

INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: IJCLab

CNRS identification code: CNRS IJCLab/UMR9012

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Internship location: 15 Rue Georges Clemenceau, 91400 Orsay

Thesis possibility after internship: YES

Funding: YES (50% secured)

If YES, which type of funding: CEA

Mapping the tower of nuclear effective field theory

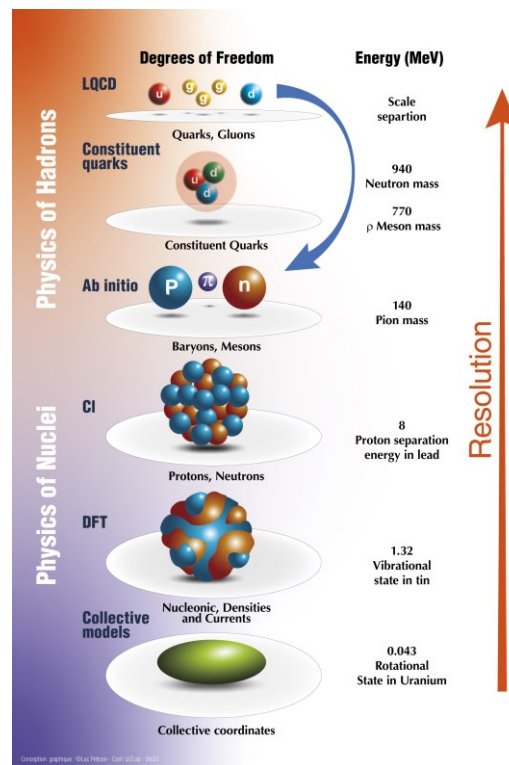
Nuclear physics is entering an era where many-body methods, particularly *ab initio* approaches that begin with protons and neutrons as the fundamental constituents, have advanced to such a degree that their accuracy is now primarily constrained by uncertainties in the effective Hamiltonian itself. Nuclear EFT methods are now the state-of-the-art tool for nuclear physicists, allowing them to derive the interactions between these constituents while bypassing the "complexities" of the non-perturbative low-energy QCD regime. These methods rely on a data-driven approach to capture the behavior of nucleons at the relevant momentum scales of the nuclear binding energy. However, the current power counting schemes are approaching their limitations, and it may soon be necessary to rely on a more hierarchical, tower of EFTs to accurately describe nuclear phenomenology.

Nuclear data repositories already contain a wealth of scattering observables that probe various degrees of freedom across a wide range of momentum scales of the incoming hadron beam. These datasets have been meticulously analyzed by evaluators for decades, and accurate interpretations using the R-matrix formalism (or plentiful of others) for non-overlapping resonant scattering have flourished. However, very little is known about the systematic application of EFT postulates to scattering systems across the full range of available data.

The advantage of this approach is that it allows for the clear identification of the relevant fields of the problem and the construction of a systematically improvable Lagrangian. If the theory reaches the limits of its validity, it will collapse in a controlled manner, signaling the emergence of a new degree of freedom.

The goal of this a PhD program, the knowledge gained during the internship will prove invaluable. We aim to push the frontier in two directions. First, the tools developed in the internship can be used to generate families of accurate Hamiltonians based on NN data.

The *ab initio* tools developed at CEA will allow us to validate, refine, or reject certain Hamiltonians, clarifying which subsets are capable of accurately reproducing many body physics and improving control over calculations. Second, we plan to explore the tower of EFTs. By starting from protons and neutrons, we can apply the powerful concept of EFT matching, where different EFTs are systematically connected, beginning with more fundamental theories and progressing towards simplified versions. Ultimately, we hypothesize that this analysis will help establish a link to the nuclear mean field, where nucleonic degrees of freedom coalesce into an independent set organized by an average potential (mean-field).



Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES/NO

Soft Matter and Biological Physics: YES/NO

Quantum Physics: YES/NO

Theoretical Physics: YES/NO