The Physics of Edge Resonant Magnetic Perturbation in Hot Tokamak Plasmas*

T.E. Evans in collaboration with the DIII-D Team, General Atomics

Resonant magnetic perturbation (RMP) experiments in DIII-D have demonstrated that the dynamics of pedestal plasmas, especially the coupling between transport and stability, are strongly modified by small changes in the edge magnetic topology. Edge localized RMPs alter the plasma rotation, E_r well, and ELM behavior. Large Type I ELMs have been completely eliminated at ITER relevant collisionalities, $\nu_e^* < 0.1$, with $dB_r(11,3)/B \sim 3x10^{-4}$ and a broad (~14% in normalized poloidal magnetic flux ψ_N) vacuum stochastic layer, resulting in an externally controlled quiescent H-mode (ECQH-mode). During ECQH-modes, changes in the edge particle and energy confinement compared to an ELMing H-mode contradict theoretical expectations. In contrast, at $\nu_e^* \sim 1$ with $dB_r(11,3)/B$ about equal to the intrinsic field-errors ($1x10^{-5}$), large Type I ELMs are suppressed without altering the confinement, pedestal profiles, or H-mode E_r well by increasing the frequency and amplitude of small intermittent transport events. This level of RMP produces isolated island chains spanning the pedestal, combined with a thin (~3% in ψ_N) vacuum stochastic separatrix region. Detailed calculations of the edge magnetic topology reveal the formation of a complex web of homoclinic tangles during the RMPs. Heat and particle flux measurements confirm the existence of these tangles and demonstrate a clear correlation between the RMPs and tangle formation. These results demonstrate that relatively small RMPs can be used to control the dynamics of the pedestal over a wide range of parameters and that they may provide an attractive ELM control option for future devices such as ITER with low ν_e^* pedestals.

*Supported by US DOE under DE-FC02-04ER54698.