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The three-dimensional MHD dynamics of ac helicity injection

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Abstract

AC helicity injection is a technique to sustain current in plasmas in which the current distribution relaxes by internal processes. The dissipation of magnetic helicity is balanced by magnetic helicity injected by oscillating the surface poloidal and toroidal loop voltages.[1] The technique is considered for current sustainment in the reversed field pinch (RFP), and similar helicity injection techniques are being studied for the spherical tokamak and spheromak. The efficiency of the current drive, the resulting current profile, and the magnetic fluctuations in these configurations are determined by 3-D MHD dynamics. We have completed a comprehensive 3-D MHD computational study of helicity injection in the RFP.[2] Our results are compared with analytical solution of 1-D models. In a classical 1-D plasma, the oscillating voltages produce a steady current in the plasma, driven by the dynamo effect associated with the oscillating axisymmetric velocity and magnetic fields. This current is localized to the plasma edge region. With full 3-D dynamics, tearing fluctuations relax the plasma current toward the core, by the tearing mode dynamo, yielding a steady plasma current over the entire cross-section. The tearing fluctuations are comparable in magnitude to those that occur in standard RFP plasmas, although a global mode resonant at the edge occurs. We have also studied partial current drive by helicity injection, and find that ac helicity injection at appropriate frequency flattens the current density profile such that magnetic fluctuations are reduced.

[1] M. K. Bevir and J. W. Gray, in Proceedings of the Reversed-Field Pinch Theory Workshop, Los Alamos, NM, 1981, Vol. III, p. A-3.
[2] F. Ebrahimi, S. C. Prager, J. S. Sarff, and J. C. Wright, to appear in Phys. Plasmas **10** (2003).