Producing Dark Matter

May 2 2006

"Colliders have been the tool of choice for particle physicists to look at smaller and smaller particles. All a sudden we are realizing that we can use them not only to understand things at smaller scales, but for understanding them as a whole." Jonathan Feng, an associate professor of physics at UC-Irvine, sees the potential the new CERN Large Hadron Collider (LHC) holds for understanding the make up of our universe.

"[It's] mostly made of dark matter and energy, which we don't really know about," he tells *PhysOrg.com*. "The thing about this collider is that it can help us understand dark matter."

Along with two colleagues, Shufang Su at the University of Arizona, and Fumihiro Takayama at Cornell University in Ithaca, NY, Feng proposes a way to use the massive LHC to produce dark matter in order to study its characteristics. "What we do know is by looking through telescopes," he says, "and we can tell that galaxies are spinning too fast if all you had is what you saw. They would fall apart without something else. So this is what we know is dark matter. All we know is that it is holding stuff together."

Using the LHC could change that. This collider, currently under construction outside Geneva, Switzerland, will be the largest scientific instrument on Earth. It is a particle accelerator and collider of massive proportions (it is housed in a tunnel with a circumference of 27 km) that will allow scientists to perform a variety of experiments. The collider is expected to begin operating in 2007, and is expected to allow physicists to answer a variety of questions about matter. Feng feels that the LHC offers the possibility to produce dark matter, and then to study it. In the paper published on *Physical Review Letters* on April 19th, Feng and his colleagues explain the possibility that dark matter is either composed of WIMPs or superWIMPs. And that the LHC is just the tool to detect these weakly interacting particles.

WIMP stands for “weakly interacting massive particle.” Feng explains that a WIMP is “kind of like a neutrino—you only know they are there because you can see that you are missing something.” The problem with WIMPs is that they may be hard to distinguish from background signals. “At the same time,” says Feng, “there is a range of possible production rates for WIMPs, and at the upper levels, it is possible to see the signal above the background.”

SuperWIMPs, on the other hand, would be much easier to see when produced in the LHC. A superWIMP is a particle that interacts mainly gravitationally, and so even more weakly than WIMPs. Nevertheless, superWIMPs create more obvious signals. “You can't see them directly,” Feng explains, “but you would make something that will decay into them. And these things will stick out like sore thumbs.” He pauses and then laughs: “What you would see is, instead of an electron, an electron on steroids barreling out of the detector.” Feng says that these particles are about a million times heavier than an electron. As with electrons, these particles could be examined in great detail, and their mass and charge measured. “Little by little we could begin pinning down the details of dark matter.”

But Feng is quick to point out that right now these are just theories. “They’ll begin experiments on this, among other things, in about eighteen months,” he says. And besides, WIMPs and superWIMPs are just two ideas of what dark matter might be made of. “People have hundreds of ideas of what dark matter could be.”

Feng, though, believes that WIMPs and superWIMPs offer the best possibilities. Both are classes of particles that include dozens of different types of particles. Additionally, computer generated models show that, when looked at in terms of particle decay since the Big Bang, WIMPs occur in the amounts that we know are needed to hold objects in the universe together. Additionally, theories that include additional spatial dimensions predict WIMPs and superWIMPs. “It is tantalizing,” says Feng, “because there are these particles, and they fit all of the profiles for dark matter.”

With the help of the CERN Large Hadron Collider, Feng sees the possibilities. “We are taking a conservative approach,” he explains, “and we’re not overly optimistic.” But he also recognizes that being able to produce dark matter here on earth would be very helpful in determining the actual characteristics of our universe. And the Hadron Collider offers that chance.

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Citation: Producing Dark Matter (2006, May 2) retrieved 27 April 2024 from
https://phys.org/news/2006-05-dark.html