25 Tesla, world-record 'split magnet' makes its debut

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Interior parts for the split coil magnet were tested and retested to ensure the magnet’s structural integrity. Credit: Florida State University

A custom-built, $2.5 million "split magnet" system with the potential to revolutionize scientific research in a variety of fields has made its debut at the National High Magnetic Field Laboratory at Florida State University.

The world-record magnet is operating at 25 tesla, easily besting the 17.5 tesla French record set in 1991 for this type of magnet. ("Tesla," named for early 20th-century inventor and engineer Nikola Tesla, is a measurement of the strength of a magnetic field.) In addition to being 43 percent more powerful than the previous world best, the new magnet also has 1,500 times as much space at its center, allowing room for more flexible, varied experiments.

To offer some perspective on the strength of the new magnet, consider this: Twenty-five tesla is equal to a whopping 500,000 times the Earth's magnetic field. Imagine that much power focused on a very small space and you have some idea what the split magnet is capable of — and why both engineers and scientists at the magnet lab are so excited.

"The Mag Lab has developed numerous world-record magnets; however, the split magnet makes the largest single step forward in technology over the past 20 years," said Mark Bird, director of the laboratory's Magnet Science and Technology division.

For decades, scientists have used high magnetic fields to probe the unusual properties of materials under extreme conditions of heat and pressure. There are unique benefits that arise at especially high magnetic fields — certain atoms or molecules become more easily observable, for example, or exhibit properties that are difficult to observe under less extreme conditions. The powerful new split magnet system holds promise for even more breakthroughs at the very edge of human knowledge.

The new magnet was funded by the National Science Foundation and represents years of intense collaboration between the lab's engineering and research teams, headed by scholar/scientist Jack Toth of the Magnet Science and Technology staff.

The magnet's design required Toth's team to rethink the structural limits of resistive magnets — that is, those in which the magnetic field is produced by the flow of electric current. The project required that the engineers invent, patent and find sometimes-elusive builders for the technology that could carry their idea through. The result of their work, the new split magnet, features four large elliptical ports that provide scientists with direct, horizontal access to the magnet's central experimental space, or bore, while still maintaining a high magnetic field.

High-powered research magnets are created by packing together dense, high-performance copper alloys and running an electrical current through them. All of the magnet's forces are focused on the center of the magnet coil — right where Toth and his team engineered the four ports. Building a magnet system with ports strong enough to withstand such strong magnetic fields and such a heavy power load was once considered impossible.

To accomplish the impossible, Toth's team cut large holes in the mid-plane of the magnet to provide user access to the bore but maintain a high magnetic field. All of this had to be done while supporting 500 tons of pressure pulling the two halves of the magnet together and, at the same time, allowing 160,000 amps of electrical current and 3,500 gallons of water per minute to flow through the mid-plane. (The water is needed to keep the magnet from overheating.)

While the technological breakthroughs enabling the magnet's construction are important, the multidisciplinary research possibilities are even more exciting. Optics researchers in chemistry, physics and biology are poised to conduct research using the split magnet, while others are optimistic about the potential for breakthroughs in nanoscience and semiconductor research.

The magnet's first user, a scientist from Kent State University, has already begun conducting experiments.

"Among other research possibilities," said Eric Palm, director of the magnet lab's Direct Current User Program, "the split magnet will allow optics researchers unprecedented access to their samples, improve the quality of their data, and enable new types of experiments."

Provided by Florida State University

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