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Machine could detect “dark matter,” physicists say

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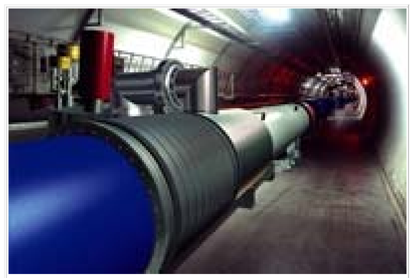
Special to World Science

A machine to start operating next year might finally detect the “dark matter” that pervades every galaxy but that no one can seem to identify, a newly published paper claims.

Dark matter is thought to be a substance that reveals no trace of itself except through its gravitational pull on objects that are visible.



The Large Hadron Collider, a new particle accelerator installed in a circular underground tunnel measuring 27 km (17 miles) around. It straddles the Swiss and French borders on the outskirts of Geneva. (Courtesy CERN)

Calculations show that every galaxy floats at the center of a blob of dark matter, estimated to account for over 80 percent of each galaxy’s weight.

The researchers are placing some hopes in the Large Hadron Collider, a device due to switch on next year, to detect dark matter.

The machine would probe the structure of matter in unprecedented depth by smashing particles up to reveal what’s inside them.

The most powerful such instrument to date, the collider would crash subatomic particles together at 99.999999 percent the speed of light. Collisions so furious would recreate the energetic conditions prevailing a fraction of a second after the Big Bang explosion thought to have given birth to the universe.

There are several theories on what dark matter is. A leading proposal holds it consists of hypothetical particles called WIMPS, or Weakly Interacting Massive

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Particles. Physicists' calculations suggest the Big Bang could have produced these in suitable numbers to form dark matter.

Scientists also believe the Large Hadron Collider—part of the Geneva-based laboratory of CERN, the European Organization for Nuclear Research—might be able to detect WIMPs. But this may be a long shot, since, as their name indicates, they're "weakly interacting." They interact little with other matter, including the stuff our detectors are made from.

No interaction means no detection.

But the physicists who offered the new proposal suggest dark matter might consist not of WIMPs, but particles called "SuperWIMPs"—the products that result when certain WIMPs decay, or fall apart.

The collider might be able to detect SuperWIMPs, said Jonathan Feng of the University of California, Irvine, a member of the research team. The group detailed the idea in the April 21 issue of the research journal *Physical Review Letters*.

These particles would be similar to neutrinos—ubiquitous but almost undetectable specks, trillions of which pass harmlessly through each of us each second. Because they also interact very weakly with matter, neutrinos slip through things leaving rarely a trace. As a result, physicists must build lake-sized detectors just to detect a handful yearly.

SuperWIMPS interact even more weakly than neutrinos, Feng said. This would make them, too, problematic to track down. But there's a solution, according to Feng and his colleagues at Cornell University in Ithaca, N.Y. and the University of Arizona in Tucson, Ariz.

SuperWIMPs are decay products of a peculiar form of WIMPs that, unlike others, carry electrical charge. And colliders can easily detect charged particles. These particular specimens would "stick out like a sore thumb," Feng wrote in an email. They "look like electrons"—charge-carrying entities in normal atoms—"but are millions of times heavier."

These progenitor particles are theorized to survive for between a few seconds and a few months before breaking down. If experimenters can catch them then, Feng and colleagues believe, the charged nuggets can be spirited somewhere where they can be observed more closely. The manner and timing of their eventual disintegration could reveal much about their SuperWIMP decay products.

Feng and colleagues have also theorized that the progenitors' relatively slow decay should leave a distinct signature in the cosmic background radiation, a faint glow that permeates the universe.

Scientists believe that to observe this background radiation is to look at what could be called the surface of the Big Bang fireball—though the view is much distorted owing to a huge expansion of the cosmos during the 14 billion years or so since the light left that place.

Feng and colleagues argue that with appropriate instruments, the SuperWIMP signature in the background radiation is detectable.

A SuperWIMP discovery could also help explain gravity, if Feng's group is correct. This is because these particles are likely to take the form of hypothetical entities called "gravitinos," which are closely related to gravitons, particles that according to some speculative theories carry the force of gravity.

The supposed gravitino-graviton kinship is part of a theory known as supersymmetry, which predicts that each known particle has a massive, as-yet-unseen "superpartner." This scheme allows for a one-to-one correspondence between two known families of particles: those that make up matter, such as the components of the atom; and those that transmit forces. The forces, in turn, control how the matter particles bunch up or otherwise interact.

In supersymmetry, gravitinos are superpartners of gravitons.

A SuperWIMP finding could moreover provide an entry point to test string theory—an also speculative set of proposals that seek to explain nature's various forces as manifestations of a single, deeper force. Supersymmetry fits neatly into string theory, widely seen as scientists' best shot for a "Theory of Everything."

String theory also predicts exotic phenomena such as extra dimensions, and proposes to resolve discrepancies between the two most powerful fundamental theories of nature devised to date: Einstein's General Relativity and quantum physics. The former applies to the universe on giant scales, and the latter to subatomic phenomena.

So "the discovery of dark matter in a collider," Feng wrote in an email, would "show us how nature works on both the largest and smallest length scales."

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Reference: J.L. Feng, S. Su, F. Takayama, Lower Limit on Dark Matter Production at the CERN Large Hadron Collider. Phys. Rev. Lett. 96, 151802 (2006)

Front page image: Map of the dark matter (shown in blue) around galaxies (yellow-red). (Courtesy Yale University)