Slow thermal quench in ITER disruptions

H. Strauss[1]

[1] *HRS Fusion, West Orange, USA*

Fast disruptions occur in JET and other present experiments. The thermal quench (TQ) occurs [1] in about $1ms$. Slow disruptions are predicted to occur in ITER. The thermal quench is predicted [2] to have a much longer time scale of order $50ms$.

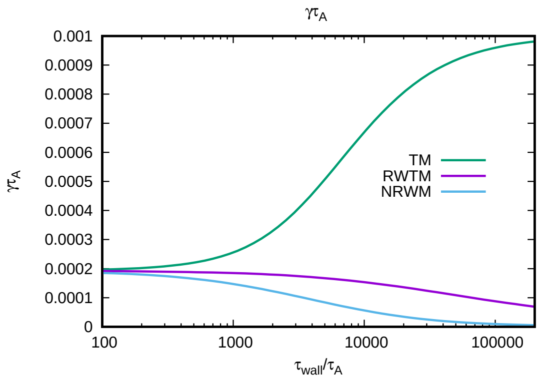

Figure 1: *Growth rates γ of TM, RWTM, and NRWM as functions of the resistive wall time τ_{wall}, where τ_A is the Alfvén time.*

Most disruptions in JET are of the locked mode type. The plasma toroidal rotation slows and locks. Tearing modes produce stochastic parallel thermal transport in the edge region, which along with impurity influx, cools the edge. This precursor stage might last $100ms$. It is followed by an MHD instability, which has recently been identified as a resistive wall tearing mode (RWTM) [1], by comparing theory and simulations with experimental data. The TQ time is the inverse of the RWTM growth rate. The RWTM in ITER grows much more slowly than in JET, because the resistive wall time τ_{wall} is two orders longer. This was confirmed by simulations [2] of an ITER baseline scenario 2 equilibrium.

The dispersion relation of the RWTM [1] also includes tearing modes (TM), and a new (neo) resistive wall mode (NRWM). These modes branch from the TM no wall limit at the left of Fig. 1, $\tau_{wall} \to 0$. The usual RWM branches from the ideal no wall limit. The growth rate γ depends on τ_{wall}, S, Δ_0, and Δ_1, where S is the Lundquist number, $\Delta_0 > 0$ depends on the no wall free energy, and $\Delta_1 = \Delta'$ with an ideal wall. The curves in Fig. 1 are with $S = 10^5$, $\Delta_0 = 0.125$, and $\Delta_1 = 1, 0, -1$.

The fastest growing mode is the TM, with $\Delta_1 > 0$. When the TM is marginally stable, $\Delta_1 = 0$, the RWTM occurs, with $\gamma \propto \tau_{wall}^{-4/9}$. If $\Delta_1 < 0$, the NRWM can occur with $\gamma \propto \tau_{wall}^{-1}$. The TM and RWTM are the precursor and TQ stages of the disruption, respectively. The NRWM might be unstable before the TMs are destabilized, a subject requiring further investigation.

References

[1] H. Strauss and JET Contributors, Effect of Resistive Wall on Thermal Quench in JET Disruptions, Phys. Plasmas **28**, 032501 (2021)

[2] H. Strauss, Thermal quench in ITER disruptions, Phys. Plasmas **28** 072507 (2021)