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### **Solenoid-free Plasma Start-up in NSTX using Transient CHI<sup>1</sup>**

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For the first time, 160 kA of closed flux current is produced in the National Spherical Torus Experiment (NSTX), without using a solenoid. Transient Coaxial Helicity Injection (CHI) is used to generate the self-contained equilibrium; an important step in the production of a starting equilibrium for solenoid free operation. Until now, almost all tokamaks and spherical torus experiments have relied on a central solenoid to produce the plasma current needed to confine the plasma. An alternate method for plasma startup is essential for developing a fusion reactor based on the spherical torus concept and could also reduce the cost of a tokamak reactor. In this method, an external power supply rapidly drives current between coaxial electrodes, in the presence of toroidal and poloidal magnetic fields, which causes the poloidal flux connecting the lower divertor plates to rapidly expand into the chamber. When the injected current is rapidly decreased, magnetic reconnection occurs near the electrodes, with the toroidal plasma current forming closed flux surfaces, which is assessed using Thomson scattering electron temperature measurements and by equilibrium reconstructions. The method has previously been demonstrated in the HIT-II device [R. Raman *et al.*, Phys Rev. Lett. 90 075005 (2003)]. The significance of these new NSTX results, which represent a proof-of-principle demonstration of the concept, are (a) demonstration of the process in a vessel volume thirty times larger than HIT-II on a size scale closer to a reactor, (b) a remarkable multiplication factor of 60 between the injected current and the achieved toroidal current, compared to six in previous experiments, and (c) for the first time, fast time-scale visible imaging of the entire process that shows discharge formation, disconnection from the injector and the reconnection of magnetic field lines to form closed flux.

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