Clues to inner atomic life from subtle light-emission shifts

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Atoms absorb and emit light of various wavelengths. Physicists have long known that there are some tiny changes, or shifts, in the light that gets absorbed or emitted, due to the properties of the atomic nucleus.

Now, a team of scientists has elucidated the so-called hyperfine structure of cadmium atoms. Relying on a method called laser spectroscopy, they have measured variations in the energy transition within cadmium atom - Cd in the periodic table. They studied a chain of isotopes with an odd number of neutrons ranging from 59 in 107Cd to 75 in 123Cd. From these high-precision measurements, they were able to identify the physical cause of the shift within the nucleus. These findings by Nadja Frömmgen from the Johannes Gutenberg University Mainz, in Germany, and international colleagues have now been published in *EPJ D*.

Two main factors influence the cadmium atom's hyperfine structure. First, electrons orbiting the nucleus create a magnetic field resulting in a force affecting the nucleus, and splitting its absorption and emission line into a number of finer lines. Second, there are influences from the way the charge is distributed within the nucleus - a quantity known as the nuclear electric quadrupole moment, which only appears for non-spherical distributions. Some nuclei are shaped like a rugby ball, a frisbee or even a pear.

A peculiar outcome of this study of Cd's hyperfine structure was the observation of a very regular anomaly in the magnetic distribution inside the nucleus - previously observed only in mercury - pointing to a possible

general feature of nuclei.

The nuclear properties identified from such precision measurement have both theoretical and practical implications in astrophysics, nuclear and plasma physics. They are also important for detection methods such as atomic, chemical and solid-state spectroscopy, as well as nuclear magnetic resonance.

More information: Nadja Frömmgen, D. L. Balabanski, M. L. Bissell, J. Biero´n, K. Blaum, B. Cheal, K. Flanagan, S. Fritzsche, C. Geppert, M. Hammen, M. Kowalska, K. Kreim, A. Krieger, R. Neugart, G. Neyens, M. M. Rajabali, W. Nörtershäuser, J. Papuga, and D. T. Yordanov (2015), Collinear laser spectroscopy of atomic cadmium, *Eur. Phys. J. D* 69: 164, DOI: 10.1140/epjd/e2015-60219-0

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