Researchers confirm nuclear structure theory by measuring nuclear radii of cadmium isotopes

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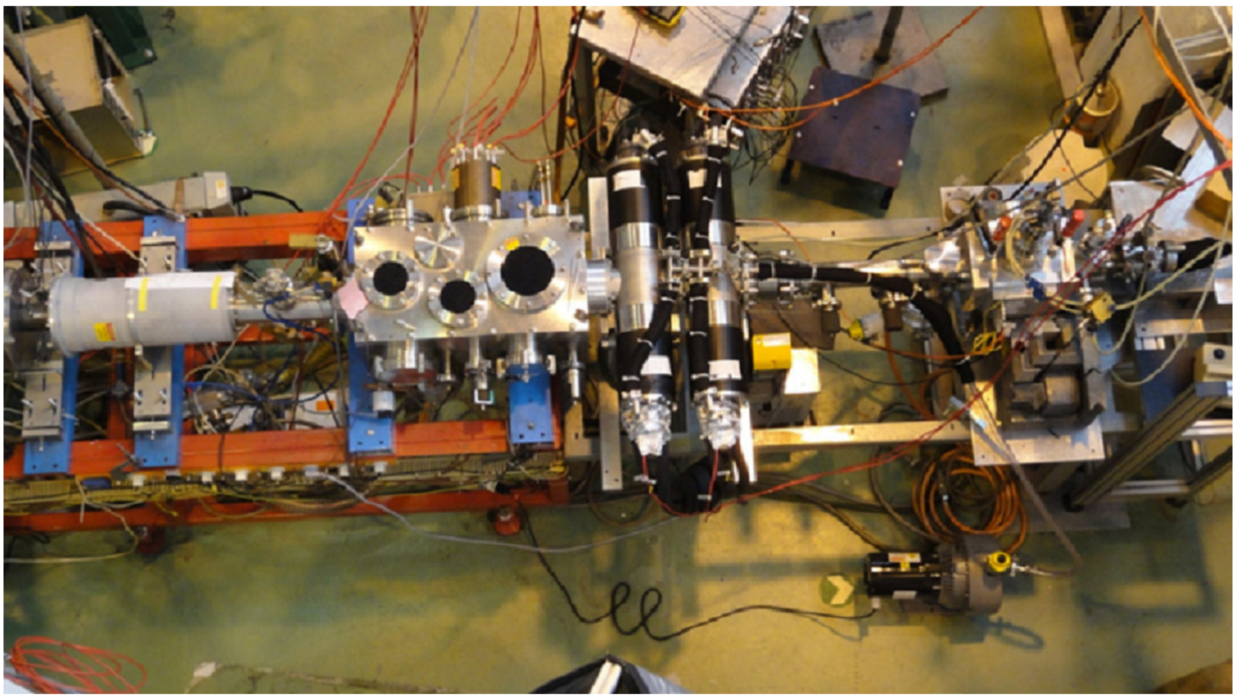
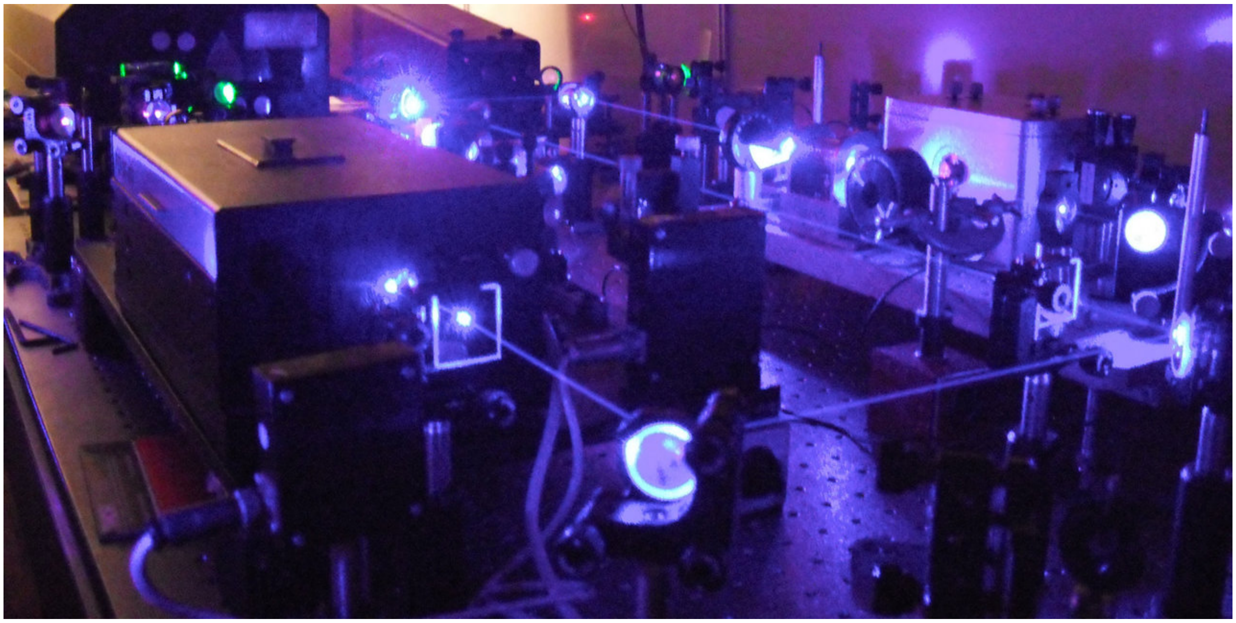


