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Large Scattering Lengths, Universality, Correlations and Few-Nucleon Systems[1]

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In a plethora of processes pivotal e.g. for Big-Bang Nucleo-synthesis BBN, the typical energy scale lies below 10 MeV. Since the scattering lengths between two nucleons are much larger than the typical range of the nucleon-nucleon interaction, Nuclear Physics at these energies is described by the Effective Field Theory of Point-Like Interactions, EFT(PLI), a model-independent theory with systematically improvable, reliable theoretical uncertainties. It helps to provide the bridge from the deceptive simplicity of high-energy QCD, the microscopic theory of strong interactions, to the richness and complexity of few-nucleon physics, and to explain in turn how universal aspects emerge from that complexity. In contradistinction to atomic systems, effective-range contributions have often to be accounted for, as they provide sizable corrections of up to 30%. EFT(PLI) is an excellent tool to check data consistencies, to extract nucleon properties by uniquely subtracting nuclear binding effects, and to model-independently predict processes which are experimentally hard to access, e.g. for BBN and interactions between neutrinos and the lightest nuclei. Furthermore, its model-independent assessment of few-body interactions explains correlations between e.g. binding energies and scattering lengths, and thus allows to differentiate between observables which are dominated by large scattering lengths from those which are sensitive to the details of the nuclear force. The same concepts apply to halo-nuclei, i.e. systems which are much larger than its constituents, namely a small core orbited by nucleons. Some of these systems exhibit e.g. Borromean binding or an Efimov-spectrum. While the nucleon-nucleon scattering lengths cannot be tuned experimentally, there are indications that they are infinite when the pion has about 1.4 times its physical mass. EFT(PLI) explores whcih impact varying fundamental parameters of QCD has on the nuclear spectrum, and in particular on BBN. This contribution will illustrate the above points, focusing on concrete examples of general relevance.

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