Two neutrons at the same time: Discovery of dineutron decay

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(Phys.org) -- Nuclear physicists recently witnessed an atomic nucleus do something that nobody had ever seen one do before – two neutrons at the same time.

Emitting them, that is.

The experiment revealed a brand new form of nuclear decay, the process by which unstable atoms release energy and transform into more stable forms. But instead of emitting known patterns of radiation, the nucleus ejected two correlated neutrons simultaneously – a dineutron. Though physicists had long theorized about the existence of this form of decay, this was the first experiment to see the dineutron event in action.

“We have for the first time unambiguously observed dineutron decay and clearly identified it in beryllium-16,” said Artemis Spyrou, professor of nuclear physics.

The newly discovered dineutron decay mode joins the 15 other known forms of atomic decay, including double proton emission, double beta decay and double positron emission. The results hold promise to strengthen scientists’ understanding of the strong force that holds nuclei together and the processes taking place within neutron stars.

The researchers caught the act red-handed. Beryllium-16 is an unbound, unstable isotope with 4 protons and 12 neutrons that decays in less than a trillionth of a second. To produce the extremely short-lived nucleus, the physicists smashed a beam of boron-17 into a solid target, occasionally knocking out a proton and forming the desired beryllium-16.

The neutrons emitted by the newly produced but instantly decaying nucleus flew straight into the Modular Neutron Array (MoNA) neutron detector, while the remaining beryllium-14 nucleus was deflected by a powerful magnet into a separate device to be measured. The resulting events clearly showed two neutrons travelling closely together – a dineutron – through the MoNA detector at the same time that a beryllium-14 nucleus was detected, giving direct evidence of the dineutron decay. In addition, the neutrons were sure to have been emitted simultaneously because it requires more energy to emit one at a time, making the dineutron decay the preferred mode.

Or, as Spyrou explained it, "You have to use energy to break off just one neutron, but the two neutrons just go."

The results have been published in a recent issue of *Physical Review Letters* as an editors suggestion and have been highlighted as a focus article by *Physics*, an online journal by the American Physical Society spotlighting exceptional research.

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