

## Novel features of 1/1 modes in Ohmic and RF heated plasmas

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New high-resolution spectroscopic imaging diagnostics permit studies of  $m=1/n=1$  instabilities in the plasma core with unprecedented temporal and spatial resolution. Long-lived impurity snakes in Ohmic plasmas in Alcator C-Mod begin as a broad, slowly growing 1/1 kink of the central impurity-ion density as the safety factor  $q$  drops below unity, that gradually undergo a seamless transition to a large helical crescent-island-like structure inside  $q<1$ , with a regularly sawtoothed hot, low-impurity-density central core. The details of their evolution and accompanying sawtooth oscillations suggest different density and temperature dynamics, not a pressure-driven process [1,3].

Many of these features arise naturally from nonlinear interactions in 3D MHD when density and temperature evolve separately [4]. A different type of 1/1 mode observed recently in C-Mod is a short-lived fishbone-like kink-mode oscillations of the electron density that appear during Lower Hybrid Current Drive [5]. Like the impurity snake, the mode forms and grows as a broad 1/1 central density kink with a nearly circular cross section, starting when the  $q<1$  region is small. It also propagates toroidally in the counter current direction and its frequency is comparable with that of the sawtooth precursors and the core toroidal rotation. It can coexist, in a different way, with sawtooth crashes. Generally it appears during a sawtooth ramp as periodic oscillations that grow, saturate, and finally damp before the sawtooth crash. It may also connect into the crash as a hybrid mode or form a train of consecutive bursts that appear when the sawtooth instability is apparently suppressed, which suggests that the two 1/1 modes have independent driving mechanisms [6]. This work was performed under US DoE contracts DE-FC0299ER54512, DE-AC02-09CH11466 and DE-FG03-96ER-54373.

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