Demonstration of Plasma Startup by Coaxial Helicity Injection

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The first successful results on the transfer of a Coaxial-Helicity-Injection-(CHI) produced discharge to inductive operation are reported. CHI assisted plasma start-up is more robust than inductive only operation and reduces volt-seconds consumption. After hand-off for inductive operation, the initial 90 kA of CHI produced current drops to 40 kA, then ramps up to 170 kA, using only 30 mVs, more than 30% higher than that produced by induction alone. CHI start-up in discharges where the central solenoid is *in the process* of being charged up have resulted in record current of 248 kA using only 52 mWb of central solenoid flux. This result is particularly important for a burning plasma ST where it is undesirable to have a current flat-top in the ohmic solenoid after it has been charged. Even though the transformer induces a negative voltage during the charging phase, it does not adversely affect the CHI start-up process. These results were obtained on the HIT-II spherical torus experiment (major and minor radius of 0.3 m and 0.2 m and an elongation of 1.75).

Successful transfer of a CHI produced discharge for inductive operation can be achieved by the following three steps: First is the generation of a high current plasma discharge in which the radiated power during the current decay phase is of comparable magnitude to the input Ohmic power during hand-off for inductive operation. The second step is to rapidly reduce the injector flux. The third step is to apply inductive drive during the lower-radiated-power phase, while there is still substantial CHI produced plasma current.

Three important new results are presented. First, it is shown that CHI produces closed field line plasma current that persists after the injector current has been reduced to zero. Second it is shown that electrode based CHI plasmas can be made sufficiently clean for fusion research purposes. This result is demonstrated by inductively ramping up the current in a CHI started discharge using only 3 V. Finally, CHI is shown to be a viable plasma start-up method for an ST. This result is demonstrated not only from the fact that a CHI produced plasma couples to an inductive drive, but that in doing so it reduces volt-seconds consumption.