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Physics of flux closure during plasmoid-mediated reconnection in Coaxial Helicity Injection

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In a low-aspect-ratio Spherical Torus (ST), and in particular in an ST-based fusion reactor, due to the restricted space for a central solenoid, elimination of the central solenoid, and thus non-inductive current-drive techniques, is necessary. Transient Coaxial Helicity Injection (CHI) is a leading candidate for plasma start-up and current formation in NSTX-U. In NSTX, transient CHI has generated over 200 kA of toroidal current on closed flux surfaces without the use of the conventional central solenoid. To correctly model current generation and to better understand the physics of CHI start-up, comprehensive resistive MHD simulations have been conducted for the NSTX and NSTX-U
geometries. It has been shown that magnetic reconnection has a fundamental role in the plasma start up and current formation in NSTX/NSTX-U. Here, we report two major findings from these CHI simulations: 1) formation of an elongated Sweet-Parker (S-P) current sheet and a transition to plasmoid instability has for the first time been demonstrated by simulations of CHI experiments and 2) a large-volume flux closure, and large fraction conversion of injected open flux to closed flux in the NSTX-U geometry have also now been demonstrated for the first time. This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Fusion Energy Sciences under Award Numbers DE-SC0010565 and DE-FG02-99ER54519.

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