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EX/P4-14: On the Formation and Stability of Impurity-generated 'Snakes' in Alcator C-Mod

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A suite of novel spectroscopic imaging diagnostics have facilitated the determination of the perturbed radiated power and impurity density inside the (1,1) 'snakes' with unprecedented temporal and spatial resolution, and made it possible to infer, for the first time, the perturbed profiles of the impurity density, plasma pressure, Zeff, and resistivity at the center of these helical modes. The observations show that in the early phase of C-Mod Ohmic discharges, snakes typically form as a growing, kink-like 1/1 helical impurity density structure with a nearly circular cross section. The circular kink structure then makes a seamless transition to a crescent-like impurity density structure that resembles the 1/1 magnetic island formed by a resistive internal kink and endures for the life of the snake. Periodic sawtooth crashes are observed during both phases. We thus offer a novel explanation for the formation of impurity-induced 'snakes' which is not in agreement with the widely accepted model developed by Wesson, which explains the formation of these modes by a plasma current density perturbation from a localized temperature loss at the $q=1$ rational surface. In particular, the conditions for finding a saturated island cannot be inferred from an extended Modified Rutherford formalism as assumed up to now, but by considering an enhanced impurity density, plasma pressure and resistivity at the center of the island as the main stabilizing effects in agreement with 3D non-linear MHD models. Although the formation mechanism of these impurity-induced 'snakes' is different than the ones which are induced by pellet-injection, our experimental result and interpretation may also explain the increased stability of pellet-induced 'snakes' which have been observed in fusion devices such as conventional tokamaks, spherical tori and reversed field pinches. This work was performed under US DoE contracts DE-FC02-99ER54512 at MIT and DE-AC02-09CH11466 at PPPL.

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