Wave Effect Discovery May Lead to Improved Fusion Machines

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Wave-plasma interaction can produce faster rotating plasmas and more efficient reactors.

An unusual wave effect in rotating plasma has been discovered by researchers Abraham Fetterman, a Princeton University graduate student and Princeton Professor Nat Fisch at the DOE Princeton Plasma Physics Laboratory (PPPL). This innovation results in sustaining fusion reactors and plasma centrifuges at considerably higher speeds with greater efficiency. Abraham Fetterman will deliver an invited talk at the American Physical Society--Division of Plasma Physics meeting this year titled**,** “Wave-induced Supersonic Rotation in Mirrors” regarding this new process.

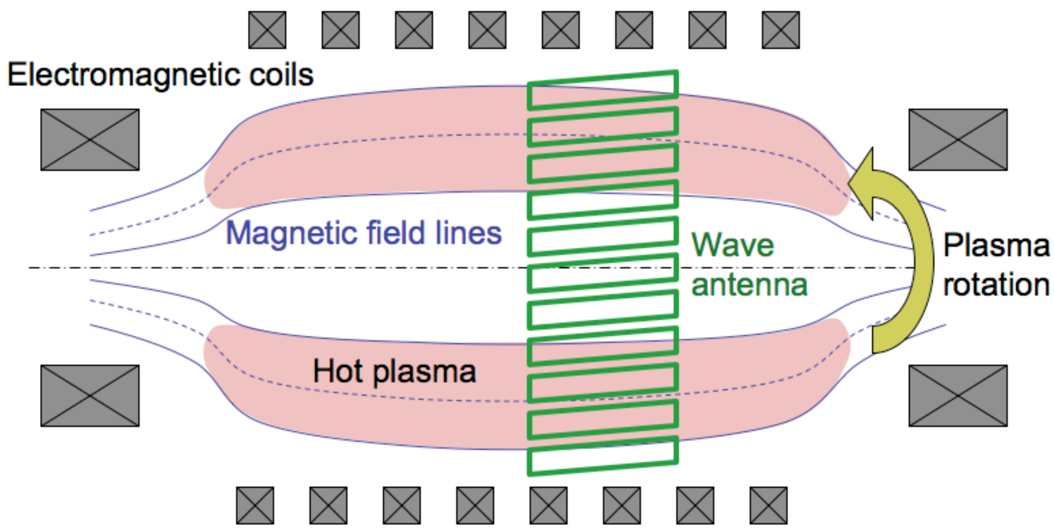
In a centrifugal mirror fusion reactor, the plasma rotates supersonically, providing additional plasma confinement. To produce the supersonic rotation in mirror machines, a radial electric field must be maintained. Normally, end-plate electrodes produce this field, but the electrodes must make contact with the hot plasma, which limits the rotation speed.

Fetterman and Fisch show how particles in supersonically rotating plasmas can be diffused by waves in both potential energy and kinetic energy, thus maintaining the radial electric field within the plasma. The ions can be alpha particles, the charged byproduct of a deuterium-tritium reaction, and the energy to sustain the wave can be derived from the alpha particle kinetic energy, making the reactor self-sustaining. A similar effect can improve a gas centrifuge. Here, the ions must be externally driven, since the alpha particle energy is absent, but the very high rotation speeds that might be obtained without electrodes will make the centrifugal separation more effective.

The plasma physicists have published on the key effect before in 2008, "Alpha-Channeling in a Rotating Plasma," Phys. Rev. Lett. 101, 205003 (2008). Since then, they have improved the concept by identifying suitable wave candidates and collaborating with graduate student Andrey Zhmoginov. The alpha-channeling effect refers to using randomly phased waves to extract energy from alpha particles by tying diffusion in energy to diffusion in space, with removal only of the low-energy alpha particles at a physical boundary. When low-energy alpha particle loss is enhanced, the wave is able to capture their kinetic energy as it removes the particles. The resulting surplus wave energy can be used to heat ions directly to create new alpha particles, making the reactor more efficient. The alpha-channeling effect was originally conceived for use in fusion devices called tokamaks (by Fisch and Rax), where the wave energy was imagined to heat ions and drive current, but the recent work by Fetterman and Fisch show this fundamental wave-particle phenomenon in plasma can be useful in simpler settings in more efficient ways.

Abstract: XI3.00001

Wave induced supersonic rotation in mirrors
Invited Speaker: Abraham Fetterman (Princeton University)
9:30 AM—10:30 AM, Friday, November 12, 2010
Grand Ballroom EF



A cross section of a rotating mirror for fusion. The plasma is confined by the magnetic field and rotates about the center axis. Supersonic rotation is maintained by waves produced by the antenna.