New approach to nuclear structure, freely available

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The atomic nucleus is highly complex. This complexity partly stems from the nuclear interactions in atomic nuclei, which induce strong correlations between the elementary particles, or nucleons, that constitute the heart of the atom. The trouble is that understanding this complexity often requires a tremendous amount of computational power. In a new study published in *EPJ A*, Susanna Liebig from Forschungszentrum Jülich, Germany, and colleagues propose a new approach to nuclear structure calculations. The results are freely available to the nuclear physicists' community so that other groups can perform their own nuclear structure calculations, even if they have only limited computational resources.

The idea outlined in this work is to describe the quantum mechanical states of nuclei in terms of relative coordinates, which makes it possible to describe the correlations between nucleons more easily. This approach also helps to separate out the motion of the centre of mass, thus further reducing the complexity of the problem. To date, most nuclear structure calculations have been performed using single particle basis states, as (in keeping with what is referred to as the Pauli exclusion principle) two identical elementary particles cannot occupy the same basis state—an aspect that is tremendously difficult to address in relative coordinates... Now, in the new work, the authors generate sets of basis states for nucleons in complex nuclei, which feature anti-symmetrical relative coordinates.

The authors introduce an algorithm designed to reflect the anti-

symmetrized nature of the nucleon states using standard harmonic oscillator states for the light p-shell nuclei. The states are produced along with their corresponding recoupling coefficients, making it possible to include two- and three-nucleon operators. The study focuses on several p-shell nuclei and examines their dependence on the harmonic oscillator frequency. Subsequently, the authors extract the binding and excitation energies of these nuclei.

More information: S. Liebig et al, Jacobi no-core shell model for p-shell nuclei, *The European Physical Journal A* (2016). DOI: 10.1140/epja/i2016-16103-5

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