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ASTRONOMY

Tiny neutrinos help provide insight on origin of universe

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Neutrinos are tiny elementary particles produced by beta decay, a process in which an unstable neutron splits into a proton and an electron. Beta decay occurs on Earth through natural radioactivity.

There are trillions of neutrinos streaming through our bodies every second, and essentially all of them pass through us and Earth without hitting a single atom. Physicists are thus forced to take extreme measures to study them.

An early neutrino BRIAN detector involved MC NAMARA placing giant tanks of tetrachloroethylene deep inside a mine and scouring the fluid for atoms that captured a neutrino.

Most of the neutrinos streaming through were created by nuclear reactions deep inside the sun. The sun's reactor core churns roughly 600 million tons of hydrogen into helium every second. It is with helium atoms that neutrinos are born.

By capturing and studying only a few hundred neutrinos per year, astronomers have been able to peer into the sun's core and map nuclear reactions that make the sun shine.

Neutrinos have caught the interest of cosmologists concerned with how galaxies and clusters of galaxies formed. A neutrino has little mass, but collectively they might be massive enough to have allowed dimples in the early universe to form and eventually create galaxies such as the Milky Way.

The problem is there are three neutrino types and each one might have a different mass. Laboratory experiments can measure only the square of their mass differences, a measurement that is too insensitive to determine whether neutrinos could have played a significant role in galaxy formation.

However, astronomers have used new measurements of the cosmic microwave background radiation — left over from the big bang — and the distribution of distant galaxies in space in combination with the laboratory measurements to measure the mass of a neutrino.

In essence, the structure in the universe itself is telling us how massive the neutrino can be. The measurements show that the neutrino's mass must be less than about one 10-billionth of the mass of a proton.

This feat rests on the simple and imaginative notion that the universe was once so small that operations at the quantum level of the neutrino might have decided the outcome of the entire universe. This innovative idea is eclipsed, perhaps, by the genius behind the discovery of the neutrino itself.

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