New Limits on the Origin of Dark Matter

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(PhysOrg.com) -- Determining the identity of dark matter, the mysterious stuff thought to make up the vast majority of matter in the universe, is one of the most fundamental challenges facing modern physics. Through theory and experiment, scientists have been gradually determining what dark matter probably isn't composed of, and now recent results from one collaboration have ruled out another possibility.

The collaboration, representing seven institutions in the U.S. and Spain, is known as CoGeNT. Their work has shed light on the results of two large experiments designed to gather information about dark matter, DAMA (as in DArk MAtter) and its second-generation version, DAMA/LIBRA.

DAMA and DAMA/LIBRA are particle detectors buried within Italy's Gran Sasso mountain, located in the country's central Abruzzo region. Over the last ten years the detectors have recorded a yearly rise and fall in signal, which scientists guessed could be the result of Earth passing through a halo of weakly interacting massive particles (WIMPs), a class of theoretical particles that are a prime candidate for dark matter. The idea of a WIMP halo as the cause of the signal pattern is controversial, but physicists could come up with no other explanation.

Other dark-matter studies have ruled out the possibility that the signal is due to WIMPs, but the detectors used were not able to track very lightweight WIMPs nor could they investigate certain interactions between the WIMPs and the sodium-iodine nuclei in the detectors.

One of those interactions, those that depend on the "spin" of the detector nuclei—an intrinsic property, like electric charge—was ruled out by a collaboration known as COUPP (the Chicagoland Observatory for Underground Particle Physics), an underground detector based at Fermilab, near Chicago.

CoGeNT has now ruled out the case in which these interactions are do not depend on spin, effectively eliminating a standard WIMP halo as the cause of the DAMA/LIBRA signal modulation.

"Our detector is ideal for exploring the veracity of DAMA's claim of dark matter discovery," explained experiment spokesperson Juan Collar, a physicist at the University of Chicago, to *PhysOrg.com.* "With it we may soon be able to reproduce or unambiguously refute their results, for more than just one type of particle candidate.

The detector is surrounded by a nested structure of passive and active shields, which act as other detecting media. Together they filter out background radiation so that it does not reach the core, which is a pure germanium crystal. The entire structure is slightly taller than an average-height person and about as wide. When a particle does reach the core, the energy it deposits is converted into a digital signal.

The spectrum of energy depositions obtained was compared with expected signals from a standard galactic WIMP halo, and they did not match.

"While the WIMP hypothesis now seems an unlikely explanation to the DAMA modulation, the DAMA collaboration has reminded us that dark matter candidates are numerous," says Collar. "The remaining controversy around the DAMA claim illustrates the point that detecting dark matter will be a very steep exercise for any single experiment in this field."

These results are described in the December 17, 2008, online edition of *Physical Review Letters*.

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