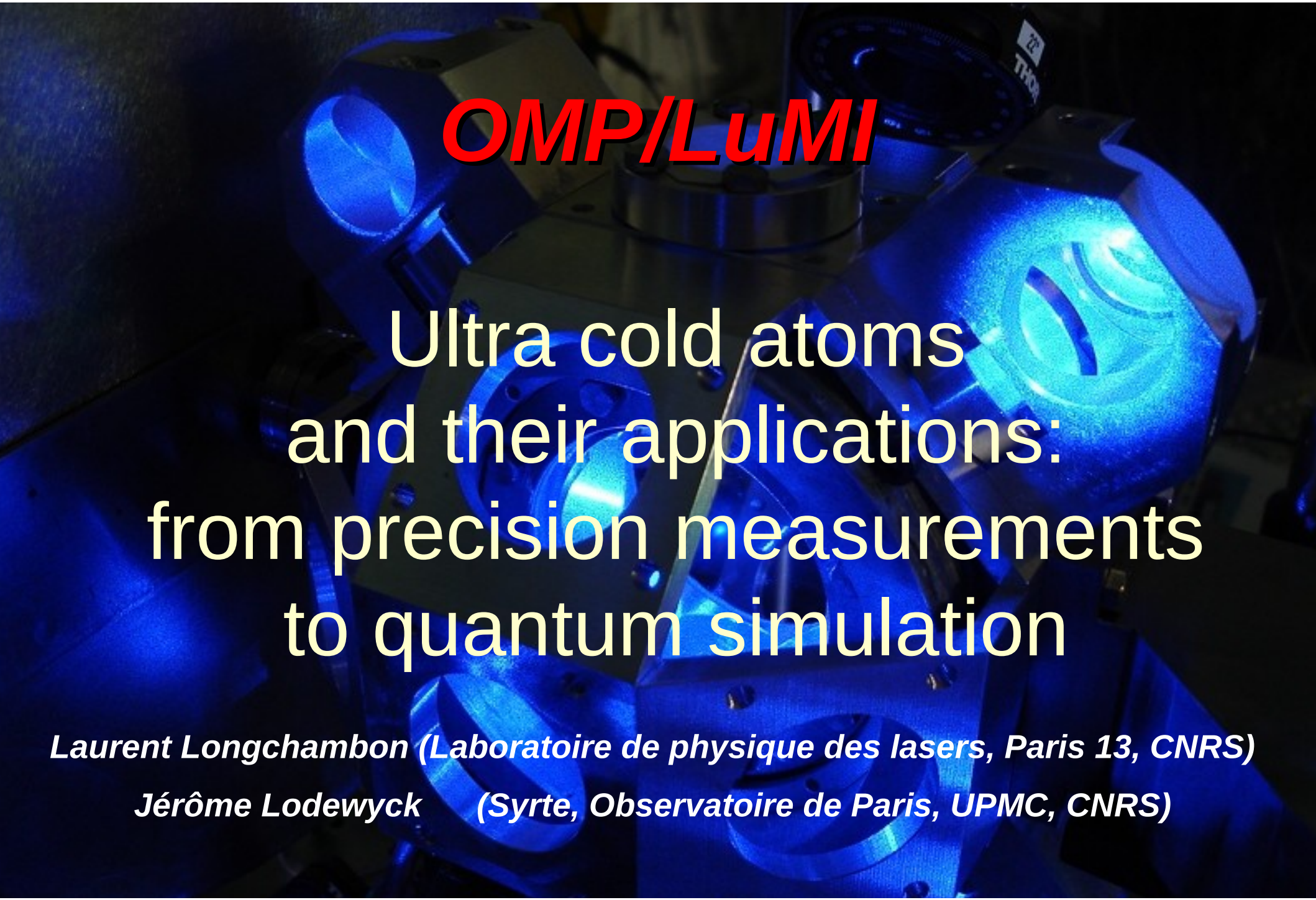


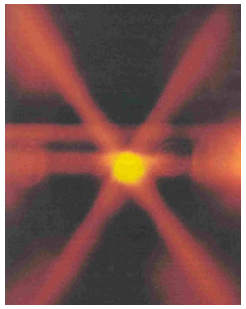
OMP/LuMI

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

Laurent Longchambon (Laboratoire de physique des lasers, Paris 13, CNRS)

