“Quarks, Neutrons, and Cold Atoms: A Lattice Window into Strongly Coupled Systems”

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Many of the questions we physicists try to answer can be split into parts: a first-order part which is easily solved ("Consider a spherical cow"), plus corrections which can be made order-by-order in powers of a small parameter. There are a few interesting and important exceptions. For example, quarks do not naturally appear as isolated particles, but are confined to live in bound states in a way which eludes such a perturbative description. These states, called hadrons, are the protons and neutrons in atomic nuclei and their heavy cousins created for brief instants at particle colliders. There are many fundamental questions in particle and hadronic physics which cannot be answered without a quantitative, nonperturbative approach. Another example is a dilute gas of strongly interacting fermions. At strong coupling we expect universal behavior: the physics is the same for the matter inside neutron stars as for trapped, cooled atoms, but it is indescribable by perturbation theory.

In this talk I will discuss lattice field theory, a numerical approach to studying these nonperturbative systems. I will focus on the phenomenon of quark flavor mixing: What is it and how can lattice calculations help us understand it better? What are the values of the Standard Model parameters governing flavor mixing? Can one see signs of non-Standard Model physics? I will also briefly describe my current effort to study dilute gases of fermionic atoms with lattice simulations.