Edge Stability of Small-ELM Regimes in NSTX*

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NSTX has observed unstable modes with characteristics similar to the edge harmonic oscillation (EHO) coincident with transition to a small-ELM regime. The EHO has been hypothesized to be a saturated kink driven unstable by toroidal rotational shear that provides sufficient transport near the plasma edge to keep the edge pressure below the peeling-ballooning stability limit. In standard aspect ratio tokamaks, the EHO leads to ELM-free operation, in contrast to this small-ELM regime observed at low-A in NSTX. These small ELMs do not have a measurable effect on the plasma stored energy (<< 1%), so this is a desirable mode of operation for future experiments. Transition to this regime is associated with a downward biased plasma as evidenced by drsep < -5 mm. Soft x-ray emission indicates that these modes are localized just inside the pedestal. Microwave reflectometry shows increased density fluctuations in the pedestal correlated with the appearance of this mode. The lowest order mode rotates at the plasma rotation frequency, indicating n=1, and harmonics up to n=3 have been observed simultaneously with the n=1, as determined by the rotation frequency of the higher harmonics. Stability analysis during the observed modes indicates instability to n=1-3 with n=3 having the highest growth rate and unstable mode eigenfunctions peaked near the plasma edge. Rotational shear has been shown to shift the most unstable mode to lower-n, possibly explaining the observation of n=1 being the predominant mode. Significant rotational shear has been observed at the mode location in these small ELM discharges, consistent with the rotational destabilization of the EHO. In contrast, discharges with similar shape and pedestal pressure without the edge instability and with large type-I ELMs have reduced rotational shear at the pedestal.

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