Numerical simulation of thermal quench triggered by density source in HL-2A

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Magnetic flux surfaces are abruptly destroyed and the plasma is no longer confined during thermal quench [1]. For a representative unmitigated disruption occurring in ITER with full deuterium-tritium performance, about 350 MJ of thermal energy and up to 1 GJ of magnetic energy may be released to the divertor and first-wall during several milli-seconds, leading to serious damage of the device [2]. Since occasional disruptions might probably be unavoidable in future fusion reactor, the realization of disruption mitigation is of crucial importance.

The mainstream methods of disruption mitigation system (DMS) include Shattered Pellet Injection (SPI) [3] or Massive Gas Injection (MGI) [4]. The location and uniformity of injected material deposition can affect the mitigation efficiency. To clarify the effect of MHD-modes-induced-transport on the injection penetration, we simulate the thermal quench (TQ) during the pre-disruption phase triggered by pure deuterium (D_2) injection at different fixed deposition location employing three-dimensional (3D) non-linear reduced MHD code JOREK. Results exhibit evidently different n=1 mode dynamics and variation of plasma density profiles, depending on the location of D_2 deposition (LoD) relative to the magnetic surface of q=2.

When LoD is outside the q=2 surface, the m/n=2/1 mode tends to be dominant and mainly couple with the m/n=3/1 mode. Magnetic stochasticity firstly happen in the m/n=2/1 island region and then expanding outwards. But when LoD is inside the q=2 surface, the m/n=1/1 mode tends to be dominant, and magnetic stochasticity firstly occur in the m/n=1/1 island region then the core plasma density greatly increases. The LoD is also found to be strongly linked to the growth rate and maximum dominant mode amplitude during the TQ, and consequently affects the TQ duration and the current spike amplitude.

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