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New Frontiers In Trapped-Electron-Mode Turbulence

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In tokamak core plasmas, trapped electron modes (TEMs) and their associated turbulence have long been identified as a central driving mechanism of heat and particle flux in electron-heated scenarios. Plasma parameters and magnetic geometries very different from such standard cases, however, can showcase new and important aspects of TEM turbulence; here, three examples are discussed. First, the outer radii of improved-confinement Madison Symmetric Torus reversed-field pinch discharges exhibit strong pressure gradients, which can overcome magnetic shear stabilization to drive TEM turbulence with exceptionally strong zonal flows. The resulting large Dimits shift collapses upon the inclusion of residual tearing fluctuations that short out the zonal flows to a significant degree. Second, on the low end of the magnetic shear spectrum, TEMs are seen in simulations of Helically Symmetric eXperiment stellarator plasmas. As before, zonal flows result from density gradient drive and affect turbulent saturation, despite indications that zonal flow shearing is insufficient, indicating catalyzed energy transfer to stable modes as the dominant process. The latter is furthermore supported by the nonlinear coalescence of a coherent structure comprised of stable eigenmode amplitudes. Third, the steep gradients in tokamak pedestal scenarios are able to bring about new excitation states whereby TEMs can take on tearing-parity structures, while remaining clearly distinct from microtearing modes. Such TEMs require a non-zero bounce average perturbation, which can be the result of spatial or temporal decorrelation as well as asymmetric magnetic geometries, all of which are more common in large-gradient regions in the plasma edge. An improved understanding of such highly excited TEMs may help understand pedestal microturbulence and predict H-mode performance in future reactors.