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Rotation and kinetic resonance effects on the spherical tokamak ideal-wall limit[1]

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Achieving plasma pressures above the no-wall kink stability limit is an important requirement for advanced operating scenarios in conventional and spherical tokamak plasmas. Previous comparisons between MISK and MARS code calculations and NSTX experiments have shown the resonances between particle motion and plasma rotation can have a strong stabilizing effect on the resistive wall mode (RWM). However, comparatively little effort has been placed on understanding possible kinetic modifications of the "plasma mode," i.e. the mode that is unstable above the ideal-wall limit. For the first time, plasma mode stability has been systematically investigated for rapidly-rotating and high-beta spherical tokamak plasmas obtained in the NSTX device using the MARS-K linear kinetic MHD stability code. The MARS-K code includes the effects of rotation and dissipation self-consistently, and calculations indicate that as the toroidal rotation is increased to experimental values in the absence of kinetic dissipation, an n=1 plasma mode is destabilized by a combination of rotation shear (Kelvin-Helmholtz-like drive) and plasma pressure gradient. The identification of rotation-shear-driven instabilities is not possible with the MISK code which uses a perturbative approach based on non-rotating ideal MHD. Plasma mode stability can also be modified by kinetic dissipation, and precession-resonance damping can provide plasma mode stability at high rotation, but only for small plasma-wall gap. Importantly, the inclusion of all drift-kinetic resonances (precession, bounce, and transit) can further increase plasma mode stability and improve agreement between predicted stability limits and experimentally measured stability thresholds. Overall, these results indicate that rotation and kinetic resonance effects are important for determining the effective ideal-wall limit in rapidly-rotating high-beta plasmas.

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