

Non-inductive plasma startup and current profile modification in Pegasus spherical torus discharges

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The Pegasus Toroidal Experiment enables the study of tokamak plasma formation, sustainment, and stability at very low aspect ratio. Inductively-driven Pegasus discharges have achieved a toroidal beta of up to 25% and a record normalized tokamak current I_N of 12. Recent Pegasus experimental studies are directed at developing techniques for non-inductive startup and current profile modification for future ST and tokamak applications.

Non-solenoidal startup using magnetic helicity injection with washer-stack current-sources (plasma guns) has produced discharges with up to 50 kA of toroidal current, and these gun-driven discharges have been successfully coupled to Ohmic drive. This startup technique is scalable to other devices, and does not intrinsically require significant modifications to the vacuum vessel. These non-inductive startup plasmas show strong evidence of poloidal flux amplification and closed flux surfaces, including plasma L/R decay times which are four times greater than for non-closed flux surface discharges and persistence of the toroidal current after shutoff of the plasma guns. The gun-driven discharges relax into a tokamak equilibrium with closed toroidally averaged flux surfaces, significant $n=1$ activity, toroidal current amplification up to three times the vacuum windup, and the maximum I_p determined by simple helicity balance. This non-inductive startup technique extends the Pegasus operating space, allowing more efficient use of the Ohmic flux and operation with higher plasma current and increased pulse length.

Due to the relatively low toroidal field and high current density, Pegasus discharges are predicted to be unstable to ideal peeling-ballooning modes, even at low beta, without transitioning to H-Mode. Experimentally, the visible onset of edge filaments coincides with magnetic oscillations (20-100 kHz, low- to intermediate- n), believed to be caused by peeling modes. Improved diagnosis of these modes, and mode control through current profile and edge density modifications, are important near-term goals of ongoing Pegasus research.

Sorting categories: A2 (high beta), A5 (other improvements in magnetic confinement)

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