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Runaway Electron (RE) Mitigation Using Supersonic Molecular Beam Injection in the Aditya-U Tokamak

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In fusion devices, runaway electrons (REs) with energies >=10 MeV, generated predominantly during plasma disruptions, can penetrate through the low-Z first wall and melt the interface of actively cooled parts. Majority of disruptions display MHD modes, as precursors. Radiation cool-off at the edge is seen to trigger abrupt growth of MHD modes, mode locking and thereby disruptions. The REs are generated due to increase in plasma resistivity following the thermal quench (TQ). REs pose severe threat to the lifetime of the first wall components and increase the machine down time substantially. Hence, mitigation of REs are a must for successful operation. Several RE mitigation techniques have been tried out in different machines, such as massive gas injection, and resonant magnetic perturbations. However, the effect of both these mechanisms are restricted to the very edge of the tokamak and REs primarily generated inside the plasma following the TQ, are not completely affected by these techniques. Enhancing magnetic fluctuations during disruptions is an alternate method and a more penetrative fueling technique is required to achieve that. Significant RE flux has been found to suppress the magnetic fluctuations and considerable RE current is generated during the disruptions. There is a recent experimental observation of suppression of the RE current during disruptions by the magnetic perturbations, excited by the supersonic molecular beam injection (SMBI). However, a detailed understanding of the underlying dynamics of such a suppression is far from being completely understood. The present campaign on Aditya-U explores such a phenomenon over a wide range of experimental parameters. An SMBI system has been installed on the low field side with a Laval nozzle of throat diameter 0.5 mm and a fast response solenoid valve. The plenum gas pressure can be varied to adjust the speed/penetration of the beam. A particle flux of 2.6E22 particles/s is achievable at a plenum pressure of 1 MPa. Volume hard X-rays are monitored along a central chord and suitable SMBI is launched based on the spatial location of the REs to mitigate them in real time. Interaction of SMBI with REs and magnetic fluctuations will be reported. Finally, a 1D code to study the transport dynamics during SMBI has been developed and simulation results in support of the experiments will also be presented.

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