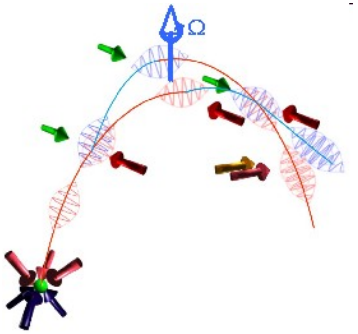
Jérôme Lodewyck (Syrte, Observatoire de Paris, UPMC, CNRS)

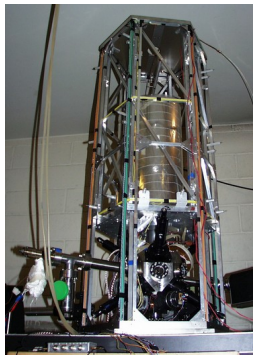
Scientific topics



Cooling, trapping, and atom manipulation with light

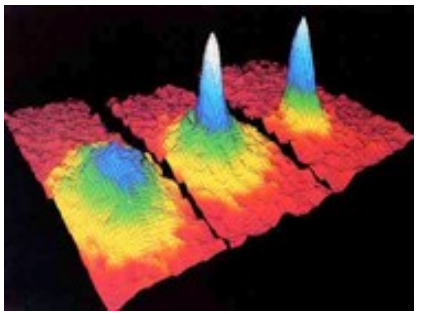
Matter waves – Atom interferometry

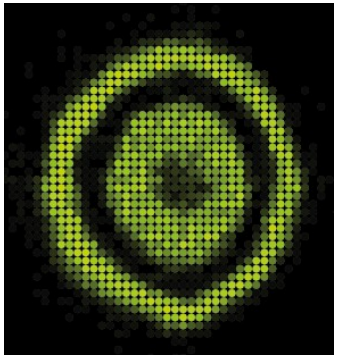




Precision measurements: atomic clocks and atom interferometers

Quantum gases: Bose-Einstein condensates



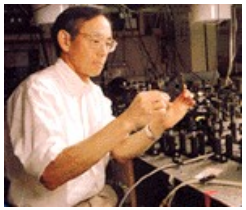


Quantum simulation

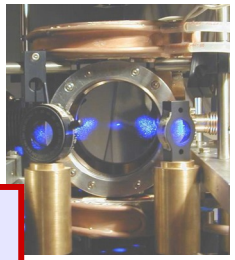
Goals : acquire a general culture in a timely topic and/or prepare a PhD in precision measurements or ultracold/quantum gases

A very active domain of research

→ Four Nobel prizes over 15 years



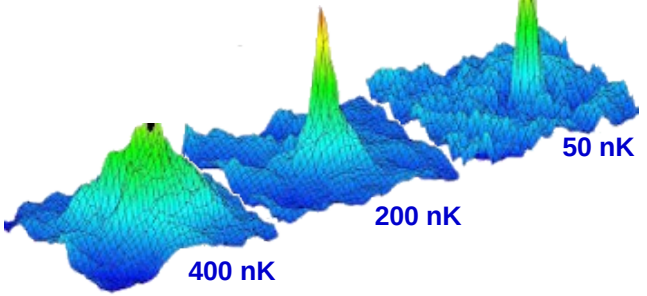
1997



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

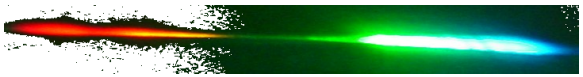
Bose-Einstein Condensation
E. Cornell, C. Wieman, W. Ketterle
Nobel Prize 2001

