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Predictive Power-balance Modeling of Pegasus and NSTX-U Local Helicity Injection Discharges[1] J.L. BARR, M.W. BONGARD, M.G. BURKE, R.J. FONCK, E.T. HINSON, J.M. PERRY, A.J. REDD, D.J. SCHLOSSBERG, University of Wisconsin-Madison — Local helicity injection (LHI) with outer poloidal-field (PF) induction for solenoid-free startup is being studied on PEGASUS, reaching $I_p \leq 0.175$ MA with 6 kA of injected current. A lumped-parameter circuit model for predicting the performance of LHI initiated plasmas is under development. The model employs energy and helicity balance, and includes applied PF ramping and the inductive effects of shape evolution. Low-A formulations for both the plasma external inductance and a uniform equilibrium-field are used to estimate inductive voltages. PEGASUS LHI plasmas are created near the outboard injectors with aspect ratio (A) $\approx$ 5–6.5 and grow inward to fill the confinement region at $A \leq 1.3$. Initial results match experimental $I_p(t)$ trajectories within 15 kA with a prescribed geometry evolution. Helicity injection is the largest driving term in the initial phase, but in the later phase is reduced to 20–45% of the total drive as PF induction and decreasing plasma inductance become dominant. In contrast, attaining $\sim$1 MA non-solenoidal startup via LHI on NSTX-U will require operation in the regime where helicity injection drive exceeds inductive and geometric changes at full size. A large-area multi-injector array will increase available helicity injection by 3–4 times and allow exploration of this helicity-dominated regime at $I_p \sim 0.3$ MA in PEGASUS. Comparison of model predictions with time-evolving magnetic equilibria is in progress for model validation.

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