A laser-cooled trapped ion cloud for heavy particle detection

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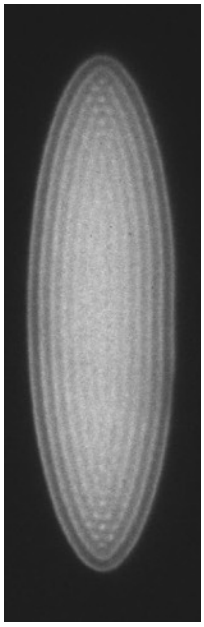

keywords : atom trapping and laser cooling, strongly correlated plasma, charged particles guiding
This internship can be continued with a PhD.

The CIML group has a strong expertise in ion trapping in radio-frequency trap, and laser cooling of these trapped ions. It is part of the European ion trapping network and one of the few groups trapping ions for fundamental physics purpose, in France. One of the experimental set-up of the group aims at the experimental investigation of the energy exchange between charged particles, sending a projectile onto a target. There, the target is a cold and dense trapped ion cloud which can be considered as a very non-conventional plasma, a one-component plasma (OCP). The projectile is a very heavy molecular ion and the perturbation that it induces in crossing the cloud of trapped ions can be used for its non-destructive detection, to demonstrate a prototype for mass spectrometer detector without mass limitation. The exploited signal is the laser induced fluorescence and the underlying process is the energy transfer between a charged projectile and the plasma target, known as the stopping power of plasmas.
In practise, the target is a laser cooled Ca+ ion cloud (see picture). As they reach temperature lower than the kelvin, these ions bunch in the trapping potential and arrange in a stationary structure that minimise the trapping+Coulomb repulsion potential energy, to form what is called a Coulomb crystal. An example of these structures, formed by several hundreds of ions, is visible on the figure showing the image of the ion fluorescence on a CCD camera.

Objectives : We propose to a master student to join this project to observe and study the energy exchange between charged heavy ions and laser cooled Ca+ OCP. It implies to develop a protocol to control the size and temperature of the trapped ions, the trajectory of the projectile and a diagnostic of the energy transferred to the ion cloud. The internship relies on an operational experimental set-up, where the detection will take place. It can also rely on a molecular dynamics simulation code that can be used to test the detection efficiency regarding the projectile characteristics, the trap and the laser-cooling parameters.
The **acquired skills** concern charged particle trapping and guiding, atom-laser interaction and laser cooling, data acquisition and processing.

REFERENCES :

[1] A. Poindron, *et al,* J. Chem. Phys. 154, 184203 (2021)

[1] Saint-Jérome campus can be reached by public transportation from the city centre in less than 25 minutes. Our group benefits from a completely new technical environment with very good technical conditions.