Impurity modulations of plasma current spike and poloidal rotation during tokamak disruption

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Plasma current spike and magnetic island poloidal rotation are commonly observed in the thermal quench phase of a tokamak disruption [1-3]. Recent resistive MHD simulations and analyses demonstrate that these characteristic features can be highly modulated by the impurity penetration and radiation, in good agreement with experiments [4-8]. In particular, the formation of the plasma current spike at the end of the thermal quench phase is found to strongly correlate to the onset of the 1/1 kink-tearing reconnection (figure 1), and the timing and magnitude of these events are subject to significant influence from the impurity species and injection level. The species dependence of impurity poloidal drift direction along with the magnetic island rotation in the poloidal plane is found (figure 2a), and the poloidal rotations are observed to be in opposite directions for low-Z and high-Z impurity species during the early phase of injection. Such poloidal asymmetric drift flow of the bottom-injected impurity density is mainly determined by a local plasmoid formed on the impurity cold front. The corresponding impurity radiation induced magnetic islands rotate along with the poloidal flow that is mainly driven by the electromagnetic torque due to the local redistribution of current density induced by impurity radiation as well (figure 2b). The results well explain the J-TEXT MGI experiments [2], and provide insights into the roles of impurity penetration and radiation in the modulation of a tokamak disruption process.

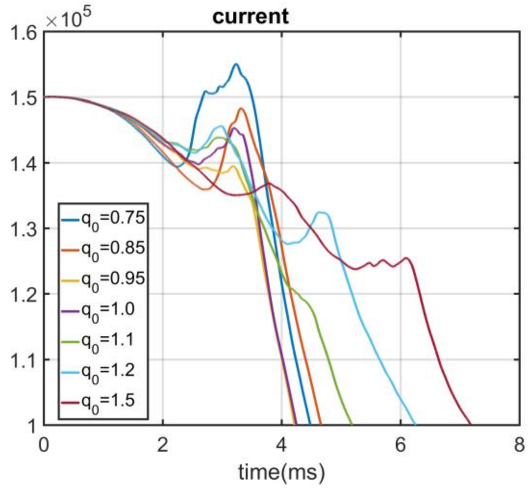

Figure 1 Plasma current as functions of time for cases with different value of q0.

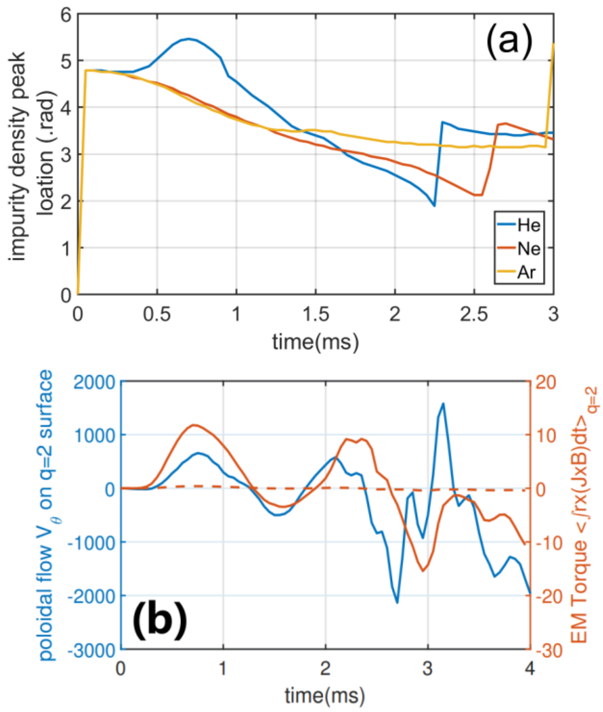

Figure 2 (a)The poloidal location of impurity density peak as functions of time for different impurity species. (b) The poloidal flow (blue solid line), the poloidal pressure gradient $dp/d\theta$(orange dashed line) and the poloidal Lorentz force (orange solid line) as functions of time.

References
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