Coupling of Coaxial Helicity Injection plasma start-up to inductive ramp-up on the National Spherical Torus Experiment

D. Mueller[1], R. Raman[2], T.R. Jarboe[2], B.A. Nelson[2], B.P. LeBlanc[1], M. G. Bell[1], A.L. Roquemore[1], and V.A. Soukhanovskii[3]

[1]*Princeton Plasma Physics Laboratory, Princeton, NJ, U.S.A.*

[2]*University of Washington, Seattle, WA, U.S.A.*

[3]*Lawrence Livermore National Laboratory, Livermore, CA. U.S.A.*

The small bore in the spherical tokamak (ST) design permits little or no room for inclusion of a central solenoid to provide inductive current drive, therefore, it is essential that alternative techniques to start-up, ramp-up and sustain the plasma current be demonstrated for the ST. Transient coaxial helicity injection, CHI, was first demonstrated on the Helicity Injected Torus-II [1]. The plasma current, I_p, from transient CHI start-up plasmas on the National Spherical Torus Experiment (NSTX) has been ramped up using inductive current drive with flux supplied by the central solenoid. So far, the CHI plus inductively driven current of 525 kA is approximately 200 kA greater than is achieved with the same inductive flux from the central solenoid alone. Low Z impurity radiation, primarily from oxygen and carbon, can reduce the electron temperature and make it impossible to ramp-up the current with induction. The sources of these impurities are both the lower and upper divertor plates. The lower divertor plates serve as the electrodes for the CHI initiation, while the upper divertor plates are adjacent to the flux-absorbing CHI insulator gap (absorber). The use of lithium evaporation from the LITER system [2] has greatly improved the performance of CHI start-up. The reduction of impurities has allowed plasmas with electron temperature, T_e, and density, n_e, of ~40 eV and ~0.7×10^{19} m^{-3} respectively to be achieved, these are similar to inductive start-up at the same current. When the CHI discharge is formed it grows rapidly from the injector region to fill the vessel volume and can provide a low impedance path across the absorber gap. The parasitic current across this gap does not aid in start-up but does provide a source of impurities. Use of coils located near the absorber to provide field that prevents the plasma from reaching the absorber has been successful in reducing this impurity influx.

References

[1] R. Raman, et al. Phys. Rev. Lett. **90**, 075005 (2003).

[2] H. Kugel, et al., J. Nucl. Mat. **390-391**, 1 (2009).