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Democracy Dies in Darkness

The machine behind the 'God particle' is on the hunt for dark matter

Researchers at CERN are firing up the Large Hadron Collider for the third time, hoping to make another historic discovery

By Pranshu Verma
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Ten years ago, a team operating the world's largest particle collider made history by discovering the Higgs boson particle, a finding key to understanding the creation of the universe, earning it the nickname the "God particle."

After a more than three year pause for upgrades, the accelerator, run by the European Organization for Nuclear Research, or CERN, is collecting data again. This time it's out to prove the existence of another mysterious substance — dark matter.

Though scientists largely believe dark matter is real, none have been able to see or create it. Data collection and power upgrades made to the particle smasher, called the Large Hadron Collider, could provide researchers one of their best chances to visualize and understand the substance.

"If we can figure out the properties of dark matter, we learn what our galaxy is made of," said Joshua Ruderman, an associate professor of physics at New York University. "It would be transformative."

Dark matter has fascinated physicists for decades. It is widely believed to make up a significant part of the universe, and learning more about it could provide clues as to how the universe came to be.

All the stars, planets and galaxies in the universe account for only 5 percent of the universe's matter, according to scientists at CERN. Roughly 27 percent of the universe is thought to be composed of dark matter, which does not absorb, reflect or emit light, making it extremely hard to detect. Researchers say it exists because they've seen its gravitational pull on objects — and have witnessed how it helps bend light.

Researchers are hoping the Large Hadron Collider can help. The collider was built over the course of a decade by the European Organization for Nuclear Research to help answer outstanding questions of particle physics. The machine is located roughly 328 feet underground in a tunnel near the French-Swiss border and the city of Geneva. Its circumference spans nearly 17 miles.

Inside the collider, superconducting magnets are chilled to roughly minues-456 degrees Fahrenheit — colder than space — while two particle beams traveling close to the speed of light are made to collide. Using advanced sensors and monitors, scientists analyze the substances created by those collisions, which replicate conditions similar to the Big Bang. It allows them to learn about the earliest moments of the universe.

The machine started working in September 2008 but has shut down multiple times for enhancements. For the past three years, engineers have upgraded the collider so it can detect more data and run at higher speeds. Now the accelerator can run at its highest energy level ever, 13.6 trillion electron volts, allowing scientists to run bigger, more complicated experiments that could yield new insights into particle physics.

“This is a significant increase,” said Mike Lamont, CERN’s director for accelerators and technology. “Paving the way for new discoveries.”

At the beginning of the universe, particles did not have mass, so scientists have long questioned how stars, planets and additional life were created. In 1964, physicists François Englert and Peter Higgs and others theorized a force field gave particles mass when they connected, but they couldn’t document the existence of the entity.

The discovery of the Higgs boson particle, a part of the hypothesized force field, won Englert and Higgs a Nobel Prize in physics.

The particle has fascinated scientists and the general public alike. CERN and the collider are featured prominently in the Dan Brown book and adapted movie “Angels & Demons.”

But now researchers want to answer more vexing questions, especially those surrounding dark matter.

During the Large Hadron Collider’s four-year experiment, scientists are hoping to find evidence of dark matter. As they fire up the machine, protons will spin at nearly the speed of light. The hope, researchers said, is that when they collide, it creates new particles resembling the properties of dark matter.

They also hope to learn more about how the Higgs boson particle behaves. On Tuesday, shortly after the collider began collecting data, scientists at CERN announced they’d found three new “exotic” particles that could provide clues as to how subatomic particles bind together.

“High-energy colliders remain the most powerful microscope at our disposal to explore nature at the smallest scales and to discover the fundamental laws that govern the universe,” said Gian Giudice, head of CERN’s theory department.

Ruderman, of New York University, said CERN’s quest to learn about dark matter and explain the origins of the universe has him eagerly awaiting the results from the experiment. The research excites him greatly. “It’s why I wake up in the morning,” he said.

Once data starts coming out from the experiment, Ruderman will see if it’s producing new particles. Even if it does, it will be hard immediately to tell if it is dark matter or not.

First, they will need to assess whether the particle in question emits light. If it does, then that makes it less likely it is dark matter. Second, the particle should show signs of existing for a long time and not decaying immediately, since dark matter should in theory be able to last billions of years. They also hope the particle behaves similarly to current theories of dark matter.

Ruderman said it could take more than four years to make the discovery.

If CERN scientists do not discover dark matter in the next four years, they have more upgrades in the works. The upgrades are likely to take three years after the current run stops, leaving the fourth round of data collection and experiments to start in 2029.

As planned, the trial could capture 10 times more data than previous experiments, according to CERN's website. But unraveling the universe's secrets isn't easy.

"This is hard," Ruderman said, "and something that could take a whole lifetime of exploration."