Pedestal characterization and stability of small-ELM regimes in NSTX

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An instability near the plasma edge known as the edge harmonic oscillation (EHO) is thought to enable access to the ELM-free QH-mode in tokamaks, which is a highly desirable operational regime for ITER because of the avoidance of periodic ELM heat loads. 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. NSTX has observed unstable modes with similar characteristics to the EHO coincident with transition to a small-ELM regime. These small ELMs do not have a measurable effect on the plasma stored energy ($<< 1\%$). 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 and are correlated with increased density fluctuations in the pedestal as measured by microwave reflectometry. 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.