COLLAPS apparatus at ISOLDE/CERN. Credit: The COLLAPS Collaboration

Physicists at the TU Darmstadt and their collaboration partners have performed laser spectroscopy on cadmium isotopes to confirm an improved model of the atomic nucleus. It has been developed to describe the exceptional behaviour of the radii of calcium isotopes. The results published in *Physical Review Letters* could be a step towards a global model of the nuclear structure.

The charge radius, which is the spatial expansion of the positive nuclear charge, is one of the fundamental parameters of an atomic nucleus, and leaves its traces in the optical spectrum of an atom even though this is created by the electrons in the atomic shell. The spectrum of every type of atom is as unique as a fingerprint, and can be measured precisely using laser light. This provides information on the size and properties of the atomic nucleus. The technique is also suitable for very short-lived nuclei which decay within a blink of an eye. Laser spectroscopy measurements on a long chain of cadmium isotopes now confirm a special nuclear model that has been developed to describe the exceptional behaviour of the radii of calcium isotopes.

Two years ago, physicists at TU Darmstadt and collaborators presented radii measurements of exotic calcium isotopes that could not be explained by any of the standard nuclear models. Now, theorists from the University of Erlangen-Nürnberg and the NSCL (USA) have presented an improved model based on nuclear density functional theory. Its parameters were specifically adapted to the progression of the calcium radii and could reproduce radii of some nuclei with similar sizes as calcium.



Generation of 215 nm light. Credit: Michael Hammen

However, the declared aim of the nuclear structure theory is to achieve a global model that is valid for a large section of the nuclear chart. The predictive power of the new model has now been tested using radii measurements on more than 30 cadmium isotopes, which have about two-and-a-half times more mass than the calcium nuclei for which it was adapted. The Darmstadt team of Professor Wilfried Nörtershäuser carried out these measurements with colleagues from the Max Planck Institute for Nuclear Physics in Heidelberg, the Johannes Gutenberg University Mainz and numerous partners from other countries at the ISOLDE Radioactive Ion Beam facility at CERN. They present the results, which are in excellent agreement with the theoretical predictions, in an article in the renowned journal *Physical Review Letters*. This is remarkable, because the charge radius is generally considered a nuclear property that is difficult to describe theoretically. This applies particularly to the minor variations of the charge radius between isotopes with an even and an odd mass number (odd-even-staggering) that is well resolved with the very precise new measurements.

The research group has now begun to investigate other chains in the neighbouring region of the cadmium isotopes in order to establish whether the theory can also be applied there with similar success. This would be an important step on the way towards developing a global model of the nuclear structure.

More information: M. Hammen et al. From Calcium to Cadmium: Testing the Pairing Functional through Charge Radii Measurements of Cd100−130, *Physical Review Letters* (2018). DOI: 10.1103/PhysRevLett.121.102501

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