

New method to better understand atomic nuclei

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The precise structure of atomic nuclei is an old problem that has not been fully solved yet, and it also constitutes a current research focus in the field of natural sciences. Together with colleagues from Bonn University, physicists at Ruhr-Universität Bochum have developed an approach to carry out precision calculations of the forces acting between the particles inside the nucleus. They published their results in the magazine *Physical Review Letters*.

Underlying theory known, but too complicated

Atomic [nuclei](#) are made up of protons and [neutrons](#), which have, in turn, a complicated internal structure and consist of so-called quarks and gluons. Even though the theory of the strong interaction between quarks and gluons has been known for a long time, it is too complicated for describing the properties of nuclei. Still, [atomic nuclei](#) can be efficiently described as systems composed of protons and neutrons without being necessary to resolve the internal structure of those particles. A description like this requires, however, that the forces acting between protons and neutrons are well understood.

The two-particle system

The properties of a proton interacting with a neutron are very well known experimentally. The challenge was, therefore, to reproduce these precise experimental data with a high theoretical accuracy. Prof Dr Evgeny Epelbaum from the Institute of Theoretical Physics II at RUB explains the method that he and his colleagues had chosen to gain that understanding: "In the course of the study, we carried out precision calculations regarding the forces between [protons](#) and neutrons using a modern approach known as effective field theory. Combined with a new method for analysing the theoretical uncertainties, which we had developed in a previous study (see info box), we were able to describe the properties of

the simplest nuclear system consisting of a proton interacting with a neutron."

In future larger atomic nuclei

In future, these studies are going to be extended to larger nuclei, in order to, for example, learn more about the forces acting between a proton and two neutrons. Such three-body forces are not yet well understood and are in the focus of current research in the field of theoretical nuclear physics.

More information: E. Epelbaum, H. Krebs, U.-G. Meißner, "Precision nucleon-nucleon potential at fifth order in the chiral expansion", *Phys. Rev. Lett.* (2015)

The first part of the study was published some time ago in *Eur. Phys. J. A* 51 (2015) 5, 53 and was voted EPJ A Highlight by the editors. epjh.epj.org/epja-news/945-epj...hiral-nuclear-forces

Moreover, the research project was voted Highlight in *Europhysics News* (Vol. 46 No. 4): www.europhysicsnews.org/compon...r-forces-vol-46-no-4

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