Radiation Asymmetries during Disruptions on DIII-D Caused by Massive Gas Injection

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Abstract: One of the major challenges that the ITER tokamak will have to face during its operations are disruptions. During the last few years, it has been proven that the global consequences of a disruption can be mitigated by the injection of large quantities of impurities. But one aspect that has been difficult to study was the possibility of local effects inside the torus during such injection that could damage a portion of the device despite the global heat losses and generated currents remaining below design parameter. 3D MHD simulations show that there is a potential for large toroidal asymmetries of the radiated power during impurity injection due to the interaction between the particle injection plume and a large n=1 mode. Another aspect of 3D effects is the potential occurrence of Vertical Displacement Events (VDE), which could induce large poloidal heat load asymmetries. This potential deleterious effect of 3D phenomena has been studied on the DIII-D tokamak thanks to the implementation of a multi-location massive gas injection (MGI) system as well as new diagnostic capabilities. This study showed the existence of a correlation between the location of the n=1 mode and the local heat load on the plasma facing components but shows also that this effect is much smaller than anticipated (peaking factor of ~1.1 vs 3-4 according to the simulations). There seems to be no observable heat load on the first wall of DIII-D at the location of the impurity injection port as well as no significant radiation asymmetries whether one or 2 valves are fired. This study enabled the first attempt of mitigation of a VDE using impurity injection at different poloidal locations. The results showed a more favorable heat deposition when the VDE is mitigated early (right at the onset) by impurity injection. No significant improvement of the heat load mitigation efficiency has been observed for late particle injection whether the injection is done "in the way" of the VDE (upward VDE mitigated by injection from the upper part of the vessel vs the lower part) or not.