Topic for a PhD position

in co-tutelle IT/FR, starting fall 2025

New avenues in axion searches through hadron decays

Scientific description:

The indirect search for fundamental interactions, which govern the behavior of matter down to the smallest reachable scales, has historically been complementary to the direct search of new particles. “Indirect” denotes that the new particle affects the prediction of precisely calculable and precisely measured quantities, such as copiously produced decay rates. Historically, **most direct discoveries** have actually been **anticipated** by “indirect” effects in such **precision measurements**. It is a fact that many so-called rare decays of mesons and baryons probe dynamical scales **exceeding even by 5 orders of magnitude** the highest scale currently accessible at the energy frontier.

The topic of the thesis is **devising new, measurable, decays that will probe the interactions with matter of light spinless particles** known as **axions**. Axions are hypothetical but highly plausible particles that elegantly address several conceptual and observational problems. These include the absence of CP violation in strong interactions, or the observed constituent of the Universe known as Dark Matter.

The axion may be produced in **decays of beauty mesons**, as well as of **baryons with strangeness, or hyperons**. We envisage to devise new search channels within both these avenues. The underlying strategy relies on looking for decays whose backgrounds are well controlled, or such that the decay products other than the axion can be reliably reconstructed. The same decays will be calculated in the framework of an established **effective theory, namely QCD at low energies (the “theory of pions”), augmented with an axion** with the Noether procedure.

This research will be conducted in a collaboration between **LAPTh Annecy (FR)**, on the theory aspects, and the **University of Cagliari (UniCa, IT)**, in iconic Sardinia, on the experimental part. The **thesis tasks are thus both theoretical and experimental**, with the aim of producing an all-round phenomenologist. The Annecy-UniCa collaboration is a long-standing one, with several former students who are now CNRS staff or accomplished postdoctoral researchers. The thesis is **funded through the IT/FR “Vinci” program**.

Keywords: effective field theory, axions, chiral perturbation theory, beauty hadrons, strange hadrons, LHCb

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Applicants should contact the supervisor(s) by mail. Applicants are welcome (but not obliged) to carry out an M2 internship at LAPTh, in order to familiarize themselves with the research subject.