Tolerable ELMs at High Density in DIII–D*

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We describe edge-localized-modes (ELMs) obtained at high density on DIII–D with characteristics acceptable for future large tokamaks. ELMs are problematic for future divertor operation because the resulting intense pulse of heat to the divertor has the potential to produce unacceptable target plate erosion. A previous study [1] of ELMs at low to moderate density on DIII–D and JET finds the energy released at each ELM scales with the magnitude of the edge pressure pedestal. This scaling indicates that ELMs tolerable for divertor operation are only consistent with a much lower edge pressure pedestal than that desired for high confinement. However, on DIII–D we find the previous low density scaling is invalid at the higher densities expected for future large tokamak operation. On DIII–D the energy released at each ELM is >30% of the pedestal electron energy for an edge pedestal density ≤40% of the Greenwald density, n_{GW}. The pedestal electron energy is defined as the electron pressure at the top of the pedestal multiplied by the plasma volume. As the pedestal density increases to ≥70% of n_{GW}, the ELM energy decreases to <5% of the pedestal electron energy. The height of the pedestal pressure decreased only slightly over this density range through the use of divertor pumping and moderate midplane gas puffing.

The smaller ELMs at high density remain in the Type I regime with the corresponding robust edge pedestal gradients. The smaller ELM energy loss results from a decrease in perpendicular transport at the ELM instability. At low density both the pedestal electron density and temperature are strongly perturbed by the ELM, as measured by edge Thomson scattering. However, at high density the electron temperature is unaffected while the density perturbation remains constant. The smaller ELMs are also characterized by a much lower magnetic fluctuation level. These characteristics are consistent with a higher toroidal mode number (*n)* ELM instability that is more localized to the edge region. The higher *n*-number ELMs might result from changes to edge stability caused by a lower edge bootstrap current at higher edge density and collisionality. Resistive corrections to ideal MHD may also slow the growth rate of the ELM. Implications of the scaling of these effects to future large tokamaks will be discussed.

The ELM characteristics also have implications for fueling H–mode plasmas at high density. The constant particle loss at each ELM implies a much higher required fueling rate at high density. As the ELM frequency also increases with heating power, adequate fueling for high performance high density plasmas is even more difficult. The scaling of ELM particle loss for future large tokamaks will also be discussed.

[1] A.W. Leonard et al., J. Nucl. Mater. **266-269** 109 (1999).

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