

Quantum Opportunities at Humboldt, Oxford and DESY

C Foot, C Issever, H Lacker, A Peters, I Shipsey, S Worm

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Quantum (Optics) R&D: Actions

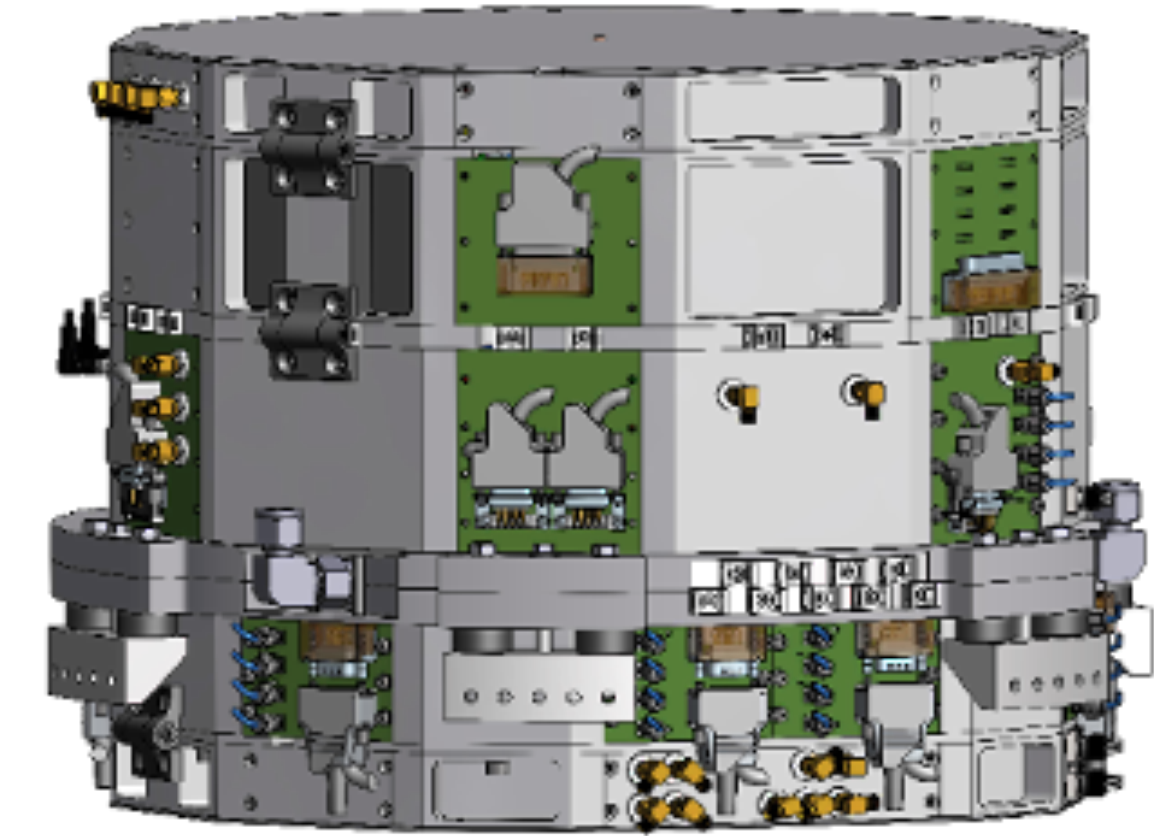
Quantum Technology Task Force (A Peters, H Lacker, C Issever, S Worm, I Shipsey, C Foot)

13. List methods, instruments and facilities in Quantum
14. Collaborations, projects or thesis topics: between institutes
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16. What internship topics could lead to papers?

