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Towards a comprehensive model of the *m*=1 mode in tokamaks

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We are developing the Extended MHD code, M3D [1], to provide a comprehensive model of global stability phenomena in tokamaks and other confinement devices. Toward that end, we have initially focused attention on the (1,1) mode, or sawtooth, as this is often the precursor to other MHD activity. The CDX-U tokamak is an attractive testbed for such simulation studies since the machine is relatively small and low-temperature, thus reducing resolution requirements. It is also very well diagnosed for a small device, with excellent spectroscopic data in particular. CDX-U exhibits a variety of *m*=1 activity, including classical Kadomtsev-like activity, a rotating 1/1 snake in the core coupled with a 2/1 island at the periphery, and the onset of disruption. In the M3D studies, we have focused on the nonlinear physics that couples the primary (1,1) mode to subsidiary modes. A large enough (monster) sawtooth can drive enough other modes unstable to cause a wide region of stochasticity, leading to a plasma disruption. We have employed new analysis tools to monitor the size of the sideband islands that are formed following the *m*=1 sawtooth reconnection. These tools allow quantification of the conditions that can lead to chaos. Other properties of the stochastic state that are calculated are the KAM surface, the Lyapunov exponent, and the fractal dimension.

[1]W. Park, *et al.*, Phys. Plasmas **6**, 1796 (1999).