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The effects of weakly 3D equilibria on the stability and turbulent transport of tokamak pedestals

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It has been widely demonstrated experimentally that externally applied resonant magnetic perturbations (RMPs) can substantially modify the properties of tokamak pedestals. In this work we demonstrate that perturbations of experimentally relevant magnitudes can have an O(1) effect on the marginal stability boundaries for ideal MHD ballooning modes and the heat flux driven by ITG instabilities. It has recently been established that RMPs can induce 3D flux surface deformations by exciting stable kink modes to finite amplitude, even when strong screening of the resonant field occurs. These deformations are usually only a few percent of the minor radius, but have a potent and generally destabilizing effect on pedestal stability. Local 3D equilibrium theory is employed to show how the deformations modify the normal curvature and local magnetic shear. We will show how helical Pfirsch-Schlüter currents can strongly modulate the local magnetic shear near rational surfaces. The sensitivity of infinite-n ideal MHD ballooning stability to these deformation-induced effects is calculated as a proxy for the onset of KBM turbulence. The effect on ITG turbulence is assessed using a newly developed "full-surface" version of the GENE code that has been designed for 3D configurations. We will show how 3D deformations enhance the ion heat flux driven by ITGs, which may be able to explain recent measurements of the sensitivity of turbulent density fluctuations to RMP fields. A hypothesis for ELM suppression will be presented, based on strong helical local shear modulations causing enhanced transport near the pedestal top. Using M3D-C1 linear response calculations to model experimentally relevant tokamak equilibria, we will quantify the magnitude of the 3D effects as well as their sensitivity to various experimental knobs.