Theory and application of magnetic self-organization

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Magnetic self-organization in a driven-relaxed plasma is a process by which magnetic energy and helicity injected at small spatial scales from a source are transported to and accumulated on system-scale magnetic fields via small amplitude fluctuations. In the laboratory, it has been used to generate plasma confining magnetic fields in spherical tokamak, spheromak, and reversed field pinch. In astrophysical settings, it explains the origin of radio lobe magnetic fields, which are powered by the accretion disk of super-massive black holes. Over the past few years, we have developed a comprehensive understanding of the physics underlying magnetic self-organization. In this talk, I will describe two essential aspects of the physics: (1) the dynamics of drive-relaxation; (2) the resonant coupling between source and driven-relaxed plasma that facilitates magnetic self-organization. The theory allows a thorough understanding of flux and current amplification in laboratory applications and points out new directions in spherical tokamak reactor startup and spheromak reactor studies. It also provides an alternative paradigm for the formation of large scale astrophysical magnetic fields.

References:

1. “Force-free Magnetic Relaxation in Driven Plasmas," Tang X.Z. and Boozer A.H., Physical Review Letters 94, 225004 (2005).

2. “Constrained Resonance in Magnetic Self-Organization," Tang X.Z. and Boozer A.H., Physical Review Letters 95, 155002 (2005).

3. “Driven resonances in partially relaxed plasmas,” Tang X. Z., Physical Review Letters 98, 175001 (2007).

4. “Scale-up of spherical tokamak solenoid-free startup by co-axial helicity injection,” Tang X. Z. and Boozer A. H. Physics of Plasmas 14, 100704 (2007).

5. “Reactor Prospect of Spheromak Concept by Electrostatic Helicity Injection,” Tang X.Z. and Boozer A. H. Physics of Plasmas, to appear (2008).

6. “Self-Organization of Radio Lobe Magnetic Fields by Driven Relaxation,” Tang X.Z., Astrophysical Journal 679, 1000 (2008).