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Developing attractive means of initiating current without using magnetic induction from a central solenoid is a critical scientific and technical challenge facing the spherical tokamak (ST). The PEGASUS program has focused on developing the physics basis and predictive models for non-solenoidal tokamak startup using local helicity injection (LHI). LHI utilizes compact, edge-localized current sources (A_inj ≤ 8 cm², I_inj ≤ 8 kA, Vinj ≤ 1.5 kV) for plasma startup and sustainment, and can initiate more than 200 kA of plasma current in a low-field (B_T ~ 0.15 T), near-unity aspect ratio (A) ST. Typical LHI plasmas have n_e ≤ 3x10^19 m^-3 and T_e ≤ 150 eV, values comparable to Ohmic L-mode discharges at these B_T values in PEGASUS. I_p increases linearly with increased helicity input. Choice of injector location allows a tradeoff between poloidal induction and helicity injection (HI) dominated current drive. In both cases, significant anomalous ion heating is seen, and has been found to scale as expected from twofluid reconnection theory. Internal magnetic measurements show three main features are present in LHI: a ~2040 kHz peak from n = 1 line-tied kink motion of the injector current streams; an intermediate region near 0.6 MHz with higher fluctuation power; and broadband turbulence for f < 3 MHz. In HI dominated LHI plasmas, a novel regime is found at low B_T ≤ 0.075 T where the n = 1 activity is suppressed, power at frequencies f > 0.1 MHz increases, and current drive efficiency is improved. This suggests that high-frequency, short wavelength activity could play a critical role in the current drive process. A major upgrade is underway to convert the PEGASUS facility into a solenoid-free ST with a four-fold increase of B_T to 0.6 T. The upgraded experiment (URANIA) will have a new mission: to examine and compare several leading non-solenoidal tokamak startup candidates in a single experiment. Initial techniques under consideration are: LHI; sustained and transient coaxial helicity injection; electron Bernstein wave electron heating and current drive; and poloidal field induction. The overarching goal is to establish routine non-inductive plasma startup that can project to MAclass startup on NSTX-U and beyond.
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