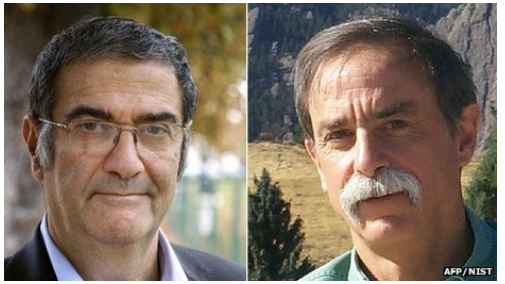
2001

2005

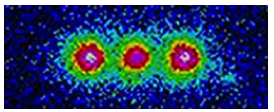

Laser-based Precision Spectroscopy
and Frequency Comb Technique
J. Hall and T. Hänsch
Nobel Prize 2005





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

2012



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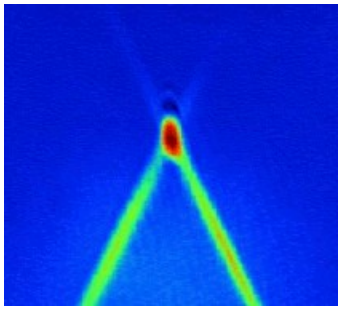
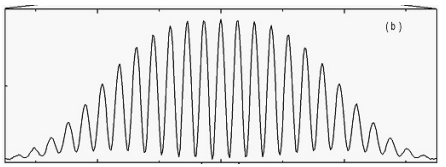


The option is organised in three parts :

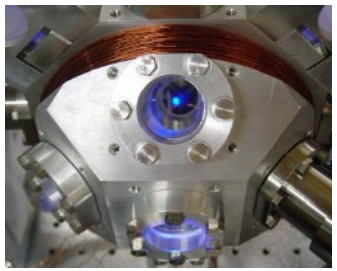
1. Laser cooling and trapping (LL) : **3** 4-hour sessions

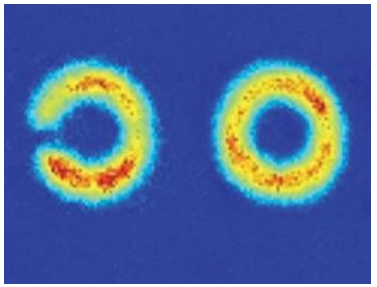
2. Atomic clocks and atom interferometry (JL) : **2** sessions

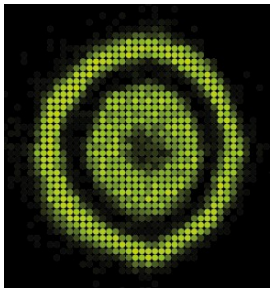
3. Quantum gases (LL) : **2** sessions

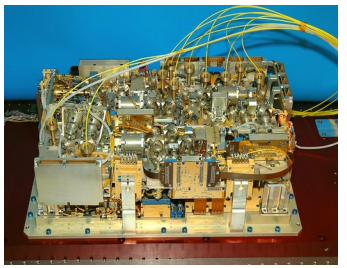


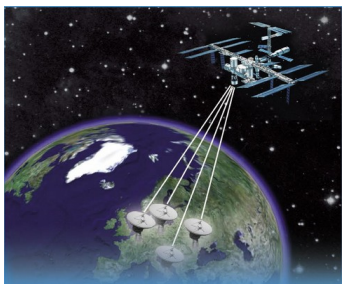
+ **½ day lab class** in a (true!) laboratory of IFRAF











