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Torque balance analysis in real-time of rotating MHD for disruption prediction and avoidance in KSTAR

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Advanced tokamak reactors require a low disruptivity ceiling to reach commercial viability. The damaging impact of plasma disruptions on machine components can greatly reduced the lifetime of a device. A precursor to disruptions is the locking dynamic of rotating MHD events that are often neoclassical tearing modes (NTM). The drag of electromagnetic and fluid viscosity torques can cause the slowing down of NTM's with a saturated island width and lock them to the wall reference frame. A balance of the driving torque from the NBI, and drag from perpendicular viscous diffusion drag and electromagnetic forces on the mode, as well as its inertia is used to model the mode rotation dynamics. Threshold rotation frequencies below which the mode rotation is expected to lead to a locking serve as a disruption forecaster. Mode identification is computed most accurately by Fourier analysis of a toroidal array of magnetic probes, or using simpler approaches generally more amenable to real-time calculation. From the rotation, the torque components are then calculated based on conditions for the expected drag torque ratios at the mode onset, changes in frequency, and Mirnov signal amplitudes. This technique is employed for offline and real-time analysis of KSTAR plasmas with potential to signal use of active mode control or disruption mitigation systems. *This research was supported by the U.S. Department of Energy under contracts DE-SC0018623 and DE-SC0016614.

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