Solenoid-free Plasma Start-up in NSTX using Transient CHI

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Until now, almost all tokamaks and spherical torus plasma confinement devices have relied on a solenoid, through the center of the device, to produce the plasma current needed to confine the plasma. Recently, a process called Coaxial Helicity Injection (CHI) has been applied in the National Spherical Torus Experiment for an unambiguous proof-of-principle demonstration of closed-flux current generation of 60kA without the use of the central solenoid. In the CHI method, a plasma current is rapidly produced by forming a discharge between coaxial electrodes connected to an external power supply in the presence of toroidal and poloidal magnetic fields. The initial poloidal field configuration is chosen such that the plasma rapidly expands into the chamber. When the injected current is rapidly decreased, magnetic reconnection occurs near the injection electrodes, with the toroidal plasma current forming closed flux surfaces. The CHI technique has previously been studied in smaller experiments, such as the HIT-II device at the University of Washington. Such 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 future tokamak reactor as well. The significance of these results are (a) demonstration of the process in a vessel volume thirty times larger than the HIT-II concept exploration device, on a size scale more comparable 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) significantly more detailed experimental measurements, including, 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. Results from these and other new experiments in NSTX will be presented. This work is supported by US DOE contracts DE-FG03-9ER54519 and DE-AC02-76CH03073.