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Multi-field/-scale interactions of turbulence with neoclassical tearing modes and impact on plasma confinement in the DIII-D tokamak[1]

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We present the first localized measurements of ITG scale temperature and density fluctuations and TEM scale density fluctuations modified by an m=2, n=1 magnetic island. These islands are formed by a Neoclassical Tearing Mode (NTM) deep in the core plasma at the q=2 surface. NTMs are important as they often degrade confinement and lead to disruption. This is the first experimental confirmation of a long-standing theory prediction [1] of decreased local small-scale turbulence levels across large-scale magnetic islands. Our measurements capture a mean reduction of turbulence inside (and enhancement just outside) the island region during island evolution. Additionally, in the island saturated state, the fluctuations at the O-point are observed to be reduced compared to the X-point [2]. These measurements allow the determination of the turbulence length scale at the island separatrix that is predicted to affect NTM stability [3]. A novel, non-perturbative measurement technique finds reduced cross-field electron thermal diffusivity (by 1-2 orders of magnitude) at the O-point, consistent with the local turbulence reduction. Initial comparisons to the GENE non-linear gyrokinetic code are promising with GENE predicting the observed turbulence reduction inside the island and increase just outside the island and replicating the observed scaling with island size. These results allow the validation of gyrokinetic simulations modeling the interaction of multi-scale phenomena as well as have potential implications for improved NTM control.

[1] McDevitt and Diamond, PoP, 13, 032302 (2006)
[2] L. Bardczi et al, PRL 116 215001 (2016)
[3] Hornsby et al, PPCF, 57, 05418 (2015)

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