UC SANTA BARBARA

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Gail Gallessich

U.S. Experiment Retakes the Lead in Race To Find Dark Matter

Scientists of the Cryogenic Dark Matter Search experiment today announced that they have regained the lead in the worldwide race to find the particles that make up dark matter. The CDMS experiment, conducted a half-mile underground in a mine in Soudan, Minn., again sets the world's best constraints on the properties of dark matter candidates.

Dark matter is thought to comprise about one-fifth of the energy in the universe, and 85 percent of all matter in the universe. Matter made of neutrons, protons, and electrons makes up the other 15 percent of matter in the universe.

Teams searching for dark matter have quadrupled in the past few years, now numbering 20. UC Santa Barbara is among 16 institutions involved in the CDMS experiment. UCSB emeritus professor David Caldwell, a physicist, was one of the originators of the experiment.

On Friday, February 22, results from the CDMS experiment were presented at the "Eighth UCLA Symposium: Sources and Detection of Dark Matter and Dark Energy in the Universe," held in Marina del Ray. Rupak Mahapatra, project scientist at UCSB, presented the data from the CDMS experiment.

A scientific paper describing the work was posted simultaneously on the public CDMS experiment website at: .

The roomful of approximately 200 scientists from around the world erupted in wild applause during and after Mahapatra's presentation. He showed that no signal has yet been detected, but the experiment is now considered the most sensitive in the world. The germanium crystals used as detectors in the underground mine have been increased by a factor of three in mass.

Mahapatra led the data analysis effort for the current announcement.

"The Big Bang and current observations suggest that the dark matter is related to the ‘Weak Interaction,' which governs certain radioactive decays, like the decay of potassium that is in bananas and people's bones," said Harry Nelson, professor of physics at UC Santa Barbara and one of the principal investigators in the experiment.

"Dark matter is also thought to consist of a massive particle, about 100 times the mass of a proton. These two concepts together make up the name of the particle that CDMS is looking for, the ‘WIMP,' for Weakly Interacting Massive Particle."

Nelson explained that the experiment uses a "billiard ball" scattering technique to seek evidence for WIMPs. It is as though the WIMP is the cue ball, and germanium atoms are the pool balls. "We can't see the WIMP directly, but our sensors can detect the sound, like a ring of a bell, if a germanium atom suddenly gets struck by a WIMP," he said.

Blas Cabrera of Stanford University is co-spokesperson of the CDMS experiment, and the Department of Energy's Fermi National Accelerator Laboratory hosts the project's management. "With our new result we are leapfrogging the competition," said Cabrera. "We have achieved the world's most stringent limits on how often dark matter particles interact with ordinary matter and how heavy they are, in particular in the theoretically favored mass range of more than 40 times the proton mass. Our experiment is now sensitive enough to hear WIMPs even if they ring the ‘bells' of our crystal germanium detector only twice a year. So far, we have heard nothing."

WIMPs, are leading candidates for the building blocks of dark matter. Hundreds of billions of WIMPs may have passed through your body as you read these sentences.

If they exist, WIMPs might interact with ordinary matter at rates similar to those of low-energy neutrinos, elusive subatomic particles first proposed in the 1930's. The CDMS collaboration found that if WIMPs have 100 times the mass of protons, they collide with one kilogram of germanium less than a few times per year; otherwise, the CDMS experiment would have detected them.

"The nature of dark matter is one of the mysteries in particle physics and cosmology," said Dr. Dennis Kovar, Acting Associate Director for High Energy Physics in the U.S. Department of Energy's Office of Science. "Congratulations to the CDMS collaboration for improved sensitivity and a new limit in the search for dark matter."

The CDMS experiment is located in the Soudan Underground Laboratory, shielded from cosmic rays and other particles that could mimic the signals expected from dark matter particles. Scientists operate the ultra sensitive CDMS detectors under clean-room conditions at a temperature of about 40 millikelvin, close to absolute zero. Physicists expect that WIMPs, if they exist, travel right through ordinary matter, rarely leaving a trace. If WIMPs crossed the CDMS detector, occasionally one of the WIMPs would hit a germanium nucleus. Like a hammer hitting a bell, the collision would create vibrations of the detector's crystal grid, which scientists could detect. Not having observed such signals, the CDMS experiment set limits on the properties of WIMPs.

"Observations made with telescopes have repeatedly shown that dark matter exists. It is the stuff that holds together all cosmic structures, including our own Milky Way. The observation of WIMPs would finally reveal the underlying nature of this dark matter, which plays such a crucial role in the formation of galaxies and the evolution of our universe," said Joseph Dehmer, director of the Division of Physics for the National Science Foundation.

The discovery of WIMPs would require extensions to the theoretical framework known as the Standard Model of particles and their forces. Mahapatra's presentation to the scientific community at the symposium Feb. 22 tests the viability of new theoretical concepts that have been proposed.

"Our results constrain theoretical models such as supersymmetry and models based on extra dimensions of space-time, which predict the existence of WIMPs," said CDMS project manager Dan Bauer, of the Department of Energy's Fermilab. "For WIMP masses expected from these theories, we are again the most sensitive in the world, retaking the lead from the Xenon 10 experiment at the Italian Gran Sasso laboratory. We will gain another factor of three in sensitivity by continuing to take more data with our detector in the Soudan laboratory until the end of 2008."

A new phase of the CDMS experiment with 25 kilograms of germanium is planned for the SNOLAB facility in Canada.

"The 25-kilogram experiment has clear discovery potential," said Fermilab Director Pier Oddone. "It covers a lot of the territory predicted by supersymmetric theories."

The CDMS collaboration includes more than 50 scientists from 16 institutions and receives funding from the U.S. Department of Energy, the National Science Foundation and from member institutions, including collaborators from Canada.

The UCSB group receives its funding through the university program of the U.S. Department of Energy.

Fermilab is a DOE Office of Science national laboratory operated under contract by the Fermi Research Alliance, LLC. The DOE Office of Science is the single largest supporter of basic research in the physical sciences in the nation.

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Institutions participating in CDMS are Case Western Reserve University; Fermi National Accelerator Laboratory; Lawrence Berkeley National Laboratory; Massachusetts Institute of Technology; Queens University, Santa Clara University; Stanford University; Syracuse University; University of California, Berkeley; University of California, Santa Barbara; University of Colorado Denver; University of Florida; University of Minnesota; Brown University; the California Institute of Technology; and the University of Zurich.

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