**Objectives**

- Transient CHI is used as a *solenoid-free* plasma start-up method in NSTX and NSTX-U.
- Comprehensive 3-D resistive MHD NIMROD simulations have been conducted for the NSTX and NSTX-U geometries.
- To study the physics of fast flux closure and magnetic reconnection in order to achieve the maximum flux closure and plasma start-up current.

**Accomplishments**

- Two mechanisms for flux closure:
  - Sweet-Parker (S-P) type reconnection (electromagnetic forces cause oppositely directed field lines to come closer in injector region and reconnect)
  - New plasmoid mediated reconnection also observed (the S-P current channel becomes unstable at high Lundquist number and breaks up into plasmoids that merge), see Fig. 2.
- A transition to plasmoid instability has for the first time been predicted by simulations in a large-scale toroidal fusion plasma [Ebrahimi & Raman PRL 2015]
- Motivated by the simulations, experimental camera images have been revisited and suggest the existence of reconnecting plasmoids in NSTX

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**Impact**

3-D 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, Ebrahimi & Raman NF 2016, and Ebrahimi et al. to be submitted.

**Fig.1** Left: Poloidal flux in NIMROD simulations. Large volume poloidal flux closure, about 70% of the initial injected flux is closed; Right: fast camera images during NSTX experiments.

**Fig.2** Poincare plot and current density during simulation with plasmoids.