Master 2: ***International Centre for Fundamental Physics***

INTERNSHIP PROPOSAL

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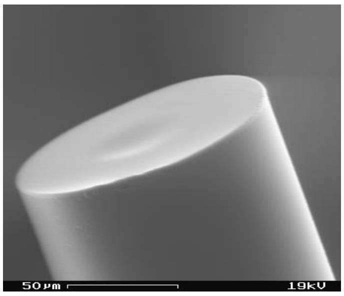
Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: EU

Cavity QED with optical microcavities for quantum technologies

When *N* well-controlled atoms (or other physical qubits) are strongly coupled to a single mode of radiation, this gives rise to a rich physical situation which is only starting to be explored. In the European Research Council (ERC) Advanced Grant project EQUEMI, our group investigates this approach with ultracold atoms in optical microcavities. This is especially promising for quantum technologies, where cavities can be used to synthesize high-quality entangled states [1], such as spin-squeezed states in ultracold atoms that reduce measurement noise in atomic clocks and sensors [2]. Another exciting idea is to use the cavity to generate long-range interactions in atomic qubit registers, going beyond the short-range interactions present in most current experiments. Experimentally, the crucial element is the high-finesse optical cavity, which must reduce photon loss to negligible levels while concentrating the field to a microscopic volume. Progress in cavity technology directly translates into better entanglement fidelity and gives access to new physical situations.



The workhorse of our experiment is the fiber Fabry-Perot microcavity (FFP) with laser-machined micromirrors on optical fibers (see photo) developed in our group [3]. Due to its exceptional properties, this FFP has been adopted by many research labs around the globe and is now employed in experiments with neutral atoms, ions, molecules, as well as with solid-state emitters such as quantum dots, color centers in diamond and carbon nanotubes.

The subject of this Master's project is to further improve FFP cavities by integrating mode-matching optics directly into the optical fiber. This is a great opportunity to gain hands-on experience with advanced optical and laser technologies and get involved in forefront quantum technology research with ultracold atoms.

[1] G. Barontini, L. Hohmann, F. Haas, J. Estève, and J. Reichel, *Deterministic Generation of Multiparticle Entanglement by Quantum Zeno Dynamics*, Science **349**, 1317 (2015).

[2] M.-Z. Huang, J. A. de la Paz, T. Mazzoni, K. Ott, A. Sinatra, C. L. Garrido Alzar, and J. Reichel, *Self-Amplifying Spin Measurement in a Long-Lived Spin-Squeezed State*, arXiv:2007.01964 (2020).

[3] D. Hunger, T. Steinmetz, Y. Colombe, C. Deutsch, T. W. Hänsch, and J. Reichel, *A Fiber Fabry-Perot Cavity with High Finesse*, New J Phys **12**, 065038 (2010).

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

Condensed Matter Physics: YES Macroscopic Physics and complexity: NO
Quantum Physics: YES Theoretical Physics: NO