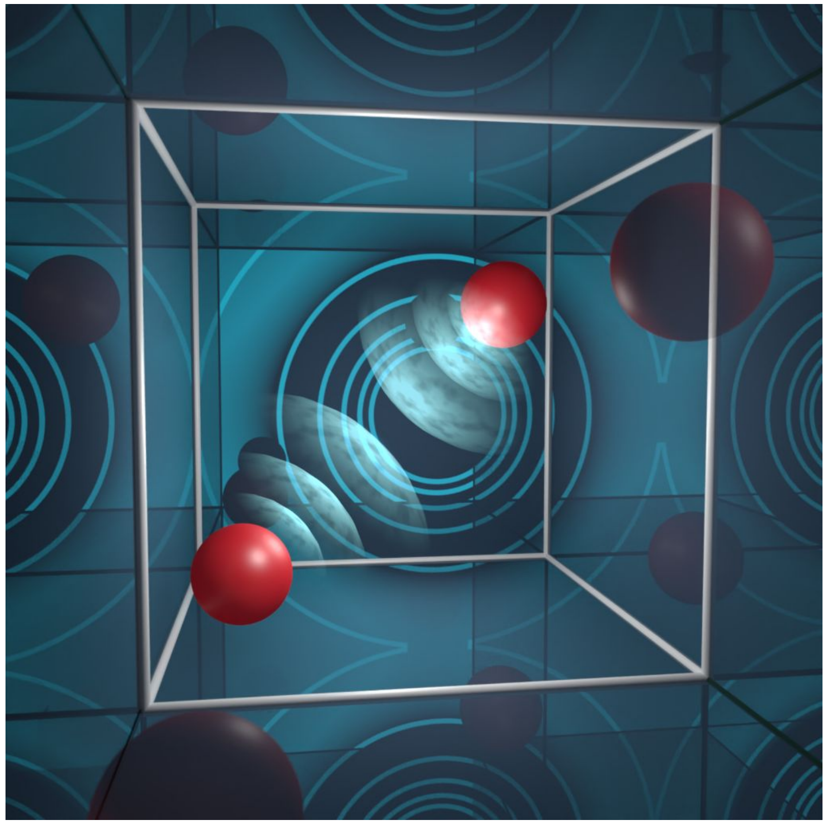
Charged-Particle Bound States in Periodic Boxes

Objectives

- This work solves a long-standing and fundamental problem regarding charged systems in a finite geometry with periodic boundary conditions.
- It derives the leading volume dependence of bound states with nonperturbative repulsive Coulomb force, thus enabling studies of such systems with finite-volume simulations, based, for example on Lattice Effective Field Theory (Lattice EFT).



Artistic representation of two particles in a periodic cubic box with a repulsive electromagnetic force between them.

Impact

- Finite-volume simulations with periodic boundary conditions, where particles leaving the volume on one side reenter on the other, approaches are useful in large-scale computations of quantum systems in nuclear physics.
- In particular, Lattice EFT for ab initio calculations in terms of nucleons as well as Lattice Quantum Chromodynamics (Lattice QCD) apply this methodology.
- While the "strong nuclear force" binds protons and neutrons together in atomic nuclei, the electromagnetic repulsion between protons plays an important role for the overall structure and dynamics.
- This force is particularly strong at the lowest energies, where many important processes take place that synthesize the elements that make up the world we know.
- The new results make it possible to extract parameters that play an important role in low-energy astrophysical reactions where one nucleus is captured by another to produce a new element.

Accomplishments

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