



OMP/LuMI

Ultra cold atoms
and their applications:
from precision measurements
to quantum simulation

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Scientific topics

Cooling, trapping, and atom manipulation with light

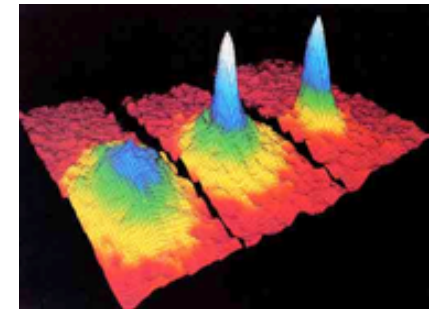
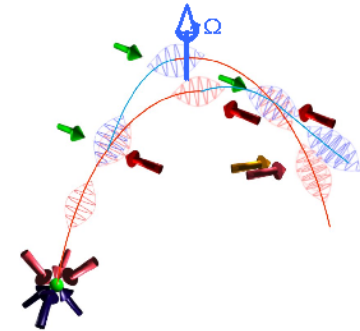
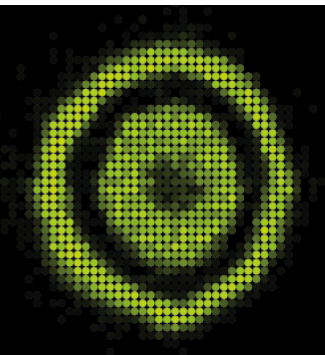
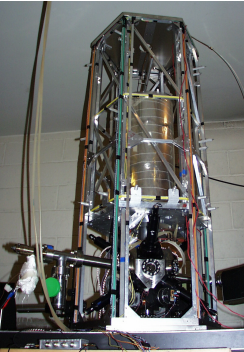
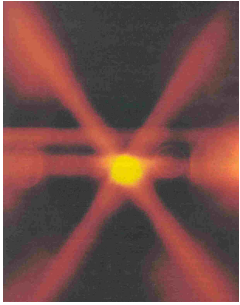
Matter waves – Atom interferometry

Precision measurements: atomic clocks and atom interferometers

Quantum gases: Bose-Einstein condensates

Quantum simulation

Goals : acquire a **general culture** in a timely topic and/or prepare a **PhD** in precision measurements or ultracold/quantum gases



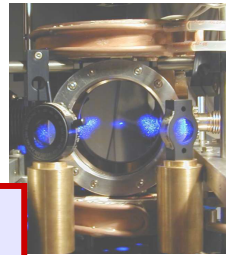
A very active domain of research

→ Four Nobel prizes over 15 years



Laser Cooling and Trapping
S. Chu, C. Cohen-Tannoudji, W. Phillips
Nobel Prize 1997

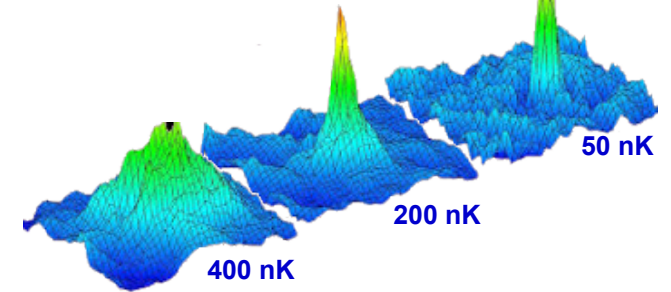
1997



Bose-Einstein Condensation
E. Cornell, C. Wieman, W. Ketterle
Nobel Prize 2001



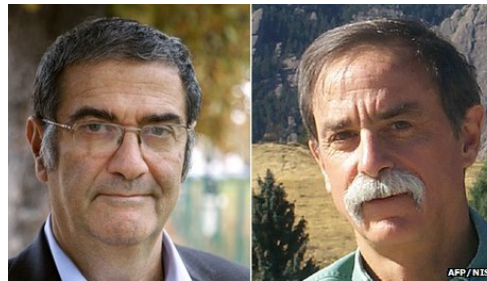
2001



2005

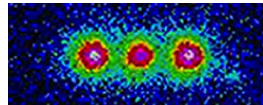
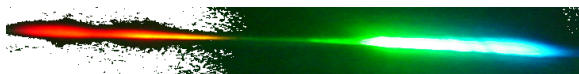


**Laser-based Precision Spectroscopy
and Frequency Comb Technique**
J. Hall and T. Hänsch
Nobel Prize 2005



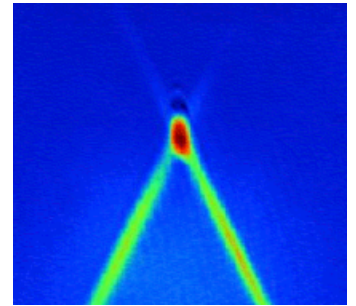
**Measuring and manipulation of
individual quantum systems
Ion clocks**
S. Haroche, D. Wineland
Nobel Prize 2012