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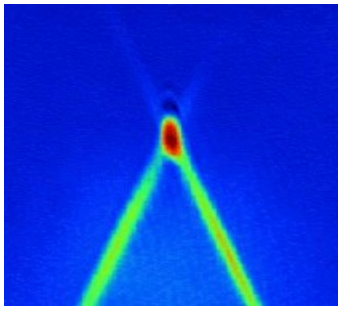
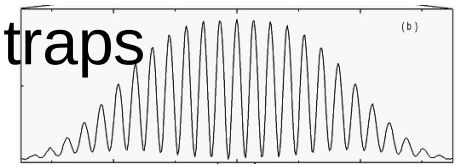
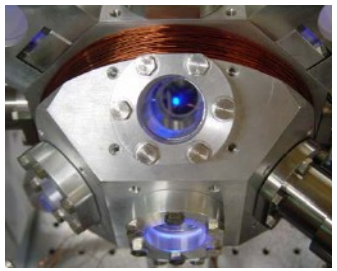


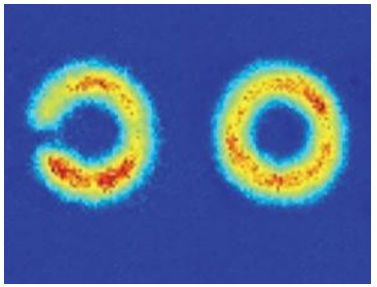
1. Laser cooling and trapping (LL)

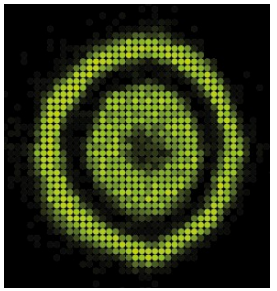
3 lectures, 3 exercice classes

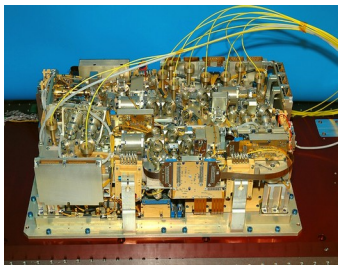
- Light forces
- Laser cooling
- Laser trapping : dipole traps, magneto-optical traps
- Magnetic traps (atom chips)
- Optical lattices
- Cold collisions, Feshbach resonances

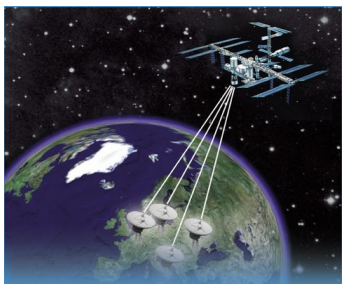












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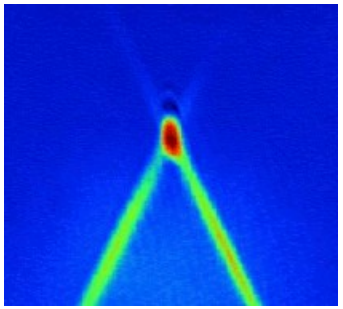
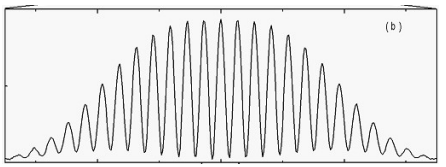
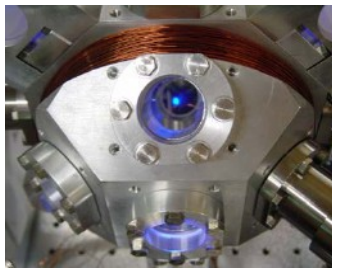


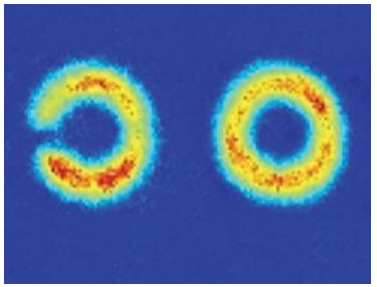
2. Atomic clocks and atom interferometry (JL)

