LIQUID JETS FOR FAST PLASMA TERMINATION IN TOKAMAKS

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ABSTRACT: Recent simulations by Putvinski, et al. [PSI conference 1996] have shown that introducing impurities to the plasma in order to mitigate adverse disruption effects in ITER may actually be deleterious because of a potentially unwelcome phenomenon: generation of multi-MeV runaway electrons by the collisional avalanche mechanism [Rosenbluth, IAEA 1995]. The injection of a liquid hydrogen jet to deliver a massive density increase is proposed as a means for avoiding runaways, while providing the same beneficial effects as impurities. A discussion of many jet-related topics, such as ablation/penetration, jet breakup time, and stability are presented in this paper. Due to an ablation pressure instability, it is predicted that the jet will quickly break up into a regular chain of droplets with dimensions of approximately the size of the jet radius. It is found that while deep penetration in the plasma can be easily achieved, bubble growth and disruptive boiling (flashing) during the propagation in the vacuum gap between the nozzle exit and the plasma are the main processes limiting the jet survival time. Calculations indicate that for ITER reference parameters, the jet can remain coherent in vacuum for a distance of ~l to 2 m before disintegrating. Based on this present understanding, the prospect for the safe termination of the ITER discharge by high-density liquid jet injection appears promising.