2012

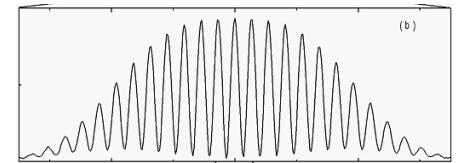


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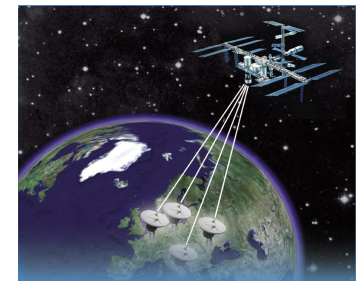
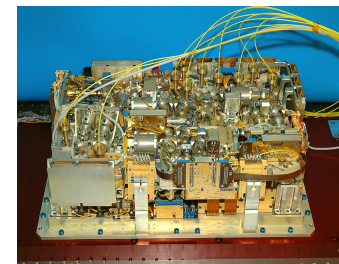
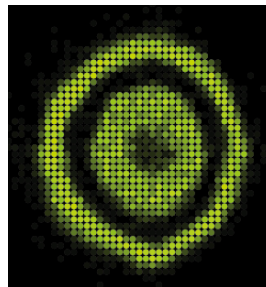
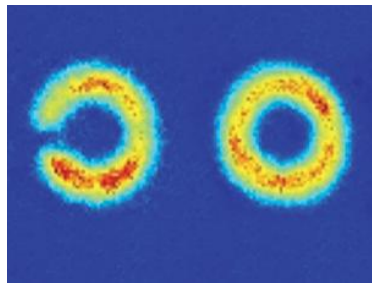
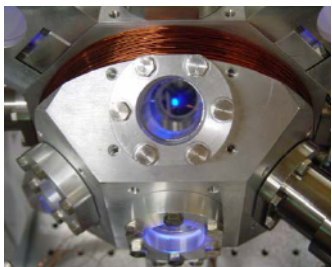
The option is organised in **three parts** :



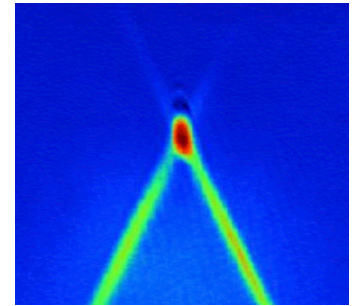
1. Laser cooling and trapping (HP) : **3** 4-hour sessions
2. Atomic clocks and atom interferometry (JL) : **2** sessions
3. Quantum gases (HP) : **2** sessions



+ **1/2 day lab class** in a (true!) laboratory of IFRAF



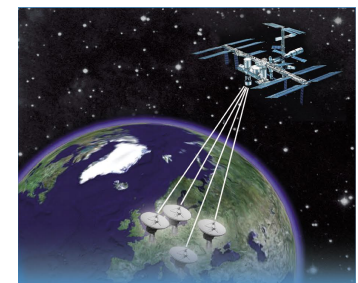
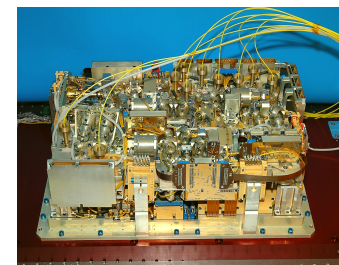
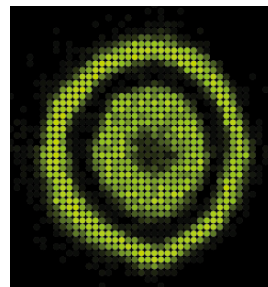
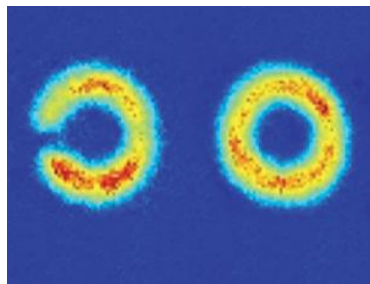
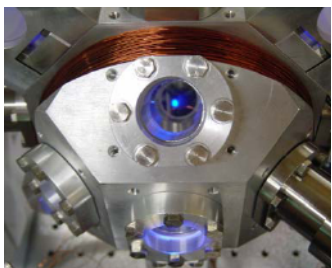
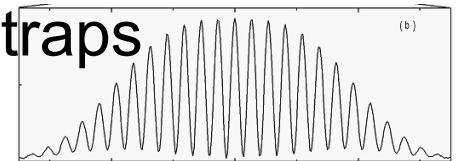
Content



