SUSTAINABILITY

*Shaping Magnetic Fusion*

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Magnetic fusion, a potential long-term source of electricity, occurs when isotopes of hydrogen, deuterium, and tritium combine at temperatures of about 200 million degrees C. At such temperatures, the electrons and the ions separate and form an electrically conducting gas called a plasma, which can be confined by magnetic fields in a chamber, shaped like an inner tube, called a torus. In a symmetrical torus, the electric current that creates the magnetic field runs both through external coils surrounding the chamber, and through the plasma. Helical shaping of the torus allows the confining magnetic field to be produced entirely by currents in the coils.

This shaping in effect forms a cage around the plasma making it more robustly stable as well as eliminating the difficulty of driving currents in the plasma. However, the helical shaping greatly complicates the issue of obtaining adequate plasma confinement. Major issues are the reduction of the power required to sustain the plasma so that power can be supplied by the deuterium-tritium reactions, and the achievement of plasma conditions consistent with engineering requirements, such as robust plasma stability.

Allen Boozer has developed the design principles by which the magnetic field strength in a helically shaped torus could be made consistent with adequate particle confinement. These ideas have been tested in the Helically Shaped Experiment (HSX) at the University of Wisconsin and will be tested in the $1 billion W7-X experiment under construction in Germany.

Boozer has played a critical role in the understanding of how the detrimental effects on confinement of an asymmetry as small as $10^{-4}$ can be controlled. He was a co-inventor of a method of driving currents in plasmas, electron cyclotron current drive, which allows the current to be driven in the precise spatial location it is needed. He also showed that thermodynamics implies the power required to drive the current in an axisymmetric torus is sufficiently large to place strong constraints on the plasma performance. Boozer has developed theoretical techniques that are used to enhance the performance of axisymmetric plasmas through feedback.

Boozer was one of two recipients who received the 2010 Hannes Alfvén Prize—the best-known European award in plasma physics. Boozer and his colleague, Jürgen Nührenberg, from the Max Planck Institute for Plasma Physics (Greifswald, Germany) were honored at the June 2010 conference of the Plasma Physics Division of the European Physical Society, which established the award in 2000. The Society cited them for "outstanding work in the formulation of criteria allowing stellarators to improve fast particle and neoclassical energy confinement." The result of their work is considered important for magnetic fusion energy, in which isotopes of hydrogen (deuterium and tritium) fuse to release energy while confined in a magnetic field at a high temperature.

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