The drive to create the coldest cubic meter in the universe

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Yale scientists working on the cryostat of the Cryogenic Underground Observatory for Rare Events (CUORE). The experiment is located in a clean room deep underneath the Gran Sasso mountain in Italy to shield the experiment from cosmic rays and other environmental backgrounds. Credit: CUORE collaboration

The drive to create the coldest cubic meter in the universe may be centered in Italy, but its ultimate success will depend on instruments developed at Yale University.

An international team of scientists recently set a world record by cooling a copper vessel with a volume of a cubic meter down to a temperature of 6 milliKelvins—or -273.144 degrees Celsius. It was the first experiment to chill an object so large this close to absolute zero.

The collaboration, called CUORE (Cryogenic Underground Observatory for Rare Events), involves 130 scientists from the United States, Italy, China, Spain, France, and other countries. It is based at the underground Gran Sasso National Laboratory of the Instituto Nazionale di Fisica Nucleare, in Italy.

"This is a major technological achievement," said Karsten Heeger, a professor of physics at Yale and director of Yale's Arthur W. Wright Laboratory. CUORE is part of the new experimental program in neutrinos and dark matter pursued at the Wright Lab.

Yale physicists are building and testing instrumentation that will be used at temperatures of 10mK in the experiment's cryostat, which is the chilled chamber. Reina Maruyama, an assistant professor of physics, is one of the original proponents for the US involvement in CUORE and is a coordinator of its data analysis

"In collaboration with the University of Wisconsin, we have developed a detector calibration system that will deploy radioactive sources into the coldest region of the cryostat and characterize our detectors," Heeger said.

Once the CUORE experiment is fully operational, it will study important properties of neutrinos, the fundamental, subatomic particles that are created by radioactive decay and do not carry an electrical charge. Specifically, the experiment will look at a rare process called neutrinoless double-beta decay. The detection of this process would let researchers demonstrate, for the first time, that neutrinos and antineutrinos are the same—thereby offering a possible explanation for the abundance of matter, rather than anti-matter, in the universe.

The experiment uses heat-sensitive detectors that operate in extremely cold temperatures. "It poses a unique challenge," Heeger said. "We are trying to detect a minuscule amount of heat from nuclear decay, but need to know this very precisely. The detector calibration will tell us if we see the heat from double-beta decay or environmental backgrounds."

Now that the cryostat has reached base temperature, the commissioning and cryogenic testing of the calibration system will take place in the next few months, Heeger said.

More information: crio.mib.infn.it/wigmi/pages/cuore.php

Provided by Yale University

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