Processes that govern helicity injection in the SSPX spheromak

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The physical processes that govern the gun-voltage and give rise to field generation by helicity injection are surveyed in the Sustained Spheromak Physics experiment (SSPX[1]) using internal magnetic field probes and particular attention to the gun-voltage. SSPX is a gun-driven spheromak, similar in many respects to CTX, although differing substantially by virtue of a programmable vacuum field configuration. Device parameters are: diameter=1m, I_{tor}~400kA, T_e~120eV, t_{pulse}~3ms. SSPX is now in its third year of operation and has demonstrated reasonable confinement (core χ_e~30m^2/s [2]), and evidence for a beta limit ($<\beta_e>_{vol}$~4%), suggesting that the route to high temperature is to increase the spheromak field-strength (or current amplification, $A_I=I_{tor}/I_{inj}$). Some progress has been made to increase A_I in SSPX (A_I=2.2 [3]), although the highest A_I observed in a spheromak of 3 [4] has yet to be beaten. We briefly review helicity injection as the paradigm for spheromak field generation. SSPX results show that the processes that give efficient injection of helicity are inductive, and that these processes rapidly terminate when the current path ceases to change. The inductive processes are subsequently replaced by ones that resistively dissipate the injected helicity. This result means that efficient helicity injection can be achieved by harnessing the inductive processes, possibly by pulsing the gun. A pulsed build-up scenario is presented which gives A_I>3 and emphasizes the need to maintain reasonable confinement while the field of the spheromak is being built.

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