1. Laser cooling and trapping (HP)

3 lectures, 3 exercise classes

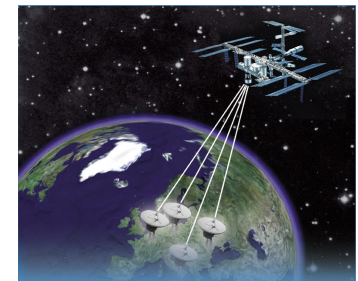
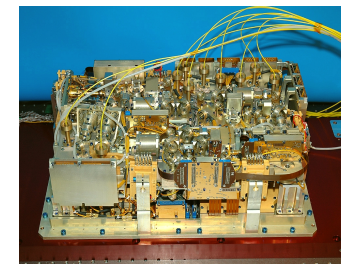
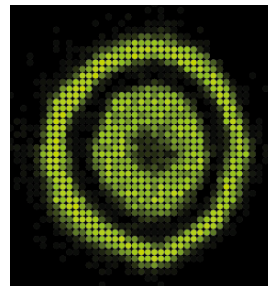
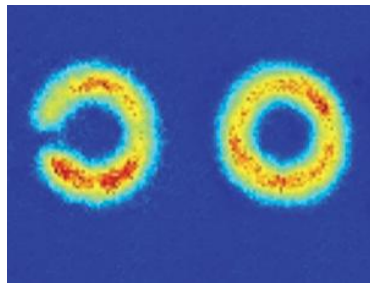
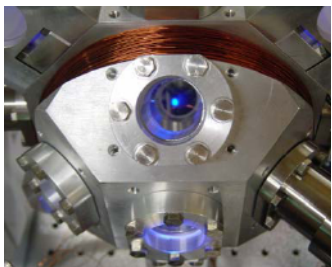
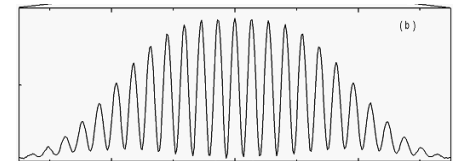
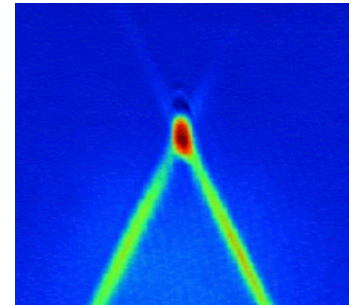
- ✓ Light forces
- ✓ Laser cooling : Doppler cooling, Sisyphus cooling
- ✓ Laser trapping : dipole traps, magneto-optical traps
- ✓ Magnetic traps (atom chips)
- ✓ Optical lattices
- ✓ Cold collisions, Feshbach resonances



Content

2. Atomic clocks and atom interferometry (JL) 2 lectures, 2 exercise classes

- ✓ Principle of atomic clocks, stability, systematics
- ✓ Collisional shift
- ✓ Atom interferometry
- ✓ Phase shift in an atom interferometer
- ✓ Quantum projection noise
- ✓ Applications of interferometers

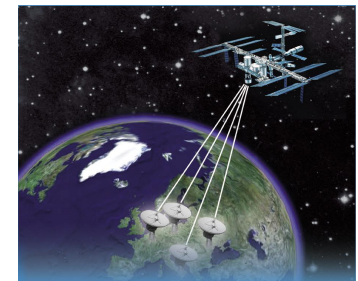
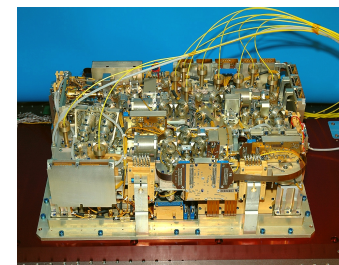
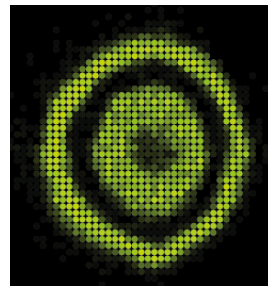
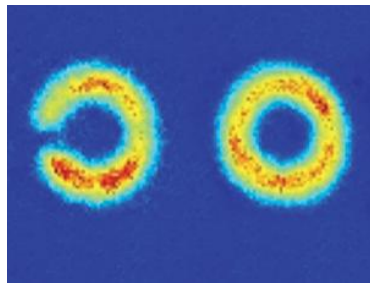
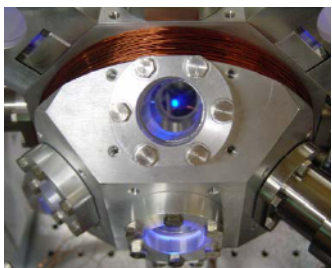
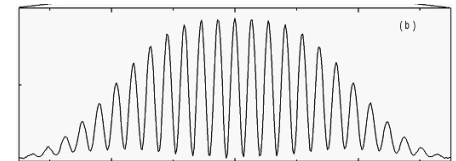
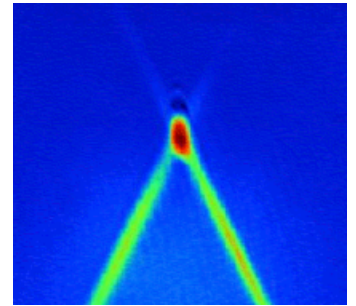


Content

3. Quantum gases (HP)

3 lectures, 1 seminar

- ✓ Evaporative cooling
- ✓ Bose-Einstein condensation
- ✓ Interacting quantum gases
- ✓ Superfluidity
- ✓ Applications of quantum gases
- ✓ Examples of quantum simulators



Final exam

Two components :

Lab class report (4 pts)

Written exam, 3 hours (16 pts)

