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Plans are underway to build a 30-cubic-kilometer neutrino telescope

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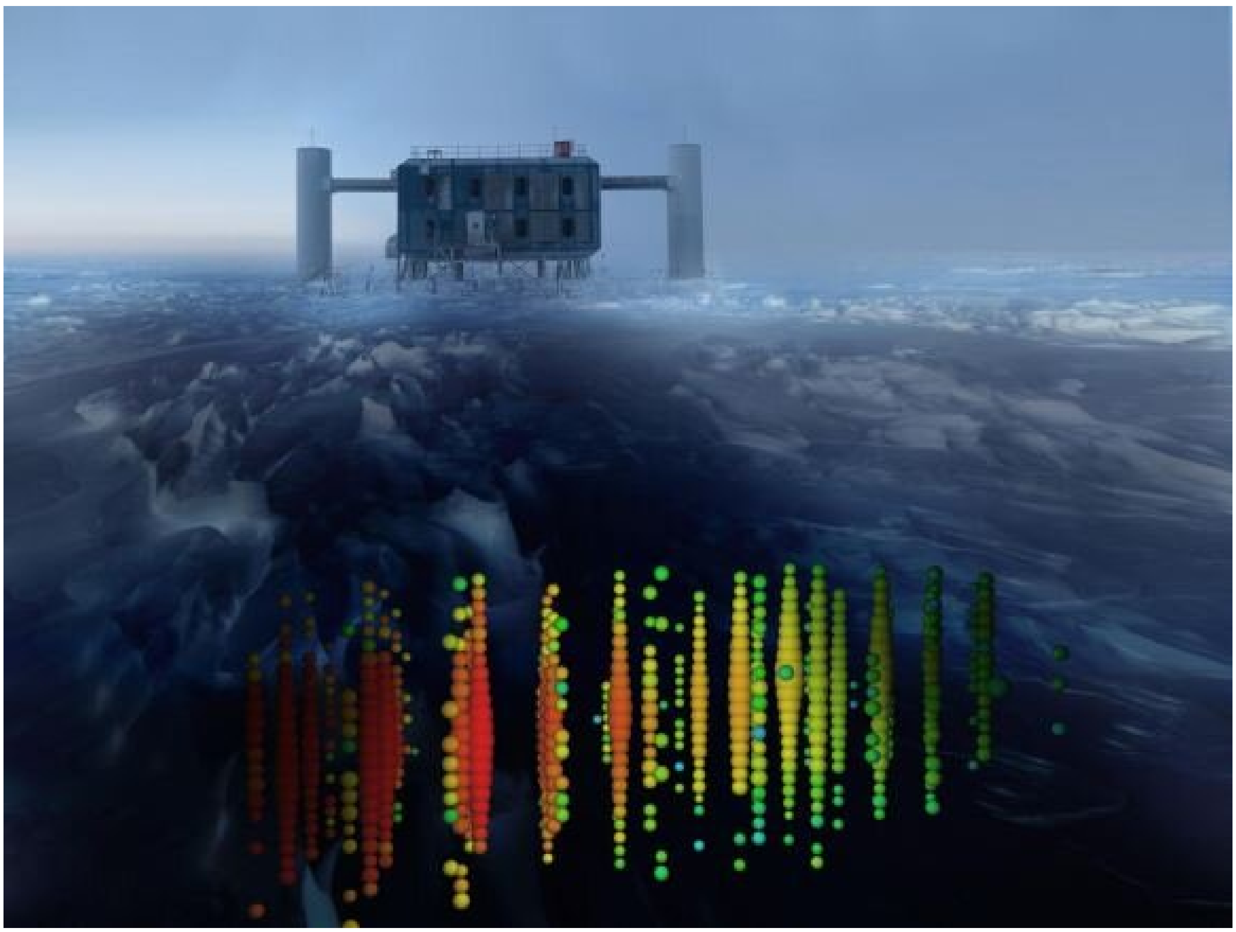

This image shows a visual representation of one of the highest-energy neutrino detections superimposed on a view of the IceCube Lab at the South Pole. Credit: IceCube Collaboration

How do astronomers look for neutrinos? These small, massless particles whiz through the universe at very close to the speed of light. They've been studied since the 1950s and detecting them provides work for a range of very interesting observatories.

