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Oscillating Field Current Drive Experiments in the Madison Symmetric Torus[1]

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Oscillating field current drive (OFCD), or AC magnetic helicity injection, is a technique proposed to drive a steady-state current in a toroidal plasma using sinusoidal toroidal and poloidal loop voltages. If the phase between the two loop voltage oscillations is nonzero, net magnetic helicity is injected into the plasma. We have extended the detailed dynamical picture of OFCD through 3D nonlinear MHD computation at a large Lundquist number of $5 \cdot 10^5$, which elucidates the important role of current diffusion by magnetic fluctuations. In MST, we have applied OFCD at modest input power (several hundred kW) to demonstrate current drive of about 10% of the total current. The OFCD-generated current is roughly consistent with theoretical expectations, based on either the 3D MHD computation or a 1D relaxed-state model. We investigate the dependence of the current drive on the phase δ between the two voltages. Maximal current is driven for $0 < \delta < \pi/2$, and not for the phase of maximal helicity injection ($\pi/2$). The difference might be attributed to the effect of OFCD on magnetic tearing fluctuations that during OFCD are observed to be smallest when the current drive is maximal. The penetration of the oscillatory field and the evolution of the current density profile during OFCD are shown through equilibrium reconstructions which use Motional Stark effect and laser Faraday rotation data for the internal magnetic field. The current profile oscillates during the OFCD cycle and becomes more centrally peaked over several cycles. Studies of the confinement properties are beginning, in particular using a new multipoint Thomson scattering system.

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[2]In collaboration with the MST team.