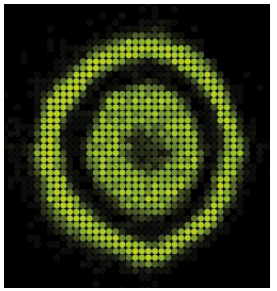
2 lectures, 2 exercice classes

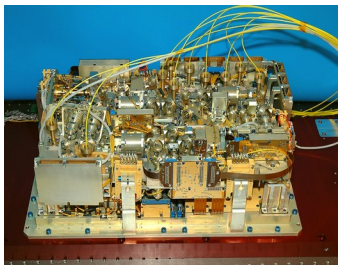
- Principle of atomic clocks, stability, systematics
- Collisional shift
- Atom interferometry
- Phase shift in an atom interferometer
- Quantum projection noise
- Applications of interferometers

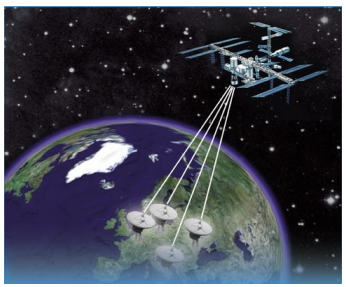












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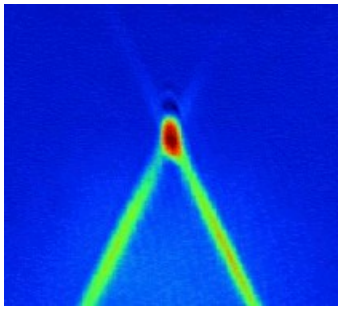
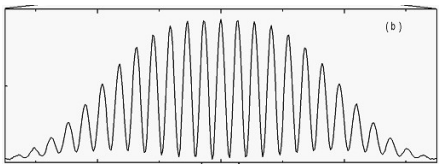
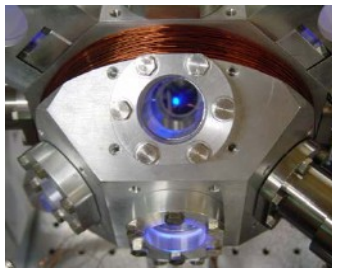


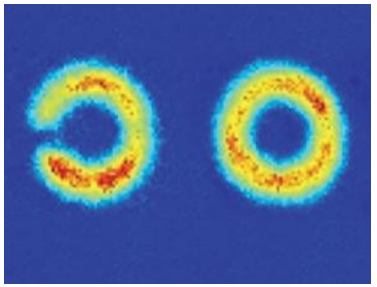
3. Quantum gases (LL)

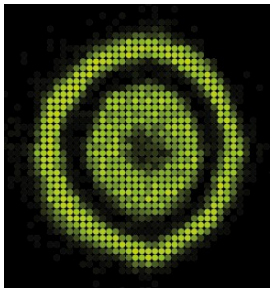
3 lectures, 1 seminar

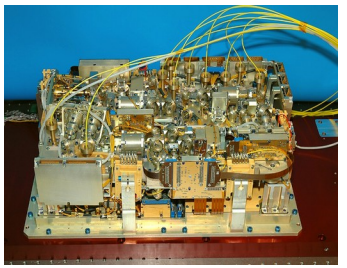
- Bose-Einstein condensation
- Interacting quantum gases
- Superfluidity
- Applications of quantum gases
- Examples of quantum simulators

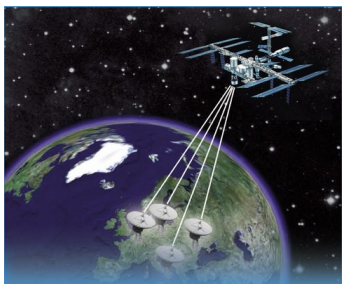




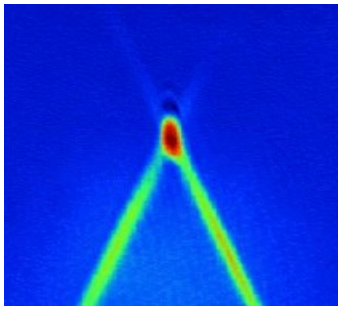








Final exam



Two components :

Lab class report (4 pts)

Written exam, 3 hours (16 pts)