Universal few-body dynamics beyond the S-shell

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I will present four instances in which quantum particles with different substructures exhibit universal, common collective dynamics which can be described and understood with zero-range interactions. With these examples, the correlation between, (a), few-body behaviour of composite particles with, (b), properties of their subsystems is analysed in the context of effective (field) theories. I will summarize the status of the latter and their shortcomings when applied to "beyond S-wave" systems. The role of numerical techniques will be discussed as those have been employed by the authors in order to obtain the data. Specifically, I will introduce Monte-Carlo and a (Gaussian) stochastic variational method for bound-state analyses along with the resonating-group technique which we utilize to extract both bound- and coupled-channel scattering systems. I will conclude with an outlook on how this fundamental research relates to practical problems in, *e.g.*, cold fusion, and how we plan to carry out the program in India.

Effective field theories as bridges between QCD and atoms [1]

To what extend the diverse features of the nuclear landscape are a consequence of Standard-Model characteristics is arguably one of the grand problems of contemporary nuclear and particle physics.

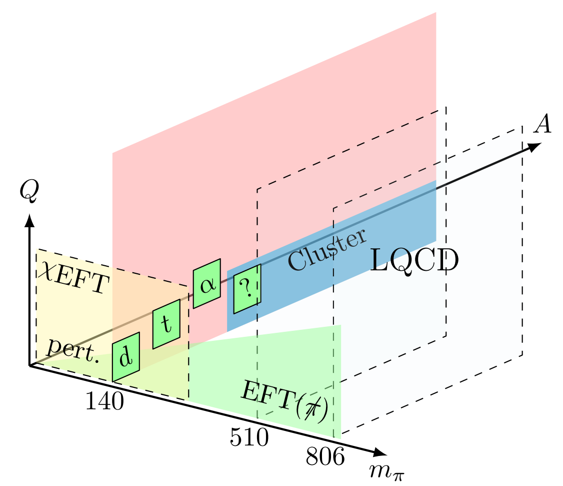

FIG. 1: Landscape of effective field theories which connect QCD with nuclear and cluster/halo physics.

To advance a solution, observables at scales differing by orders of magnitude have to be related. This challenge is addressed with a set of effective (field) theories (EFT) whose solution demand techniques bespoke to the scale of interest: QCD → lattice formulation of the path integral, and nuclear realm → few-body wave function propagation/expansion;

Emergent scales [2, 3]

As an example where details of particle substructure matters, *e.g.*, where a slight modification of parameters in an underlying theory will result in very different few-body behaviour, I will present a feature found in the spectrum of four identical bosons and in spectra of non-S-wave nuclei.

Universal fermionic resonances [4, 5]

The fermionic nature of nucleons is key to the understanding of bulk features of nuclei. Prominent examples of the latter include shell structure, mass gaps, drip lines, and excited, almost-bound resonant states. Most of these phenomena are expressed in larger nuclei, and this part will introduce results that address the problem of describing resonances in mixed-symmetry systems like 4-hydrogen and 5-helium within an EFT approach combined with state-of-the-art algorithms in order to remove the model dependence plaguing other approaches.

Exotic Universality [6]

Finally, I will demonstrate the potential of contact theories in the realm of hadronic molecules. For these exotic systems, data is hard to obtain. However, the few measurements allow for their assignment to the same universality class as nuclei and certain atomic systems. I will show how this membership allows, nevertheless, for predictions of their

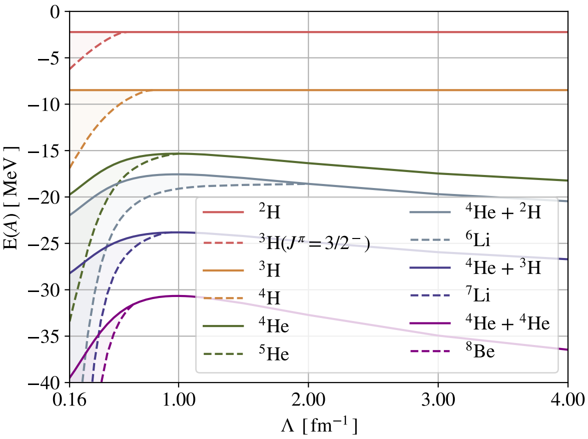

FIG. 2: Instability of P-wave systems in the zero-range limit.

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