MASTER PHYSIQUE ET APPLICATIONS
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Master Dispositifs Quantiques
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Internship offer

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Deep miniaturization of ion trapping devices: a surface science approach to heating rate charactrization

Scientific project:

Laser cooled trapped ions are among the few physical systems in which quantum logic operations have been demonstrated (e.g. 2012 Nobel Prize for Physics awarded to David Wineland and Serge Haroche).
First demonstrations of quantum logic operations have been obtained using macroscopically sized ion traps (tens of millimeters), but miniaturized devices can be successfully micro fabricated in a cleanroom (as it has been done, for example, at MPQ laboratory). Our group develops a research project devoted to the extreme miniaturization of these devices that will be capable of performing elementary quantum logic operations, a major challenge in experimental quantum information science.

In this research field the characterization and the optimization of devices performances in terms of "heating rate" is a fundamental and challenging step. In fact, an ion initially cooled to sub-millikelvin temperatures by laser cooling gains back kinetic energy at a rate that limits the fidelity of quantum operations in very small traps (tens of microns). Recent experiments show that the surface quality of the trapping electrodes affects the trap performances: in particular the presence of adsorbates may increase the heating rate by several orders of magnitude ("anomalous heating").

We recently implemented a sophisticated technique for fast and reliable measurements of the heating rate of the traps [1]. We also fabricated in a single batch a series of ion traps that spans dimensions from 20 to 120 μm. Finally, we installed a dedicated vacuum cell allowing for Ar^+ ion bombardment for cleaning the surfaces of trap electrodes. With this setup we aim to understand and mitigate the effect of anomalous heating, allowing for a deeper miniaturization of ion trapping devices.

During the internship, the succesful candidate will participate to the characterization of microtrap devices in an experimental environment that includes surface physics tools as well as a whole setup dedicated to laser cooling of ions (sub mK temperatures).

[1] V. Tugayé, J.-P. Likforman, S. Guibal and L. Guidoni, arXiv:1809.10972v1.

Methods and techniques: Ultra-high vacuum, ion milling of surfaces, laser cooling, ion trapping

Possibility to go on with a PhD ? YES
Envisaged fellowship ? An application to a funding agency will be necessary for a PhD grant.