Temporal evolution of a 3D QSH equilibrium in MST using advanced diagnostics and V3FIT

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In high current and low density (large Lundquist number) RFP plasmas, the island associated with the innermost resonant tearing mode can grow to sufficient width that it envelops the magnetic axis, leaving behind a helical axis. This Quasi-Single Helicity (QSH) state is observed to have improved core particle and temperature confinement and reduced tearing mode amplitude at larger radii. Presented here are experimental efforts to characterize any role magnetic shear may play in the formation and sustainment of QSH.

A time series of magnetic equilibrium reconstructions of a 3D helical state in the MST reversed-field pinch (RFP) suggest the development of significant localized magnetic shear between the helical core and nearest tearing mode resonant surface, potentially reflecting a decoupling of the unstable core mode from higher-order damped tearing modes. Reconstructions show there can be significant shear during the ramp up from a multi-helicity state to the QSH state which reduces in amplitude and broadens in width in a sustained QSH state. 3D equilibrium reconstructions on MST are based on advanced internal diagnostics such as high-rep-rate Thomson scattering, multi-chord laser polarimetry and interferometry, and an array of external magnetic diagnostics. Data from these diagnostics are used in V3FIT non-axisymmetric MHD equilibrium reconstruction code [1], originally developed for stellarators and now adapted for use in RFP plasmas. The 3D equilibria are computed with VMEC [2].

Magnetic shear is a key element of recent theoretical work that seeks to explain the emergence and persistence of the 3D state, which, while robust in experiments is not yet completely understood. Recent modeling work that invokes a shear-suppression mechanism for QSH formation and sustainment resulted in a predator-prey model with temporal dynamics that qualitatively reproduce the behavior observed in the experiment [3], in particular the increased persistence of the QSH state with increased plasma current. Work supported by USDOE.

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