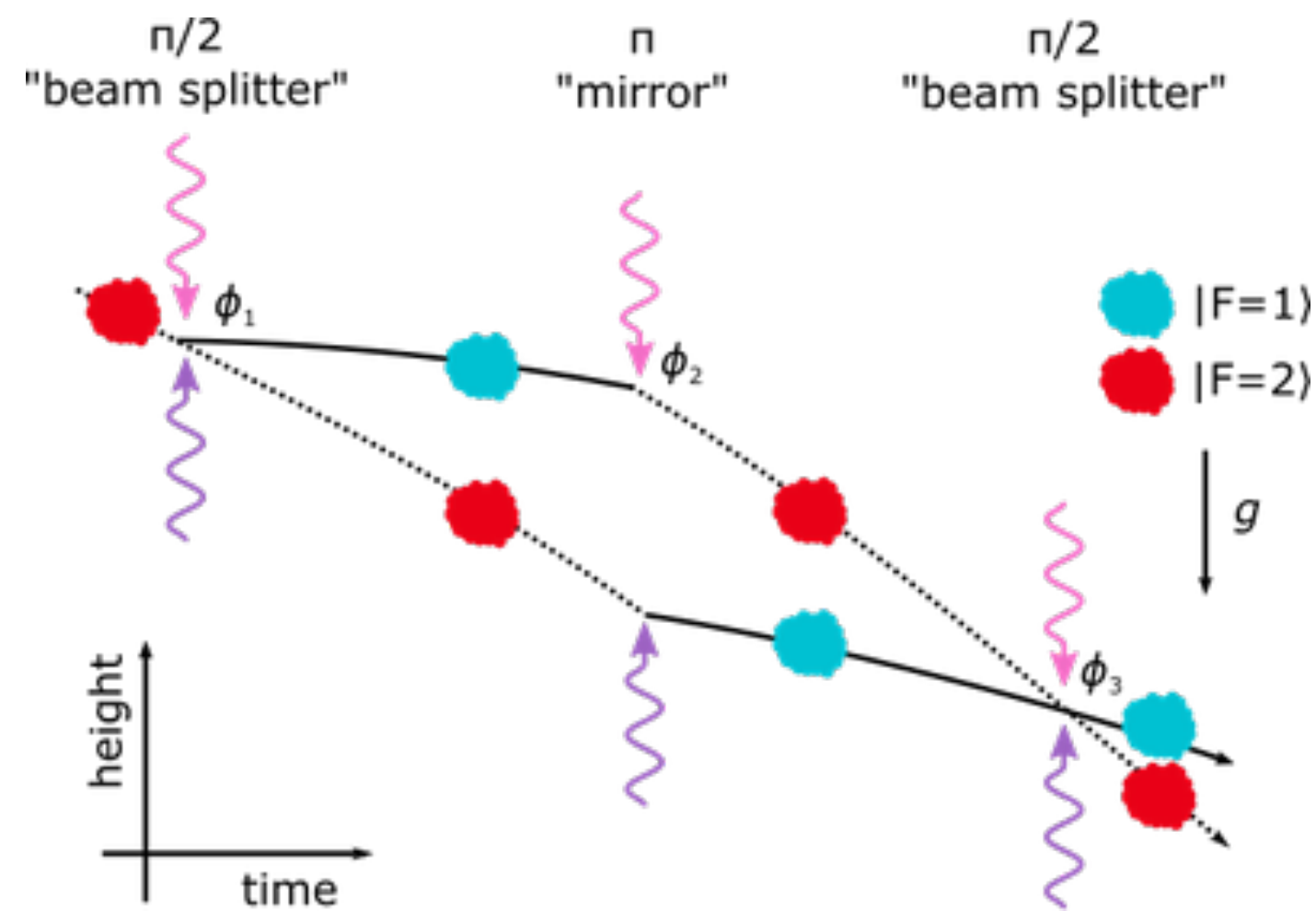
Humboldt Quantum Optical Metrology

Group of Achim Peters

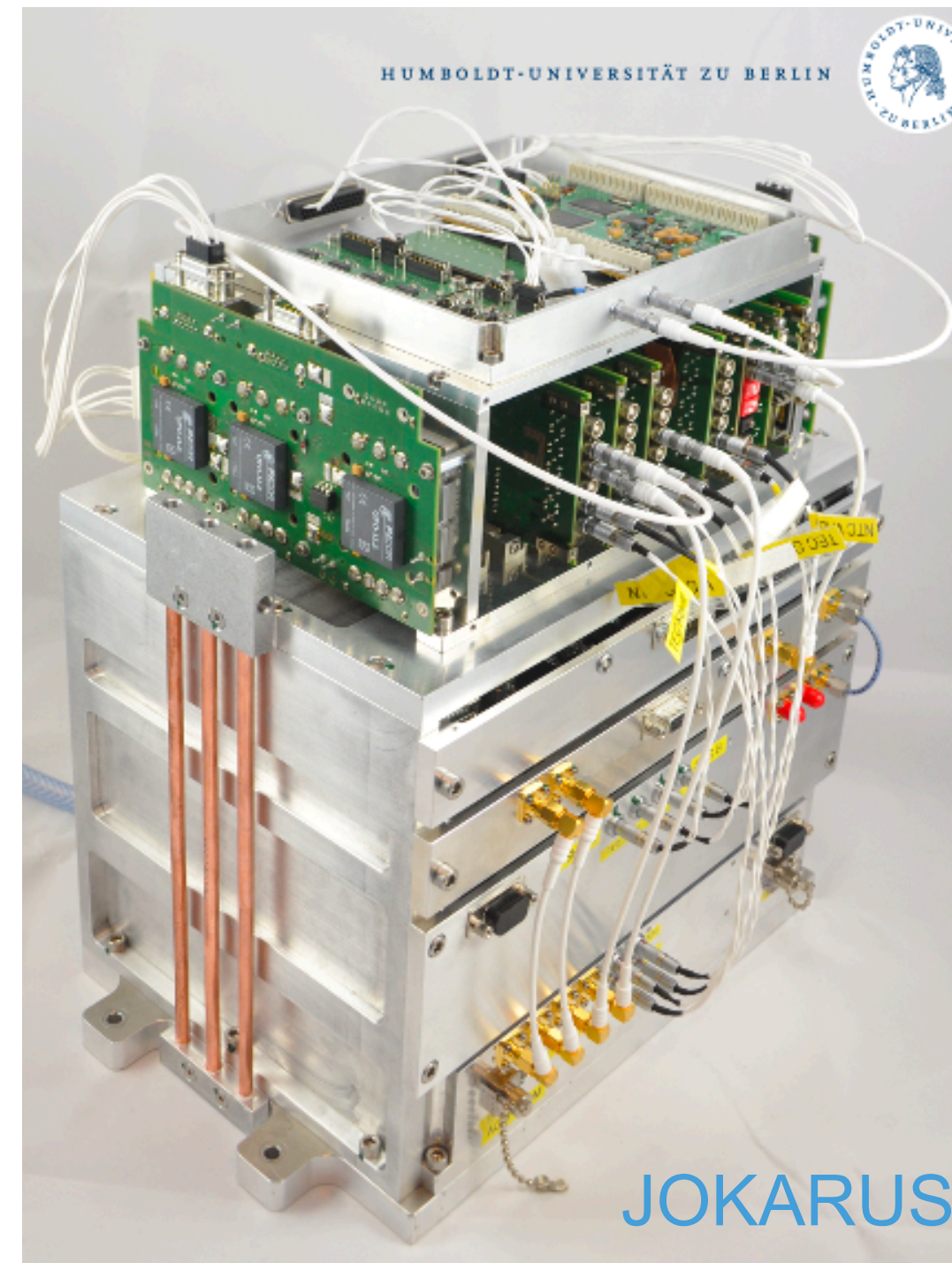
- Atom interferometry (e.g. GAIN)
- Tests of Lorentz Invariance
- Cold molecules
- Frequency comb, novel laser systems
- Extensive experience with space missions



