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Modification of H-mode Pedestal Instabilities in the DIII-D Tokamak[1]

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The high edge-localized pressure pedestal that is a key driver of improved confinement in the tokamak H–mode results in edge localized MHD instabilities (ELMs). ELMs result in large heat pulses into the divertor region, perturbations that can prevent formation of internal transport barriers, and triggering of neoclassical tearing modes. Experiment and theory indicate that "type I" ELMs are low toroidal mode number (n) kink/peeling modes driven by the high edge pressure gradient ($P'_{\rm edge}$) and the accompanying bootstrap current density. Observed values of $P'_{\rm edge}$ at the ELM threshold are as high as five times the predicted first regime stability limit for ideal infinite-n ballooning modes. The ideal infinite-n ballooning mode is usually stable in the pedestal region because the second stable regime is locally accessible, but large changes in ELM character have been produced by eliminating this second regime access. In discharges with either very high or low squareness shape there is no second stable regime access predicted in the pedestal region. In the experiment, $P'_{\rm edge}$ is equal to the first regime limit, and the ELM amplitude is reduced dramatically, consistent with a shift to higher n instabilities more like high n ballooning than low n kink modes. In standard single-null and double-null divertor discharges with edge second stable regime access, an exceptionally large low-n instability is often observed at the end of the ELM-free period. Methods investigated to avoid this severe initial ELM include injection of a deuterium pellet to start the ELMing phase early in the growth of the pedestal and the use of impurity gas injection to reduce $P'_{\rm edge}$ through enhanced radiation. During the phase of continuous type I ELMs, the pedestal height and $P'_{\rm edge}$ have been modified through changes in the triangularity, δ. Higher δ yields higher $P'_{\rm edge}$, pedestal height and improved confinement.

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