Shedding light on the existence of dark matter

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Elena Aprile

Some light has been shed on the search for dark matter.

A global team of scientists looking for evidence of the existence of dark matter announced that they found none from the leading candidates. The analysis of 13 months of data at the Gran Sasso National Laboratory (LGNS), a collaborative effort led by Elena Aprile, professor of physics at Columbia, provided no evidence for the existence of Weakly Interacting Massive Particles, the phenomenally-named WIMPs, that are the leading candidates for dark matter. This doesn't mean that dark matter doesn't exist, only that potential candidates can be ruled out.

The latest results draw from 225 days of gathering data, more than twice as much as was previously assessed in 2011. Such negative findings are an important step towards proving the existence of dark matter. By demonstrating what is not dark matter, researchers can further refine the realm of what might yet prove that dark matter does exist.

Cosmological observations consistently describe a universe where ordinary matter as we know it – people, the Earth, and planets – comprise only about 4 percent, with the rest being made up of new, as yet unobserved forms of so-called dark matter and dark energy. The Standard Model of physics, the theory that explains how all matter interacts with each other, also suggests that dark matter exists. It is thought that dark matter is made of clouds of exotic subatomic particles left by the Big Bang, the aforementioned WIMPS.

“We’ve mastered one the most promising technologies for making the next step in sensitivity required to see if dark matter is indeed made of new particles,” said Aprile. “It is hard for anyone to intuitively grasp that we live in a universe dominated by stuff which we cannot see—but how can anyone resist finding out what this stuff is which permeates us all? Whatever it is, we know it's out there in huge amounts. It can be hiding in places we are not even looking, but this only means that we must continue to search to test all possible scenarios until we find the truth.”

Aprile’s experiment utilizes an ultra-sensitive device, the XENON100, which measures tiny charge and light signals expected from rare collisions between WIMPs and the nuclei of xenon atoms. The detector, which was built at Columbia, consists of a stainless steel container filled with ultra-pure liquid xenon –one of the heaviest elements, three times the density of water – sandwiched between two highly sensitive cameras. It is located beneath 5,000 feet of rock at LGNS, part of Italy’s National Institute of Nuclear Physics facility some 80 miles from Rome, in a chamber of lead and copper to help filter out cosmic and background radiation that may otherwise be mistaken for WIMPS.

“As an experimentalist, I could not be more proud of the amazing performance of the XENON dark matter project,” said Aprile. “The new XENON100 results show that this detector is the most sensitive for the direct observation of particle dark matter. The absence of a signal in the larger data sample means even more rare interaction rates of the dark matter with normal matter. This makes the search more challenging and at the same time widens the gap between XENON and the other direct searches. It feels lonely but at the same time exciting to be at the forefront of this search.”

Aprile will continue to lead experiments with XENON100, as well as XENON1T, now under construction, which will be a larger, more massive, and even quieter detector than XENON100. In Aprile’s describes it, whereas the XENON100 is about the size of a room, the XENON1T will be the size of a house. The new experiment should either find evidence for WIMPs or push scientists to consider other forms of dark matter.

Provided by Columbia University

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