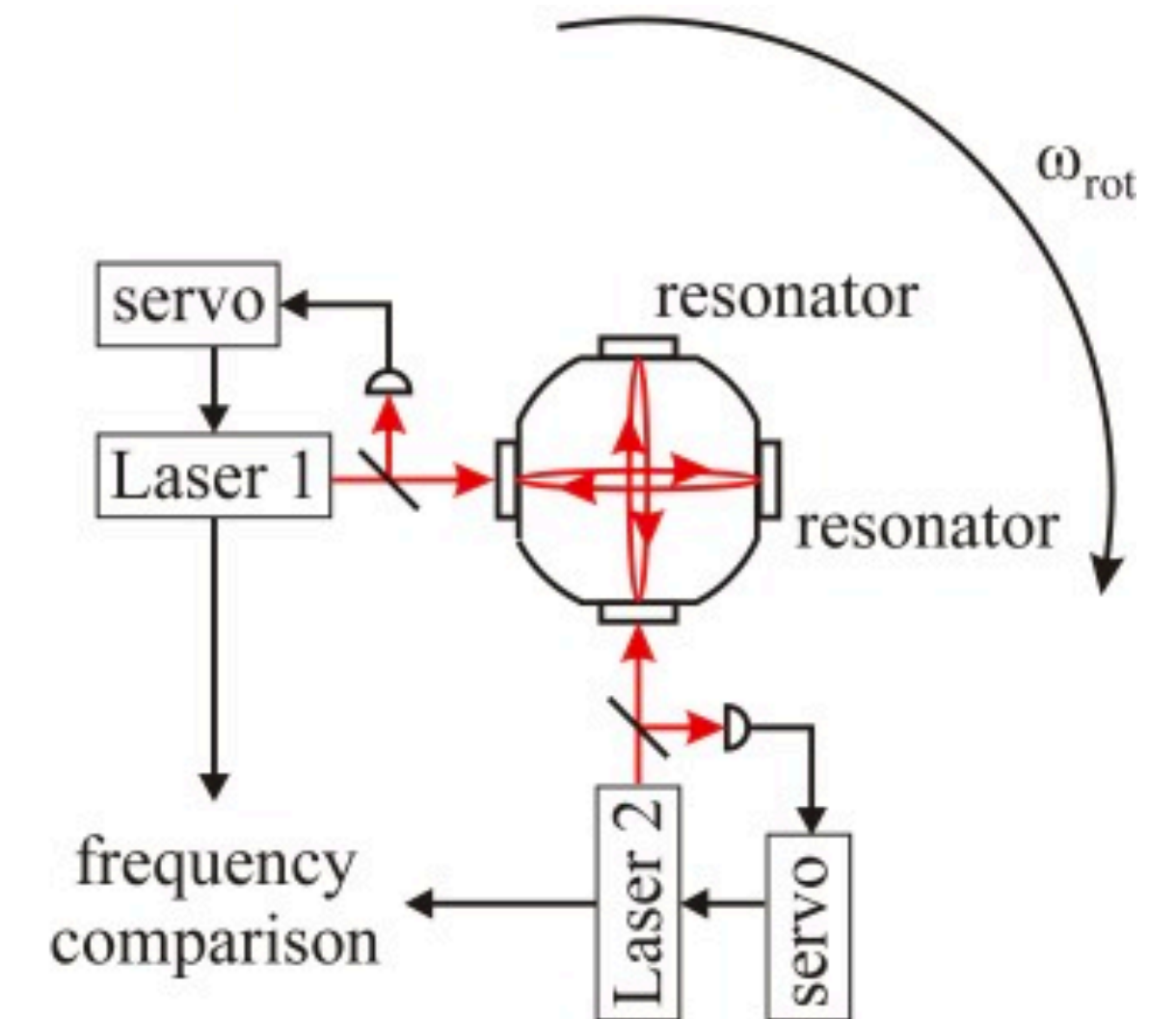
MAIUS B laser system



Atom Interferometry



JOKARUS

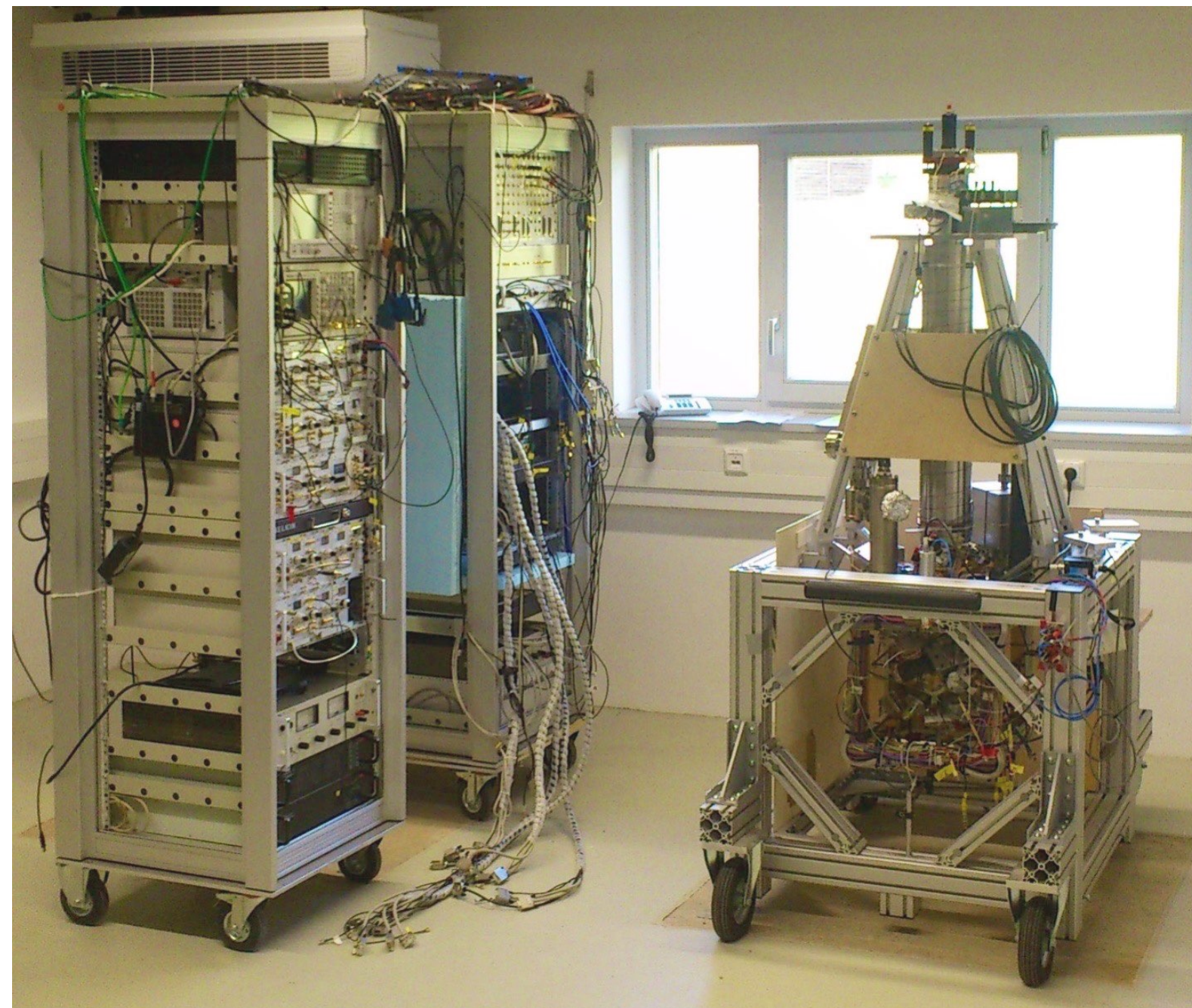


Optical test of Lorentz Invariance

Quantum Sensors & Metrology – Examples



