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Demonstration of Inductive Flux Saving by Transient CHI on NSTX

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Experiments in NSTX have now demonstrated the saving of central solenoid flux equivalent to 200kA of toroidal plasma current after coupling plasmas produced by Transient Coaxial Helicity Injection (CHI) to inductive sustainment and ramp-up of the toroidal plasma current [R. Raman, et al., PRL 104, 095003 (2010)]. This is a record for non-inductive plasma startup, and an important step for developing the spherical torus concept. With an injector current of only 4kA and total power supply energy of only 21 kJ, CHI initiated a toroidal current of 250 kA that when coupled to 0.11 Vs of induction ramped up to 525 kA without using any auxiliary heating, whereas an otherwise identical inductive-only discharge ramped to only 325 kA. This flux saving was realized by reducing the influx of low-Z impurities during the start-up phase through the use of electrode conditioning discharges, followed by lithium evaporative coating of the plasma-facing surfaces and reducing parasitic arcs in the upper divertor region through use of additional shaping-field coils. As a result of these improvements, and for the first time in NSTX, the electron temperature during the CHI phase continually increased with input energy, indicating that the additional injected energy was contributing to heating the plasma instead of being lost through impurity line radiation. Simulations with the Tokamak Simulation Code (TSC) show that the observed scaling of CHI start-up current with toroidal field in NSTX is consistent with theory, suggesting that use of CHI on larger machines is quite attractive. These exciting results from NSTX demonstrate that CHI is a viable solenoid-free plasma startup method for future STs and tokamaks. This work supported by U.S. DOE Contracts DE-AC02-09CH11466 and DE-FG02-99ER54519 AM08.