Neutron stars can be more massive, while black holes are more rare

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Neutron stars and black holes aren't all they've been thought to be. In fact, neutron stars can be considerably more massive than previously believed, and it is more difficult to form black holes, according to new research developed by using the Arecibo Observatory in Arecibo, Puerto Rico. Paulo Freire, an astronomer from the observatory, will present his research at the American Astronomical Society national meeting in Austin on Jan. 11.

The Arecibo Observatory is managed by Cornell University for the National Science Foundation.

In the cosmic continuum of dead, remnant stars, the Arecibo astronomers have increased the mass limit for when neutron stars turn into black holes.

"The matter at the center of a neutron star is highly incompressible. Our new measurements of the mass of neutron stars will help nuclear physicists understand the properties of super-dense matter," said Freire. "It also means that to form a black hole, more mass is needed than previously thought. Thus, in our universe, black holes might be more rare and neutron stars slightly more abundant."

When the cores of massive stars run out of nuclear fuel, their enormous gravitation then causes their collapse then becomes a supernova. The core, typically with a mass 1.4 times larger than that of the sun is compressed into a neutron star. These extreme objects have a radius about 10 to 16 kilometers and a density on the order of a billion tons per cubic centimeter. Freire says that a neutron star is like one single, giant atomic nucleus with about 460,000 times the mass of the Earth.

Astronomers had thought the neutron stars needed a maximum mass between 1.6 and 2.5 suns in order to collapse and become black holes. However, this new research shows that neutron stars remain neutron stars between the mass of 1.9 and up to possibly 2.7 suns.

“The matter at the center of the neutron stars is the densest in the universe. It is one to two orders of magnitude denser than matter in the atomic nucleus. It is so dense we don’t know what it is made out of,” said Freire. “For that reason, we have at present no idea of how large or how massive neutron stars can be.”

From June 2001 to March 2007, Freire used Arecibo’s “L-wide” receiver (sensitive to radio frequencies from 1100 to 1700 MHz) and the Wide-Band Arecibo Pulsar Processors – a very fast spectrometer on the Arecibo telescope – to examine a binary pulsar called M5 B, in the globular cluster M5, which is located in the constellation Serpens.

Like a lighthouse emits light, a pulsar is a strongly magnetized neutron star that emits large amounts of electromagnetic radiation, usually from its magnetic pole. As in the case of a lighthouse, distant observers perceive a sequence of pulsations, which are caused by the rotation of the pulsar. In the case of M5 B, these radio pulsations arrive at the Earth every 7.95 milliseconds.

These radio pulsations were scanned by the wide-band spectrometers once every 64 microseconds for 256 spectral channels, and then recorded to a computer disk, with accurate timing information. The precise arrival time of the pulses were then used by the astronomers to accurately measure the orbital motion of M5 B about its companion.

This allowed the astronomers to estimate the mass (1.9 solar masses) of the pulsar.

Source: Cornell University

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