Portable atomic quantum gravimeter GAIN



- Mobile setup
- Atomic fountain
 $h \cong 0.7\text{m}$
 $T \leq 0.3\text{s}$

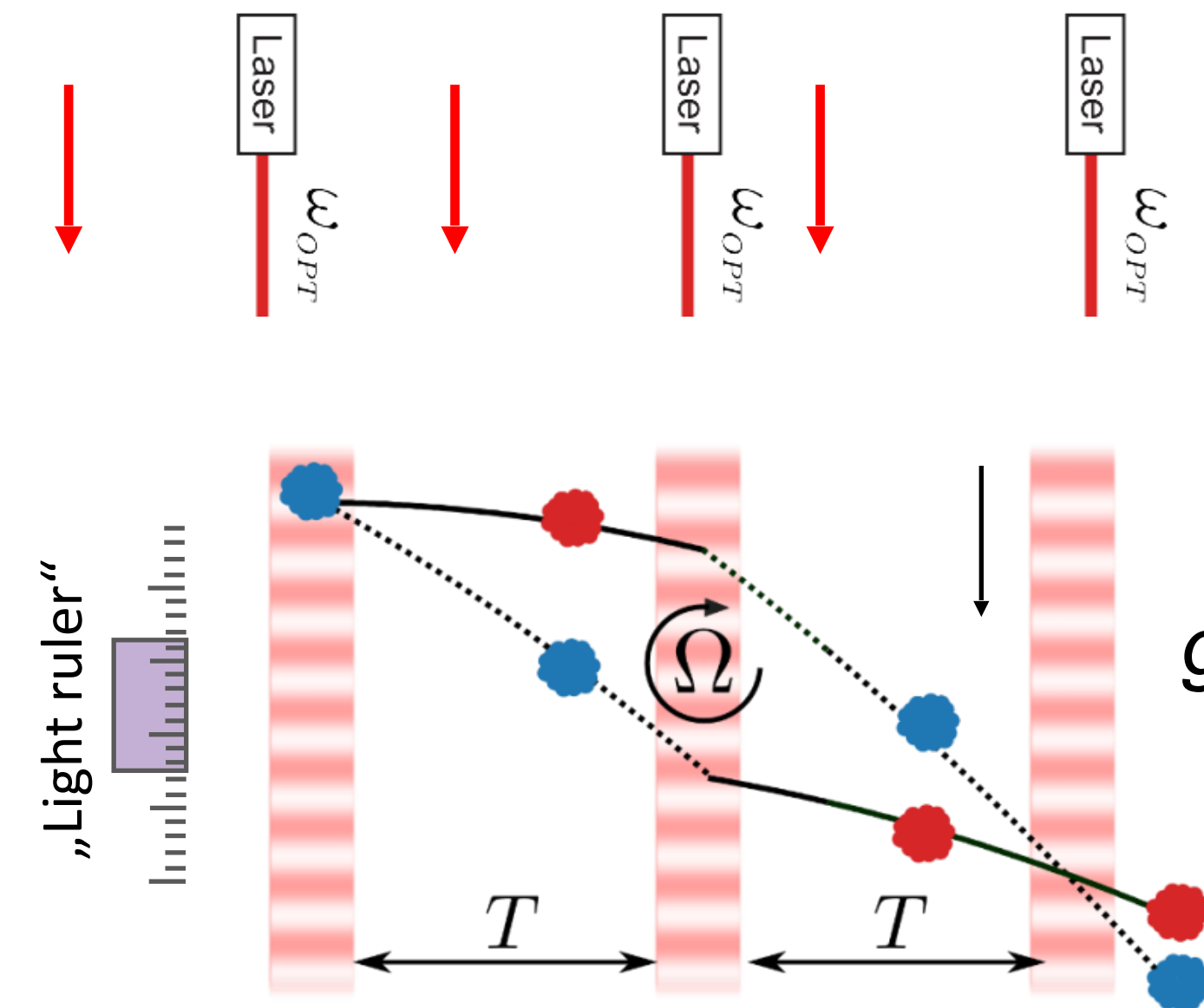
- Rubidium 87
- Diode Laser System @ 780nm

