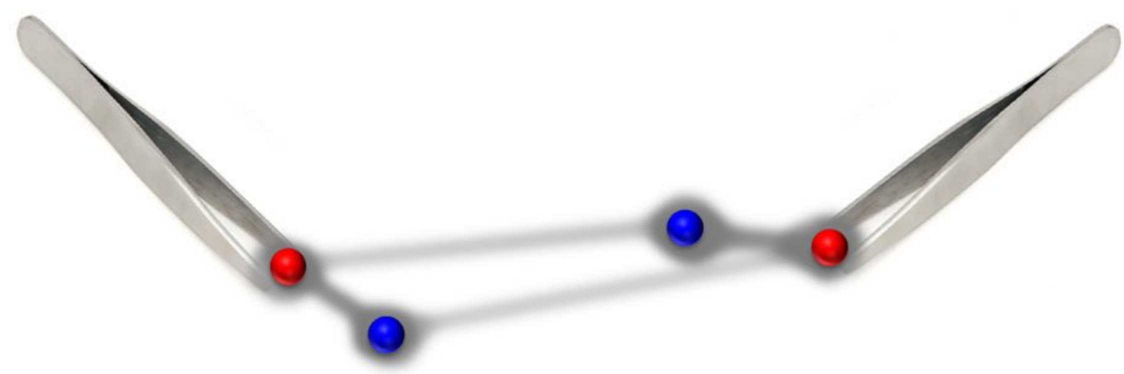
Physicists use numerical 'tweezers' to study nuclear interactions

June 9 2017, by Tracey Peake



Numerical tweezers used to measure the effective potential between two quantum states. Credit: North Carolina State University

Researchers from North Carolina State University and the Ruhr-Universität Bochum have developed numerical "tweezers" that can pin a nucleus in place, enabling them to study how interactions between protons and neutrons produce forces between nuclei. They found that the strength of local interactions determines whether or not these nuclei attract or repel each other, shedding light on the parameters that control attraction or repulsion in quantum bound states.

"Ultimately we want to understand how nuclear forces determine nuclear structure by studying how nuclei attract or repel one another," says Dean Lee, professor of physics at NC State and corresponding author of a paper describing the work. "So we needed a way to hold particles in place and move them around relative to one another in order to measure attraction or repulsion."

Lee, along with Ruhr-Universität Bochum colleagues Evgeny Epelbaum and Hermann Krebs and graduate student Alexander Rokash, utilized a numerical lattice with attractive potentials in order to isolate the particles they wanted to study. The attractive potentials created a way for a particle to get "stuck" in one place - like a hole in the ground that a marble could roll into. These were the numerical tweezers.

The team began simulations with two single particles held in different positions, then with particle pairs. They looked at two types of interactions between the groups of particles: local interactions, where the particles' positions relative to one another don't change; and non-local interactions, where the positions do change.

"We found that the local interactions had a much bigger effect on determining whether nuclei would stick together, or become bound," Lee says. "Specifically, the strength and range of the local interactions determined whether or not the nuclei would bind to each other. In non-local interactions, on the other hand, the nuclei sometimes repelled each other.

"We're interested in finding out why nuclei bind together to form new elements," Lee continues. "Numerical tweezers allow us to do simple simulations using just a few particles, giving us insight into the most basic particle interactions and the ways in which nuclear interactions inform nuclear structure."

The findings appear in *Physical Review Letters*. Rokash is first author of the paper.

More information: "Effective Forces Between Quantum Bound States" *Physical Review Letters* (2017). DOI: 10.1103/PhysRevLett.118.232502

Provided by North Carolina State University

Citation: Physicists use numerical 'tweezers' to study nuclear interactions (2017, June 9) retrieved 19 April 2024 from
https://phys.org/news/2017-06-physicists-numerical-tweezers-nuclear-interactions.html

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