Contribution ID: **90** Type: **Contributed Oral**

Thermal Energy Mitigation and Toroidal Peaking Effects in JET Disruptions

Wednesday, 4 September 2024 11:35 (25 minutes)

Previous investigations on JET suggest thermal stored energy (W_{th}) is poorly mitigated by either Massive Gas Injection (MGI) or Shattered Pellet Injection (SPI) Disruption Mitigation Systems (DMS), when measured by weighted averages of bolometer channels. A contrasting investigation on ASDEX-Upgrade found that thermal energy is well mitigated with MGI. We investigate whether the apparent poor thermal mitigation on JET is explained by radiation peaking near the injected impurity plume, combined with the limited toroidal resolution of bolometry diagnostics. High toroidal peaking in the pre-thermal quench (pre-TQ) is found in Ar/D2 MGI on JET, with >3x higher radiation near the injection location than elsewhere throughout the pre-TQ. A previously unexplained toroidal peaking measurement in neon SPI is also successfully reproduced with similar peaking. These observations agree with literature from Alcator C-Mod, ASDEX-Upgrade, and KSTAR. This peaking is not captured by the bolometry used in previous JET studies that found poor thermal mitigation. A set of 10% Ar / 90% D2 mix MGIs is analyzed using the Emis3D radiation modeling code. With injector-localized peaking, almost two thirds of W_{th} is radiated, where estimates that do not account for injector peaking would indicate less than half. The toroidal spread of the injector peaking feature is poorly constrained, and up to 85% of the plasma's thermal energy may be radiated using the largest possible spread. Similar radiated fractions are seen in a second set of MGI discharges and in a set of neon SPI discharges. The improved thermal mitigation found here suggests a reduced divertor melt risk in high performance mitigated disruptions on ITER and SPARC. However, the higher peaking near DMS injectors could increase flash melting risk on nearby plasma facing components. Only single-injector mitigation is studied here. Multiple injector mitigation, as planned for ITER and SPARC, might further increase the radiated fraction and decrease pre-TQ peaking, but that is not addressed in this study.

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Session Classification: Mitigation

Track Classification: Mitigation