INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: LAPTh
CNRS identification code: UMR 5108
Internship director'surname: DELAUNAY
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Internship location: LAPTh, 9 chemin de bellevue, 74000 Annecy

Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

Direct Detection of Mass-Varying Dark Matter

Dark matter makes up about 25% of the Universe's total energy density today. We infer its presence from its gravitational effects, including the way galaxies rotate, but we still do not know what it is made of. Direct-detection experiments search for dark matter by looking for nuclear recoils produced by weakly interacting massive particles (WIMPs). These searches typically assume that the WIMP mass is constant. What if it changed while we were trying to detect it? If WIMPs couple to an ultralight scalar field that oscillates in the Galactic halo, their mass can vary periodically. This changes the energies they can transfer to nuclei and can shift part of the recoil spectrum above or below the detector threshold over an oscillation cycle.

The student will calculate the time-dependent recoil spectrum for spin-independent elastic scattering and implement it numerically for a benchmark xenon experiment such as LUX-ZEPLIN (LZ). The project will examine two signatures: a periodic modulation that can be sought using event times, and a distortion of the recoil spectrum that survives averaging over many cycles. By varying the mean WIMP mass, oscillation amplitude, and period, the student will quantify how the oscillations affect published limits on the WIMP–nucleon cross section and identify where a time-dependent search could improve sensitivity.

The internship will also explore what kind of particle physics could produce these signatures. The student will investigate simple couplings between a WIMP and an ultralight scalar, including axion-like fields. A central question is whether the coupling can produce an appreciable variation in the WIMP mass while keeping the scalar ultralight despite quantum corrections from the much heavier WIMP.

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

Condensed Matter Physics: NO Soft Matter and Biological Physics: NO
Quantum Physics: NO Theoretical Physics: YES