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"Mug Handles" Help Get a Grip on Lower-Cost, Controllable Fusion Energy

A novel containment method requires less energy to maintain stable plasma confinement.

PROVIDENCE—Researchers around the world are working on an efficient, reliable way to contain the plasma used in fusion reactors, potentially bringing down the cost of this promising but technically elusive energy source. A new finding from the University of Washington could help contain and stabilize the plasma using as little as 1 percent of the energy required by current methods.

"All of a sudden the current energy goes from being almost too much to almost negligible," said Thomas Jarboe, a UW professor of aeronautics and astronautics. He presents the findings this week at the 54th Annual Meeting of the APS Division of Plasma Physics in Providence, Rhode Island

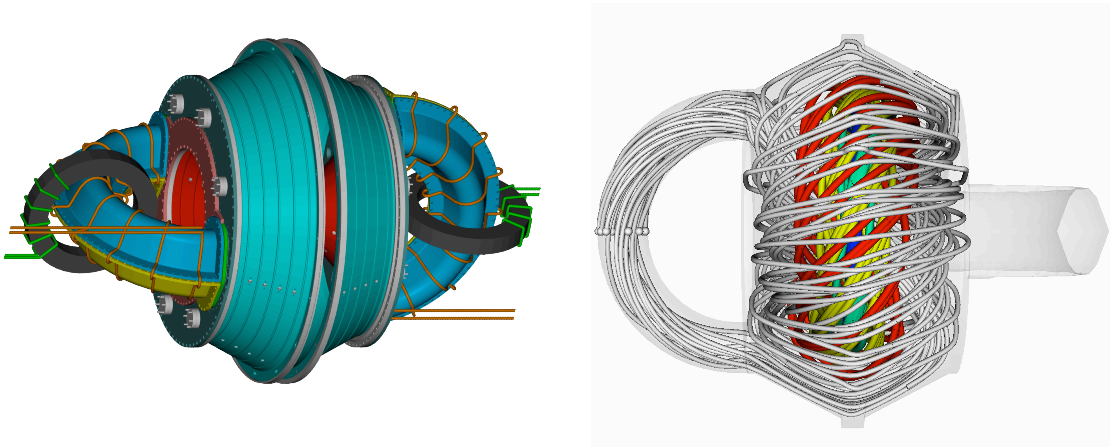
The new equipment looks like handles on a coffee mug—except they attach to a vessel containing a million-degree plasma that is literally too hot to handle.

Most people know about nuclear fission, the commercial type of nuclear power generated from splitting large atoms in two. Nuclear fusion, however, smashes two small atoms together, releasing energy without requiring rare elements or generating radioactive waste. Of course, there's a catch—smashing the atoms together takes a lot of energy, and scientists are still striving to get more energy out than they put in.

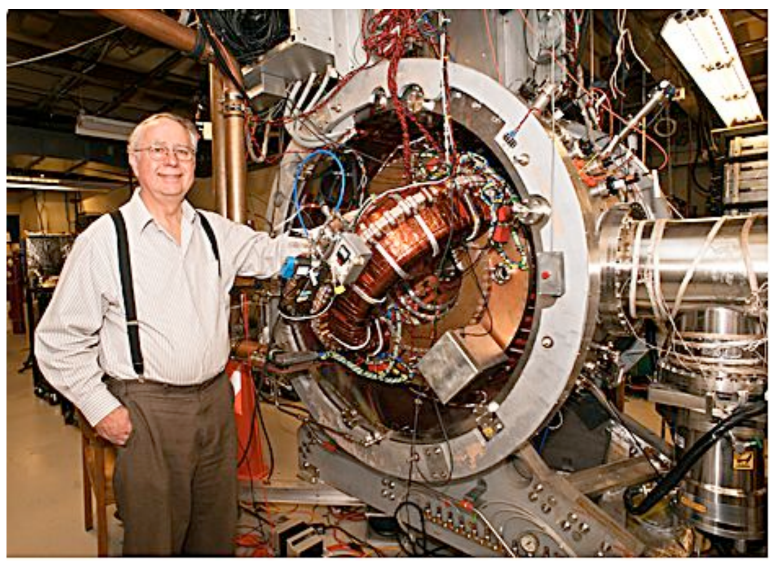
An international project in France, ITER, is building a multibillion-dollar fusion reactor to see whether a big enough reactor can generate fusion power. The reactor will inject high-frequency electromagnetic waves and high-speed hydrogen ions to sustain the plasma by maintaining an even hotter 100-million-degree operating temperature and enclosing it with magnetic fields.

"That method works," Jarboe said, "but we think our approach can lead to much smaller, more compact and cost effective fusion reactors."

For two decades Jarboe's team has worked on helicity injection as a more efficient alternative. Spirals in the plasma produce asymmetric currents that generate the right electric and magnetic fields to heat and confine the plasma within a magnetic "bottle." Keeping the plasma hot enough and sustaining those magnetic fields requires a lot of energy.



The HIT-SI machine (left) has the magnetic bottle region and two mug-handle dynamo drivers, which are electrically powered by connecting to the wires shown. The drivers drive current in the edge gray field lines (right). The currents that produce the colored field lines of the magnetic bottle are sustained by dynamo action. Below, Jarboe next to HIT-SI..



“We would drive it until it was unstable,” Jarboe said of his approach. “Like you twist up a rope, the plasma twists up on itself and makes the instability and makes the current drive.”

Results showed the UW strategy required less energy than other methods, but the system was unstable. In the case of plasma, unstable equilibrium means that a twist in the plasma could cause it to escape and potentially lead to a costly reactor shutdown. This instability was a major impediment to applying the UW method.

“The big issue is whether, when you distort the bottle, it will leak,” Jarboe said.

By contrast, in a stable equilibrium, any shift will tend to come back toward the original state, like a ball resting at the bottom of a bowl that will settle back where it started.

“Here we imposed the asymmetric field, so the plasma doesn’t have to go unstable in order for us to drive the current,” Jarboe said. “We've shown that we can sustain a stable equilibrium and we can control the plasma, which means the bottle will be able to hold more plasma.”

The UW apparatus uses two handle-shaped coils to alternately generate currents on either side of the central core, a method the authors call imposed dynamo current drive. Results show the plasma is stable and the method is energy-efficient, but the UW research reactor is too small to fully contain the plasma without some escaping as a gas. Next, the team hopes to attach the device to a larger reactor to see if it can maintain a sufficiently tight magnetic bottle.

The research is funded by the U.S. Department of Energy. Co-authors are Brian Nelson, research associate professor of electrical engineering; and research associate Brian Victor, research scientists David Ennis, Nathaniel Hicks, George Marklin and Roger Smith and graduate students Chris Hansen, Aaron Hossack, Cihan Ackay and Kyle Morgan, all in UW aeronautics and astronautics.

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Abstracts:

PP8.00061	**Progress on the HIT-SI3 Experiment**
Session	**PP8: Poster Session VI: NSTX, Field- Reversed Configurations, Other Magnetic Confinement; Intense LPI and FI; Beams and Coherent Radiation,** Hall BC, Wednesday, October 31, 2012, 2:00 PM–2:00 PM