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Plasmoids formation in a laboratory and large-volume flux closure during simulations of Coaxial Helicity Injection in NSTX-U[1]

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In NSTX-U, transient Coaxial Helicity Injection (CHI) is the primary method for current generation without reliance on the solenoid. A CHI discharge is generated by driving current along open field lines (the injector flux) that connect the inner and outer divertor plates on NSTX/NSTX-U, and has generated over 200 kA of toroidal current on closed flux surfaces in NSTX. Extrapolation of the concept to larger devices requires an improved understanding of the physics of flux closure and the governing parameters that maximizes the fraction of injected flux that is converted to useful closed flux. Here, through comprehensive resistive MHD NIMROD simulations conducted for the NSTX and NSTX-U geometries, two new major findings will be reported. First, formation of an elongated Sweet-Parker current sheet and a transition to plasmoid instability has for the first time been demonstrated by realistic global simulations. [F. Ebrahimi and R. Raman, PRL 114, 205003 (2015)] This is the first observation of plasmoid instability in a laboratory device configuration predicted by realistic MHD simulations and then supported by experimental camera images from NSTX. Second, simulations have now, for the first time, been able to show large fraction conversion of injected open flux to closed flux in the NSTX-U geometry. [F. Ebrahimi, R. Raman Nuclear Fusion 56, 044002 (2016)] Consistent with the experiment, simulations also show that reconnection could occur at every stage of the helicity injection phase. The influence of 3D effects, and the parameter range that supports these important new findings is now being studied to understand the impact of toroidal magnetic field and the electron temperature, both of which are projected to increase in larger ST devices.

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