Researchers observe the competitive double-gamma nuclear decay

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(Phys.org)—A team of researchers with Technische Universität Darmstadt, in Germany and an associate with the University of Saskatchewan in Canada has detected, for the first time, the double gamma decay of a nuclear quantum transition that vies with the allowed single γ-decay. In their paper published in the journal *Nature*, the team describes how they managed to capture the one in 487,805 chances phenomenon. Alexandra Gade with Michigan State University offers a News & Views piece on the work done by the team in the same journal issue, along with a brief history of the study and application of double-gamma nuclear decay.

Double gamma rays, denoted as γγ-gama rays, occur when two γ-rays are emitted as the excited quantum state of atomic nuclei decays, simultaneously, rather than the normal one at a time. The idea was first put forth by Maria Göppert-Mayer back in the late 1930's. A decade later famed physicists Edward Teller and colleague Gregory Breit suggested that double-gamma nuclear decay was likely the mode at play during certain states of hydrogen, when single photon emission was not possible due to angular-momentum rules. It took forty more years for the rare process to be verified in the lab. In this new work, the researchers have succeeded in actually observing the process as it occurred with a barium nucleus.

To make the observation, the team used an established means for detecting single γ-rays, but added five scintillation detectors and lead lining in the chamber to reduce scattering of the rays from one of the detectors to any of the others. Then, they ran the experiment for 50 days, taking measurements along the way. It was at that point that they finally received a verifiable (by being observed by more than one of the detectors at the same time) signal at the predicted energy levels, the first ever, though other teams have been trying for several years.

In addition to serving as what Gade describes as an experimental tour de-force, the work likely will be used in the future to further study the nature of atomic nuclei. Next up is to find a way to measure the energy distribution of the γγ-gama rays.

More information: Observation of the competitive double-gamma nuclear decay, *Nature* 526, 406–409 (15 October 2015) DOI: 10.1038/nature15543

Abstract
The double-gamma (γγ)-decay of a quantum system in an excited state is a fundamental second-order process of quantum electrodynamics. In contrast to the well-known single-gamma (γ)-decay, the γγ-decay is characterized by the simultaneous emission of two γ quanta, each with a continuous energy spectrum. In nuclear physics, this exotic decay mode has only been observed for transitions between states with spin-parity quantum numbers Jπ = 0+. Single-gamma decays—the main experimental obstacle to observing the γγ-decay—are strictly forbidden for these 0+ 0+ transitions. Here we report the observation of the γγ-decay of an excited nuclear state (Jπ = 11/2−) that is directly competing with an allowed γ-decay (to ground state Jπ = 3/2+). The branching ratio of the competitive γγ-decay of the 11/2− isomer of 137Ba to the ground state relative to its single γ-decay was determined to be (2.05 ± 0.37) × 10^{-6}. From the measured angular correlation and the shape of the energy spectra of the individual γ-rays, the contributing combinations of multipolarities of the γ radiation were determined. Transition matrix elements calculated using the quasiparticle–phonon model reproduce our

measurements well. The γγ-decay rate gives access to so far unexplored important nuclear structure information, such as the generalized (off-diagonal) nuclear electric polarizabilities and magnetic susceptibilities.