Introduction to Nuclear Effective Field Theories

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One of the main goals of nuclear physics is to understand the emergence of nuclear physics from the underlying theory of strong interactions, QCD. This is a set of three two-hour *informal* lectures where we discuss how effective field theories (EFTs) help with this task.

Nuclear physics typically involves distance scales $\gtrsim 1$ fm, which are larger than the distance ~ 0.2 fm where QCD becomes non-perturbative. In the first lecture, we introduce EFT as a general framework to tackle systems with separate scales, and use atomic QED as an example.

The EFT appropriate for typical nuclear scales is constructed in the second lecture, using the approximate chiral symmetry of QCD as the crucial ingredient. The unique features of the generalization of chiral perturbation theory to systems with two or more nucleons are discussed, including outstanding issues of renormalization-group invariance.

Many nuclear states, for example halo nuclei, are particularly large and can be described with simpler EFTs, in which pions are treated as short-range effects. We discuss these EFTs and arrive at the current problem of going beyond few-body systems in the third lecture.