There's IceCube in Antarctica, which uses a cubic kilometer of ice at the South Pole as its collector. Another neutrino detector, called KM3Net, is under development deep beneath the surface of the Mediterranean sea. It joins existing detectors around the world.

Now, a consortium of Chinese scientists has plans to develop another deepwater neutrino "telescope" that will be more extensive than any current technology online today.

According to lead researcher Chen Mingjun at the Chinese Academy of Sciences, the facility will be the largest neutrino observatory in operation. "It will be a 30-cubic-kilometer detector comprising over 55,000 optical modules suspended along 2,300 strings," said Chen.

Why study neutrinos?

Neutrinos come from a number of sources across the universe. Astronomers know that energetic events produce them, such as a supermassive star explosion. Often, a rush of neutrinos alerts astronomers to the fact that a supernova has exploded. They reach Earth before the light from the catastrophic event can get here.

Neutrinos (along with cosmic rays) also come from the sun, from stellar explosions, from objects called blazars, and there were even neutrinos created in the Big Bang. On Earth, they emanate from the decay of radioactive materials beneath the surface, and from nuclear reactors and particle accelerators.

Neutrino astronomy is a way to use these particles (as well as cosmic rays) to search out their sources and understand the physics behind them. Neutrinos offer a chance for astronomers to "see" processes that they can't catch any other way. That includes activity in the sun's core, the hidden cores of galaxies, gamma-ray bursts, and the events in starburst galaxies.

How to detect neutrinos

Spotting and measuring these fast-moving, nearly mass-less particles isn't an easy task. They don't interact very easily with regular matter, which makes them difficult to pin down. Depending on where they originate, neutrinos can travel through many light-years of space before interacting with interstellar gas and dust, or a planet, or star. Once they do, they pass almost completely unimpeded. But, they do interact briefly with matter. That interaction produces other detectable reactions and particles.

Since they're such slippery objects, neutrino detectors have to have a large "collecting area" to detect enough for study. The first neutrino observatories were built underground. That isolated the detectors from local radiation "pollution." Detection requires extremely sensitive equipment and even the best ones on Earth only measure a relative few.

Some neutrino observatories use a fluid called tetrachloroethylene to "capture" clues to neutrinos passing through. You might know this material better as dry cleaning fluid. When a neutrino hits a chlorine 37 atom in the tank, it converts it to an argon-37 atom. That's what the instruments detect.

Another way to measure neutrinos is through what's called a Cherenkov detector. The name refers to Cherenkov radiation, which is emitted whenever charged particles such as electrons or muons move through water, heavy water, or ice. The charged particle generates this radiation as it moves through the detector fluid. That's the method IceCube, KM4Net, Lake Baikal, and others use. The Chinese underwater detector will improve on this method and go hunting for neutrinos on a much larger scale.

Linking neutrino and cosmic ray sources

The aim of building such an extensive telescope is to detect high-energy neutrinos, but Chen thinks that there may be a link to cosmic rays. He expects that the neutrinos the facility detects will contribute to solving a century-old scientific puzzle of the origin of cosmic rays.

In the early 1900s, scientists discovered that energetic particles constantly bombard Earth. Since then, astronomers have tracked neutrinos as well as gamma rays from space. In 2021, China's Large High-Altitude Air Shower Observatory (LHAASO) in Sichuan province detected 12 sources of gamma rays. These probably came from the same sources as some cosmic rays.

Chen said one popular hypothesis is that the high-energy neutrinos and gamma rays are potentially produced simultaneously when high-energy cosmic rays originate. "If we can detect the two particles together, we can determine the origin of the cosmic rays," said Chen. The team wants to see if neutrino collisions in their detector produce secondary particles. These should emit light signals for their underwater detectors to see. Some research already hints at this possibility, and Chen believes that neutrino detection could trace the origin of this mystery space radiation.

Next steps

Most members of the team have spent years in the study of cosmic rays, particularly through project LHAASO. Now they're gearing up to do the same with neutrinos in a whole new facility. There's no doubt hunting extraterrestrial neutrinos from deep water will present new challenges. Underwater equipment and operations are very costly. In addition, the team has to develop a detector that can be completely waterproofed. However, work is underway, and the team just completed the first sea trial to test the detecting system at a depth of 1,800 meters underwater.

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