



Contribution ID: 24

Type: poster

The Current Drive Mechanism of Helicity Injection

Helicity injection is a non-inductive current drive method used in the startup of Spherical Torus and Spheromak. The mechanism of current drive is explained by Taylor relaxation by which the plasma will relax into the Taylor state. The most important feature of Taylor state is that $\lambda \equiv j \cdot B/|B^2|$ is constant all over the plasma. However, the research of how the relaxation occurs is still under progress. We propose a mechanism of Taylor relaxation through nonlinear interaction of tearing mode. We find that the nonlinear interaction of tearing mode will drive different amounts of current at different sides of rational surface, which modifies λ to be flat near the rational surface. Therefore, when many tearing modes are destabilized and overlap each other, λ will be constant all over the overlap area, which means the equilibrium state will relax into Taylor state. We also observed Taylor relaxation process in NIMROD simulation of the free decay phase of cylindrical plasma. The nonlinear modification effect of tearing modes is identified in the simulation.

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Session Classification: Poster session