Targeted Performance:

Sensitivity
 $10^{-8} \text{ g}/\sqrt{\text{Hz}}$

Accuracy:
 $5 \times 10^{-10} \text{ g}$

Measure inertial forces: Atom interferometers



Atom interferometers measure inertial effects with relative stability of
 $\Delta g/g \approx 10^{-11}$

Opportunities / Interests: Fundamental physics with quantum devices

- **10m fountain**: no cold strontium experiments at HU yet, but work on stable lasers and high performance frequency references for Strontium.
- Plans to set up **cryogenic strontium apparatus** for, e.g., tests of the Equivalence principle for charged particles.
- Foundational issues of quantum mechanics using our existing **mobile Rubidium fountain** GAIN (probably to be upgrade for use with a degenerate source) and **space / microgravity** related setups (QUANTUS 2 --> Droptower, MAIUS B --> sounding rockets, BECCAL --> ISS).
- Other strong interests / experiences here include various **electromagnetic resonators** (cryogenic microwave, macroscopic optical, mesoscopic optical, room temperature / cryogenic).
- Interest/expertise in **cryogenics** at temperatures all the way down to the to the mK regime.

Quantum Technologies for Fundamental Physics (QTFP)

£40M UK Programme being reviewed now

Many w/ Oxford involvement and HU expertise:

AION: Atom Interferometer Observatory and Network

- <https://www.hep.ph.ic.ac.uk/AION-Project/>
- <https://arxiv.org/abs/1911.11755>

QSNET: Networked Quantum Sensors

- <https://qsnet19.wixsite.com/home>

Many others:

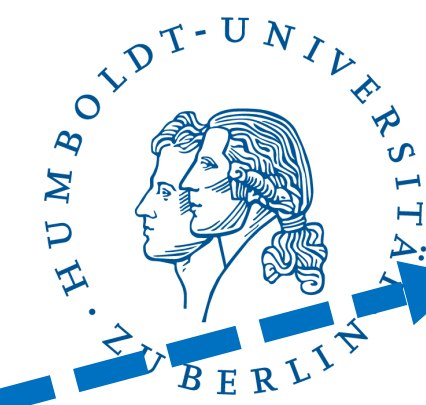
- Absolute Neutrino Mass
- Collective quantum excitations as quantum sensors
- QI: Quantum-enhanced Interferometry for New Physics
- Gravitational Waves...

Final Funding Decisions: April 2



Optische Metrologie

Miniaturized Optical Technologies*



(* lasers, laser systems, frequency references)

