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Characteristics of the thermal-quench process in the EAST disruptions and its interpretive MHD modelling with JOREK

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During the thermal quench (TQ), the stored thermal energy is released with a short timescale and might cause serious damage to plasma-facing components (PFCs), especially in future large-scale tokamaks. Here presents the detailed description of the TQ database consisting of 164 disruption discharges, including both major disruptions (MDs) and hot vertical displacement events (VDEs), on EAST [1]. The dependence of the TQ time on plasma parameters has been statistically analysed. Besides, the TQ process triggered by neon massive gas injection (MGI) in EAST is simulated with the JOREK 3D non-linear MHD code [2].
On EAST, the TQ duration of MDs is within 60~800 μs, and the value of VDEs is approximately in the range of 100~3000 μs. In particular, for MDs, the lower bound of TQ duration decreases as the plasma current increases. This decrease is due to the connection length shortening and the plasma temperature increasing. For MDs, two typical TQ processes, single-stage TQ and double-stage TQ, are characterized by different magnetic perturbations. For hot VDEs, the plasma temperature collapses step by step from the edge to the core, and every progressive collapse corresponds to a magnetic perturbation, the growth rate of which is approximately equal to or less than double-stage TQ.
First simulations of neon MGI into an EAST L-mode plasma with the JOREK MHD code are presented and compared in detail to experimental data. The effect of several parameters on MHD activity and TQ dynamics is studied and MHD influence on ablation is shown. The MGI creates a local density deposit that rapidly expands in the direction parallel to the magnetic field. TQs are obtained quickly after injection in most simulations with a typical duration of 3 ms. Although the $n = 1$ magnetic perturbation dominates in the simulations, toroidal harmonics up to $n = 5$ contribute to stochastization and stochastic transport in the plasma core. With 1020 atoms injected, TQ is typically incomplete. At a larger number of injected atoms, TQ can set in when the local density deposit is close to the $q = 2$ rational surface and substantial (up to 90%) 'thermal collapse'energy is lost during TQ.
[1] W Xia et al Plasma Phys. Control. Fusion 65 (2023) 085011;
[2] D Hu et al Nucl. Fusion 61 (2021) 026015

*See Hoelzl et al 2021 (https://doi.org/10.1088/1741-4326/abf99f) for the JOREK Team.

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