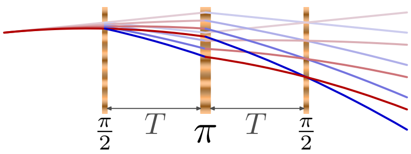
I.C.E.: towards long-baseline atom interferometry

Long interrogation times for high-precision atom-interferometric inertial sensing

Ultra-precise, exact, gravito-inertial sensing

Light-pulse interferometer



$$\Delta\varphi = \mathbf{k}_{\mathrm{Ram}} \cdot \mathbf{g}\, T^2$$

Fundamental measurements

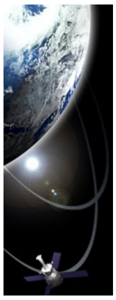
- Test mass = atoms
- Measured on optical ruler
- Trajectories follow a geodesic

Tests of GR

Long interrogation times

- Larger fall height
  Drop tower, orbital station

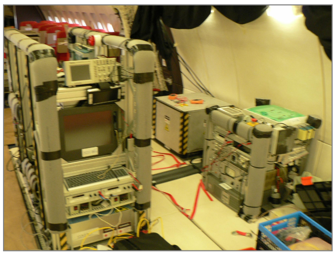
- Well-collimated atomic source
  Need narrow momentum spread
  + Controlled trap release



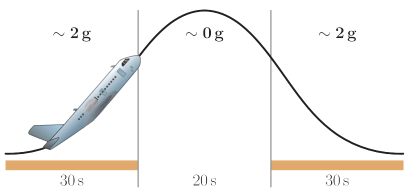
Ballistic flights for long free-fall distance

Successful test flight

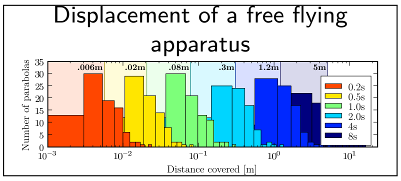
- Rubidium MOT in flight
- Harsh environment:
  5° – 20° thermal cycling
  Nightly power cuts
  800 – 1000 hPa pressure
  High level of vibrations



An airbus as an Einstein elevator

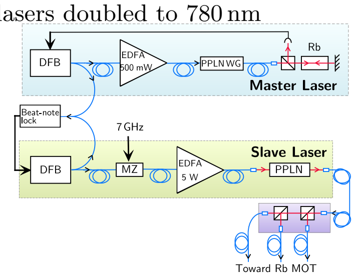


4 s of true free fall



Modular, robust, apparatus

- Fibered ultra-stable telecom lasers doubled to 780 nm



- Fully rack-mounted optics and electronics (9 g structural strength)
- Minimalistic vacuum system on breadboard with free space optics

Degenerate atomic gases for a collimated source

BEC: collisional shift

⇒ uncontrollable systematic errors.

Fermi sea: Pauli blocking

- No collisional shift in spin-polarized samples
- Broadened velocity distribution

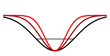
^{87}Rb – ^{40}K mixture

- 780 nm & 767 nm laser cooling transitions
- Tunable interactions via Feschbach resonances

All optical cooling

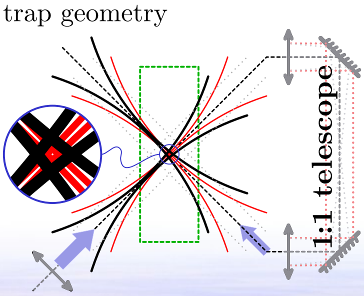
for controlled trap release

- Compressible trap for optimized evaporation



control of density and trap depth

- Recirculating crossed dipole trap geometry

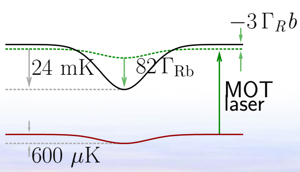


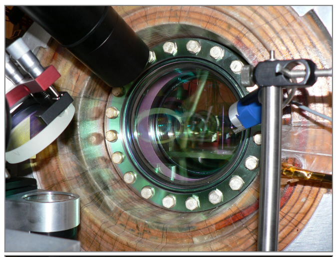
Boson-Fermion coherent atom-interferometer

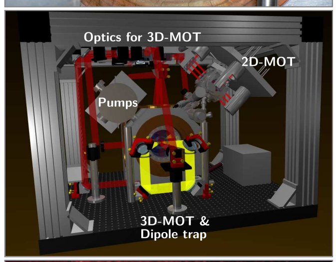
- 2D-MOT as an atomic source
- Moderately compact apparatus (900 × 700 × 700 mm)

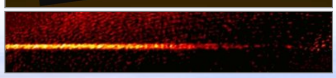
Dipole trap at 1565 nm

- 50 W erbium fiber laser
- 40 nm to the red of highest upper level transition









INSTITUT d'OPTIQUE GRADUATE SCHOOL
ONERA THE FRENCH AEROSPACE LAB

G. Varoquaux†, J-F. Clément†, N. Zahzam‡, J-P. Brantut†, R. A. Nyman†, F. Pereira Dos Santos⋆, O. Carraz‡, Y. Bidel‡, A. Bresson‡, A. Landragin⋆, A. Aspect, and P. Bouyer
gael.varoquaux@normalesup.org

† Institut d'Optique, Campus Polytechnique, RD128, 91127 Palaiseau, France.
‡ LNE-SYRTE, UMR8630, Observatoire de Paris, 61 av. de l'Observatoire, 75014 France.
⋆ Office National d'Etude et de Recherche Aérospatiales, Chemin de la Hunière, 91761 Palaiseau, France.

l'Observatoire de Paris – SYRTE
Systèmes de Référence Temps Espace
cnes