Master 2

INTERNSHIP PROPOSAL

Laboratory name: **LCAR, CNRS Université Paul Sabatier, Toulouse**
CNRS identification code: **UMR 5589**
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Internship location: **Toulouse**

Thesis possibility after internship: **YES**
Funding: **YES for the Internship / Funding for thesis not yet confirmed**

Quantum calculation with qudits using a Bose Einstein condensate

Our team specializes in the manipulation of quantum gases with optical lattices [1,2]. Using state-of-the-art quantum control methods, we have recently demonstrated our ability to generate an arbitrary superposition of a finite set of discrete momentum components [2]. This vector in Fourier space is nothing but a qudit (the generalization of a qubit to higher dimensions).

Theoretically it is known that qudits allow for "shorter" quantum circuits (involving fewer transformation) than their qbits-based counterparts. The proposed internship will consist in investigating theoretically and numerically the potentialities offered by this newcomer for quantum calculation, and to use it in a concrete manner experimentally to realize elementary quantum circuits.

Besides the experimental demonstrations, we plan to investigate the advantages and limitations of qudit computation in the context of our setup. In particular, we would like to study their interest for the so-called hybrid-quantum calculator that mixes quantum and classical operations. Our team benefits from the expertise of theorists specialists of quantum control and quantum calculation.

[1] Chaos-assisted tunneling resonances in a synthetic Floquet superlattice
M. Arnal, G. Chatelain, M. Martinez, N. Dupont, O. Giraud, D. Ullmo, B. Georgeot, G. Lemarié, J. Billy and D. Guéry-Odelin, Science Advances 6, eabc4486 (2020).

[2] Quantum state control of a Bose-Einstein condensate in an optical lattice
N. Dupont, G. Chatelain, L. Gabardos, M. Arnal, J. Billy, B. Peaudecerf, D. Sugny, D. Guéry-Odelin, PRX Quantum 2, 040303 (2021) / sélectionné dans les Actualités de l'Institut de Physique du CNRS