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Physics of Intense Electron Current Sources for Helicity Injection[1] E.T. HINSON, J.L. BARR, M.W. BONGARD, M.G. BURKE, R.J. FONCK, B.T. LEWICKI, J.M. PERRY, A.J. REDD, G.R. WINZ, University of Wisconsin-Madison — DC helicity injection (HI) for non-solenoidal ST startup requires sources of current at the tokamak edge. Since the rate of HI scales with injection voltage, understanding of the physics setting injector impedance is necessary for a predictive model of the HI rate and subsequent growth of I_p. In Pegasus, arc plasma sources are used for current injection. They operate immersed in tokamak edge plasma, and are biased at ~1–2 kV with respect to the vessel to draw current densities $J \sim 1$ kA/cm^2 from an arc plasma cathode. Prior to tokamak formation, impedance data manifests two regimes, one at low current (< 1 kA) with $I \sim V^{3/2}$, and a higher current mode where $I \sim V^{1/2}$ holds. The impedance in the $I \sim V^{3/2}$ regime is consistent with an electrostatic double layer. Current in the $I \sim V^{1/2}$ regime is linear in arc gas fueling rate, suggesting a space-charge limit set by n_{edge}. In the presence of tokamak plasmas, voltage oscillations of the order 100s of volts are measured during MHD relaxation activity. These fluctuations occur at the characteristic frequencies of the $n = 1$ and $n = 0$ MHD activity observed on magnetic probes, and are suggestive of dynamic activity found in LHI simulations in NIMROD. Advanced injector design techniques have allowed higher voltage operation. These include staged shielding to prevent external arcing, and shaped cathodes, which minimize the onset and material damage due to cathode spot formation.

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M.W. Bongard
mbongard@wisc.edu
University of Wisconsin-Madison

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