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Destabilization of High-Field-Side Micro-Instabilities by Large Shafranov Shift in Present and Future Devices[1]

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A new gyrokinetic study of internal transport barrier (ITB) stability shows that large Shafranov shift can destabilize high-field-side (HFS) instabilities in addition to stabilizing conventional drift-ballooning modes. Recent analysis [1] of a typical DIII-D high βp discharge shows that while the high local Shafronov shift (as quantified by α ˜-q2Rdβ/dr) in the ITB region is able to suppress all the conventional drift-ballooning instabilities, it also destabilizes micro-tearing modes (MTM), which become the unique instability limiting the ITB kinetic gradient. Interestingly, the destabilized MTM is found to be a slab-like mode whose eigenfunction peaks in the high field side (HFS), with a mode structure requiring extremely high grid resolution to accurately capture. These results provide the first direct validation of MTM transport levels as predicted by nonlinear gyrokinetics for measured core ITB parameters. Moreover, this finding demonstrates that there are potential limits to confinement improvements that can be achieved through α stabilization, independent of global stability considerations. Extrapolation to future tokamak regimes suggests that while the HFS MTM mode is likely to be stabilized due to reduced collisionality, other electrostatic slab-like HFS modes will be destabilized by large values of α and act as dominant instabilities. A detailed gyrokinetic analysis shows how the effective "squeezing" of the bad curvature region by large α (the mechanism which leads to stabilization of conventional drift-ballooning modes) also opens a window to destabilization of HFS modes. This work supported by US DOE under DE-SC0018287. [1] X. Jian et al., Phys. Rev. Lett. 123, 225002 (2019)

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