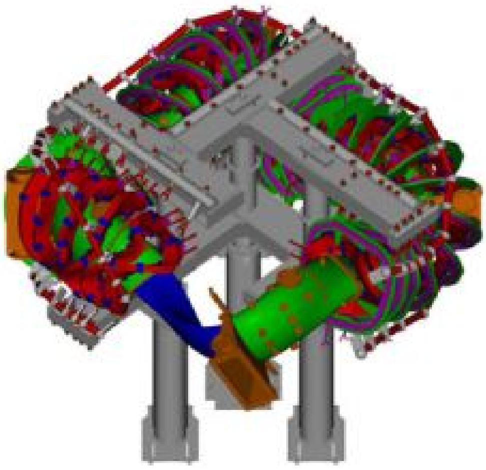
New stellerator a step forward in plasma research

9 March 2007



A picture of the helically symmetric experiment. Credit: HSX/University of Wisconsin-Madison

A project by University of Wisconsin-Madison researchers has come one step closer to making fusion energy possible.

The research team, headed by electrical and computer engineering Professor David Anderson and research assistant John Canik, recently proved that the Helically Symmetric eXperiment (HSX), an odd-looking magnetic plasma chamber called a stellarator, can overcome a major barrier in plasma research, in which stellarators lose too much energy to reach the high temperatures needed for fusion.

Published in a recent issue of *Physical Review Letters*, the new results show that the unique design of the HSX in fact loses less energy, meaning that fusion in this type of stellarator could be possible.

Plasma is very hot, ionized gas that can conduct electricity - essentially, it's what stars are made of. If heated to the point of ignition, hydrogen ions could fuse into helium, the same reaction that powers the sun. This fusion could be a clean, sustainable and limitless energy source.

Current plasma research builds on two types of magnetic plasma confinement devices, tokamaks and stellarators. The HSX aims to merge the best properties of both by giving a more stable stellarator the confinement of a more energetically efficient tokamak. "The slower energy comes out, the less power you have to put in, and the more economical the reactor is," says Canik.

Tokamaks, the current leader in the fusion race, are powered by plasma currents, which provide part of the magnetic field that confines the plasma. However, they are prone to "disruptions."

"The problem is you need very large plasma currents and it's not clear whether we'll be able to drive that large of a current in a reactor-sized machine, or control it. It may blow itself apart," says Canik.

Stellarators do not have currents, and therefore no disruptions, but they tend to lose energy at a high rate, known as transport. The external magnetic coils used to generate the plasma-confining field are partially responsible for the high transport rates in conventional stellarators. The coils add some ripple to the magnetic field, and the plasma can get trapped in the ripple and lost.

The HSX is the first stellarator to use a quasi-symmetric magnetic field. The reactor itself looks futuristic: Twisted magnetic coils wrap around the warped doughnut-shaped chamber, with instruments and sensors protruding at odd angles. But the semi-helical coils that give the HSX its unique shape also direct the strength of the magnetic field, confining the plasma in a way that helps it retain energy.

The team designed and built the HSX with the prediction that quasisymmetry would reduce transport. As the team's latest research shows, that's exactly what it does. "This is the first demonstration that quasisymmetry works, and you can actually measure the reduction in transport that you get," says Canik.

These results excited and relieved the researchers who have spent years working on the project. "We all thought the machine would do what it's turning out to do, but there are a million reasons why it might not: the theory might be wrong, (or) we might have built it badly," says Anderson. "But everything is panning out and supporting the fact that the ideas on which it was based were correct, and really points the way of the future for the stellarator."

The next step for the project is to establish how much symmetry in the coils is necessary to achieve low transport rates. They hope to make the coils easier to engineer, with the mindset that the principles used in the HSX could someday be incorporated into fusion generators, the reason that Anderson and his team began designing the HSX 17 years ago.

"It's an exciting field. It's something where one can contribute positively to mankind with an energy source that's completely sustainable, doesn't involve nuclear proliferation or radioactive waste, with a limitless fuel supply," says Anderson. "Plus, the machines look cool."

Link: Helically Symmetric eXperiment (HSX) -- www.hsx.wisc.edu/

Source: University of Wisconsin-Madison