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Quasi-steady multiple flux tubes induced by localized current perturbation in toroidal plasma[1]

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Quasi-steady helical modes with dual, triple, or more flux tubes are easily produced by localized current drive in the core of *sawtoothing* plasma on the KSTAR tokamak [1, 2]. Individual flux tubes have $m/n = 1/1$ helicity, co-rotate around the magnetic axis, and later merge into a single $m = 1$ mode. The merged mode eventually crashes with rapid collapse of the core pressure and the next cycle repeats the same pattern, exhibiting sawtooth-like oscillations in the core pressure. The generation mechanism of multiple flux tubes (MFTs) has been studied in two different approaches to understand the observed trend that the number of flux tubes increases as the current drive location moves away from the magnetic axis up to about the magnetic surface of the safety factor $q = 1$ at the mode collapse: (1) nonlinear reduced MHD simulation with a localized current source modeling the time-varying interaction between the current source and flux tubes [3] and (2) linear MHD simulation with a prescribed q profile with a radially localized current blip. Both studies show that MFTs can be produced only in plasmas with nearly flat q profile close to unity, *suggesting the collapse of the $m = 1$ mode (i.e., sawtooth crash) is complete.* Recent observation of long-lived MFTs induced by localized current drive in non-sawtoothing plasma suggests that q profile evolution toward lower-m instability is required for the merging and crash of MFTs.

[1] G.S. Yun et al., Phys. Rev. Lett. 109,145003 (2012)
[2] G.H. Choe et al., Nucl. Fusion 55, 013015 (2015)
[3] A. Bierwage et al., Nucl. Fusion 55, 013016 (2015)

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