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Nuclei from quarks and gluons: low-energy QCD, nuclear forces, and the quantum computing frontier of first-principles nuclear physics

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Understanding how nuclei emerge from the fundamental quarks and gluons of Quantum Chromodynamics (QCD) remains one of the most profound challenges in modern physics. Many open questions, ranging from the structure of dense matter in neutron stars to the origin of the elements in the universe, to searches for physics beyond the Standard Model in low-energy experiments, require a predictive and quantitative understanding of low-energy QCD. At the heart of this effort lies the goal of deriving nuclear structure and interactions from first principles. I will review progress in our understanding of hadron structure, nuclear forces, and light nuclei using lattice QCD and effective field theories, and address the conceptual and computational meaning of “deriving nuclear physics from QCD.” The talk will conclude with a forward-looking perspective on the role of quantum computing in tackling the exponentially hard problems of low-energy QCD, and how it may eventually unlock a truly first-principles description of complex nuclear systems.

Altas energias

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