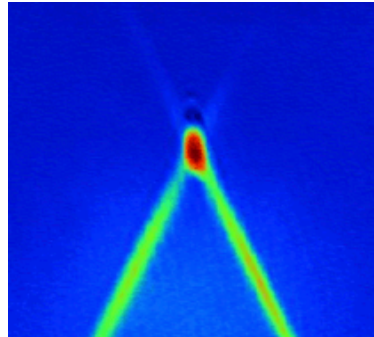


## Ultracold atoms and applications (3 ECTS)

*Teachers : Laurent Longchambon (LPL, Sorbonne Paris Nord) and Bess Fang (SYRTE, Observatoire de Paris) + Île-de-France researchers to supervise laboratory work.*



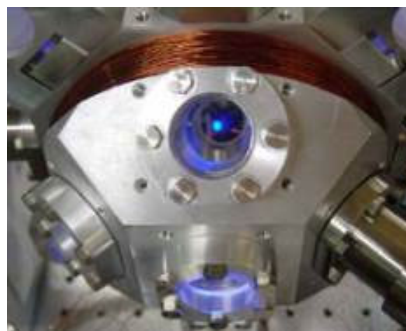
Caesium atoms confined in an optical trap (HP/LKB)

This option is dedicated to the field of physics where atoms, cooled to temperatures close to absolute zero, must be considered as atomic waves that can interfere, like electromagnetic waves, and reveal a set of fascinating quantum properties. Applications of atom interferometers range from ultra-precise clocks for testing general relativity, improving the GPS system or its European competitor GALILEO, to oil prospecting by detecting variations in the gravitational field. Applications of quantum gases include the development of a new class of simulators - quantum simulators - for studying superfluidity, magnetism or superconductivity on a model system.

This option also includes a practical laboratory session on a laser atom cooling experiment.

### **Objectives :**

Understand the basics of laser manipulation of atoms' internal and external degrees of freedom; learn about precision measurements with cold atoms (clocks, gyrometers, gravimeters); understand interactions between cold atoms and the description of Bose-Einstein condensates by the nonlinear Schrödinger equation.



Strontium atoms in a magneto-optical trap (JL/SYRTE)

### **Content :**

#### First part :

lecture : radiative forces

lecture : Doppler cooling

lecture : magneto-optical trap

- TD dipolar force : optical lattice and sideband cooling
- TD diffraction by an optical lattice
- TD Zeeman slower

Second part :

lecture : atomic clocks: basic principles, stability, systematic effects

- TD collisional shift OR magic wavelength in an optical clock

- TD (optionnal) : Ramsey fringes

lecture : Atomic interferometry

- TD phase shift calculation, quantum projection noise in a gravimeter

Third part :

lecture : evaporative cooling

lecture : Bose-Einstein condensation

lecture : interacting condensats, superfluidity and excitations

- TD : Condensate and thermal gas density profiles, in situ and after time of flight

TP :

This option also includes a laboratory practical work session on a laser atom cooling experiment in a laboratory in the Paris region.

**Place :** Jussieu (excep for pratical session)