Evidence for a new nuclear phase transition could rewrite physics textbooks

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Physics textbooks might have to be updated now that an international research team has found evidence of an unexpected transition in the structure of atomic nuclei.

The discovery was published in the journal *Physical Review Letters*. Lead author Bo Cederwall, professor of nuclear physics at KTH Royal Institute of Technology, says that lifetime measurements of neutron-deficient nuclides in a range of short-lived heavy metal isotope chains revealed never-before-observed behavior at the lowest states of energy.

Cederwall says the patterns indicate a phase transition – that is, rapid change in matter from one state to another – that is unexpected for this group of isotopes and unexplained by theory.

"Discoveries of phenomena that go against standard theory are always very exciting and rather uncommon," Cederwall says. The research team from KTH included doctoral students Özge Aktas and Aysegul Ertoprak, Assistant Professor Chong Qi, Professor Emeritus Robert Liotta, postocs Hongna Liu and Maria Doncel, and visiting researchers Sanya Matta and Pranav Subramaniam.

"Continuing with theory development and with complementary experiments could lead to the need to revise what is said about atomic nuclei in the textbooks," Cederwall says.

The research focused on excited states in nuclei situated closely above the ground state in energy that are extremely short-lived, on the order of millionths of a millionth of a second.

"Not only are the states we are studying very short-lived, the nuclei we have investigated are so unstable, difficult to produce and to identify, that very little information about their structure has been measured before," he says.

For a year, the research group analyzed several terabytes of data. Gamma radiation has been studied from nuclear reactions at the particle accelerator facility at the University of Jyväskylä, Finland. The measuring equipment, which uses high-purity germanium crystals at its core, can identify the rarest nuclear species from a vast background of more stable nuclides produced in the reactions.

In addition to in-depth understanding of how the universe's smallest components are built, the methods and detector systems that the research team has developed can be applied in medicine and technology. Diagnosis and radiation treatment of cancer, technologies for detecting radioactive substances in the environment, and nuclear safety control against nuclear proliferation are some examples. The nuclear physics group at KTH also works with such applications of its basic research.

"It is the extreme sensitivity of the measurement technique that is crucial to our results. Our increasingly refined technology will serve both new applications and next-generation experiments," Cederwall says.

More information: B. Cederwall et al. Lifetime Measurements of Excited States in Pt172 and the Variation of Quadrupole Transition Strength with Angular Momentum, *Physical Review Letters* (2018). DOI: 10.1103/PhysRevLett.121.022502

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