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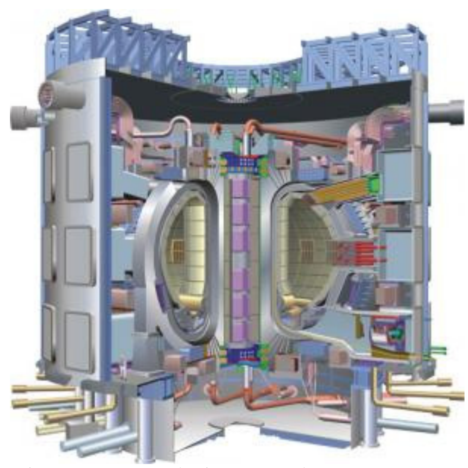
Physicists Persevere In Quest For Inexhaustible Energy Source

As gas prices soar and greenhouse gases continue to blanket the atmosphere, the need for a clean, safe and cheap source of energy has never seemed more pressing.

Scientists have long worked to meet that need, exploring alternative energy technologies such as wind and solar power. But, after decades of quiet progress, the spotlight is now on another potentially inexhaustible energy source.



The International Thermonuclear Experimental Reactor. (Image courtesy of ITER)

Seven countries signed an agreement in Brussels last week (May 24) to launch construction of the multibillion dollar International Thermonuclear Experimental Reactor (ITER) in southern France. The largest fusion-energy experiment ever conducted, ITER is the culmination of years of research by scores of scientists, and is poised to answer long-standing questions about the real-world viability of fusion energy. The United States, China, the European Union, India, Japan, the Republic of Korea and the Russian Federation are joint sponsors of the project, which will experimentally generate up to 500 million watts of energy.

An international collective of physicists and engineers is working to both complement and lend expertise directly to the ITER initiative - and researchers at the University of Wisconsin-Madison are firmly placed among them.

"[ITER] is a major threshold that we've been waiting to get to for 20 years," says Raymond Fonck, a UW-Madison professor of engineering physics and the chief scientist of ITER's U.S. project office. "The project is the No. 1 priority in fusion research in the country and the world, and essentially takes us to a regime we've never been to before."

Fusion energy describes the energy that is released when atomic particles "fuse" together to form heavier particles. The process is fundamental to our universe, fueling both the sun and the stars. Here on Earth, physicists have tried to harness the energy potential of nuclear fusion by working with plasma, essentially a collection of particles, such as hydrogen nuclei, that carry electric charge. Because hydrogen can be easily extracted from seawater - a cheap and abundant resource - scientists have been tantalized by the prospect of plasma one day serving as an inexhaustible fuel.

But plasma has to be very, very hot - on the order of millions of degrees - for its gas particles to efficiently collide and release energy. "Basically, we're trying to make a sun here on Earth," says Stewart Prager, a UW-Madison physics professor, who also advises the U.S. government on national fusion-energy research. "But it turns out to be one of the most difficult scientific problems in the world."

One of the biggest hurdles, of course, is finding a container that can hold searing hot plasma without burning down itself. Scientists have been working around the problem by using invisible magnetic fields to hold the plasma in place, but they are still searching for the most efficient and optimal ways to do it. UW-Madison scientists are delving into pure physics and engineering research questions surrounding the issue. Their work both complements ITER's goals and, in a sense, looks one step beyond it.

Prager and his team, for instance, run the Madison Symmetric Torus (MST) - the largest fusion-energy experiment on campus. Shaped like a donut, the MST holds plasma heated to 10 million degrees. But instead of using a strong magnetic field to hold the plasma, Prager is exploring whether weaker - and therefore more economical - magnetic fields could accomplish the same task. The work has led to new insights about properties of plasma, and, in turn, has given rise to unique partnerships with astrophysicists, who are using the MST to explore basic questions about the plasma around black holes, galactic discs and other mysterious happenings of the solar system.

"We are now starting to appreciate and explore links between plasmas in the lab and plasmas in the universe, which is really interesting," Prager says.

Working with a device known as Pegasus, Fonck and his group are also exploring weaker magnetic fields, but are approaching the issue in a different way. Unlike the donut shape of the MST, the plasma within Pegasus looks more like a ball with a small hole in it, which influences how the plasma behaves. Fonck's work relies on the same fundamental physics that is at the heart of ITER's design, and could one day lead to new methods for testing large-scale components in future fusion reactors.

David Anderson, a professor of electrical and computer engineering and another plasma researcher at UW-Madison, recently made waves when he designed a new device that holds plasma within a magnetic field, without an electric current in the plasma to power the field.

"The current is running in external wires and not in the plasma itself, and that represents a tremendous engineering advantage," says Anderson, who works with a plasma instrument known as the Helically Symmetric eXperiment, the only machine of its kind in the world. Plasma can become unstable in the presence of a current, so Anderson is exploring ways to trick the plasma into staying in place by twisting the surrounding magnetic field into a special - and highly complicated - shape.

"It's very exciting to work on something that's totally new and offers potential advantages to the field," says Anderson. "A lot of what we're all doing here in Wisconsin is looking for what the next research steps will be beyond ITER. In that way, we really do have a unique place in the world's fusion-energy research program."
