current decay time, and divertor deposited energy (diagnosed by infrared camera and surface thermocouple thermography) are investigated and compared between unmitigated and single- and two-jet mitigated disruptions. The role of low-n MHD modes in the mitigated disruption sequence is explored through a scan of plasma elongation and safety factor, as well as through simulation.

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