EX-W

Demonstration of 200 kA CHI Startup Current Coupling to Transformer Drive on NSTX

B.A. Nelson[1], R. Raman[1], T.R. Jarboe[1], D. Mueller[2], L. Roquemore[2], V. Soukhanovskii[3], and the NSTX Research Team[2]

[1]*University of Washington, Seattle WA USA*
[2]*Princeton Plasma Physics Laboratory, Princeton NJ USA*
[3]*Lawrence Livermore National Laboratory, Livermore, CA, USA*

Discharges started by Transient Coaxial Helicity Injection (CHI) in NSTX [R. Raman *et al.*, *Nuc. Fus.*, **49**, 065006 (2009)] have attained peak currents up to 300 kA for the first time. When these discharges are coupled to induction, it has produced up to 200 kA additional current over inductive-only operation. For the first time, the CHI-produced toroidal current that couples to induction has continued to increase with the energy supplied by the CHI power supply at otherwise similar values of the injector flux. Furthermore, CHI in NSTX has shown to be energetically quite efficient, producing a plasma current of about 10 A/Joule of capacitor bank energy. These results indicate the potential for substantial current generation capability by CHI in NSTX and in future toroidal devices. Solenoid-free startup is a critical issue for future spherical tori (STs) designs, as the central-axis region is limited both physically and by the nuclear environment. Toroidal magnetic configurations based on the conventional tokamak might also benefit if the central solenoid could be eliminated.

In earlier work, up to 50 kA of toroidal plasma current produced by the non-inductive method of CHI was successfully coupled to inductive ramp-up in NSTX. However, in these experiments, the CHI current that could be successfully coupled was limited by impurity production in the divertor region and the occurrence of absorber arcs (*i.e.* parasitic discharges across the insulating gap in the upper divertor). In recent experiments, extensive conditioning of the divertor plates that serve as the electrodes for the CHI discharge greatly reduced impurity production during CHI. Further, by energizing, for the first time, the axisymmetric absorber field-nulling coils [T.R. Jarboe, *Fus. Tech.* **15**, 7 (1989)] located near the upper divertor in NSTX, the absorber arcs could be delayed or suppressed. In addition to these combined improvements, the use of evaporated coatings of lithium on the plasma facing components in NSTX [H.W. Kugel *et al.*, *J. Nuc. Mat.*, **390-391**, 1 (2009)] increased the current at the hand-off from CHI to induction to nearly 200 kA. Later in the inductive ramp-up, the discharges with CHI applied reached significantly higher plasma current than discharges with only the inductive loop voltage applied.

These results represent a factor of four improvement in the magnitude of current that was ramped up by induction, a factor of three increase in the initial start-up current, and the first results demonstrating flux savings in NSTX. The CHI started discharge, when coupled to induction produces about 60% more current than the comparison inductive-only case. These results confirm that CHI could be an important tool for non-inductive start-up in next-step STs. This work was supported by U.S. DOE contract #DE-FG02-99ER54519