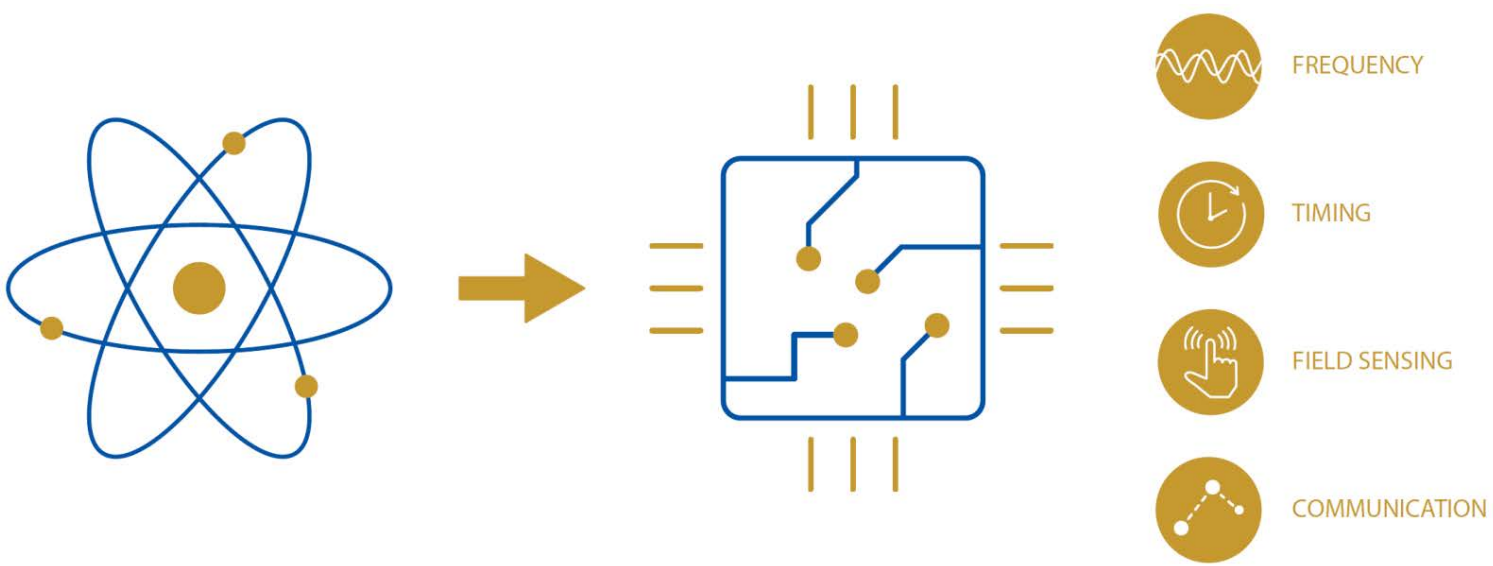
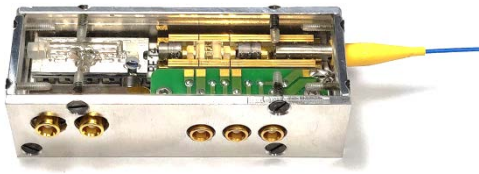
Joint Lab Integrated Quantum Sensors (Krutzik)



Joint Lab Integrated Quantum Sensors (Est. 2019)

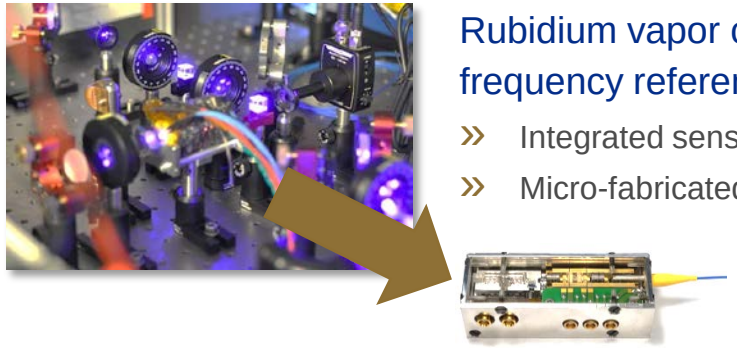
Humboldt-Universität zu Berlin & Ferdinand-Braun-Institute



Innovationsforen Mittelstand
Bundesministerium für Bildung und Forschung
Gefördert durch: Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

R&D and interests at JL Integrated Quantum Sensors (Krutzik)

Devices based on spectroscopy of atomic gases



Rubidium vapor cell based optical frequency references and clocks

- Integrated sensor heads
- Micro-fabricated vapor cells

Devices based on interferometry of atomic gases

Strontium beam Ramsey-Bordé interferometer

- All diode laser based system
- Compact source cells and integrated optics

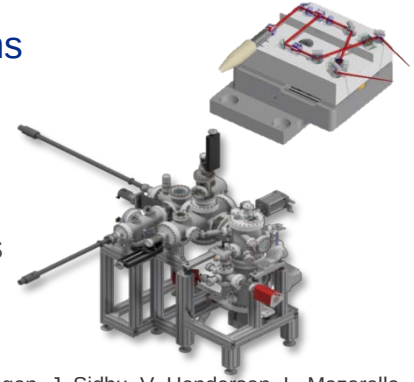
Gravimetric Atom Interferometer GAIN (with A. Peters)

- More on next slides

Hybrid-integrated systems and tools for atom manipulation in UHV

Miniaturized hybrid traps for ultracold atoms and integrated Physics packages

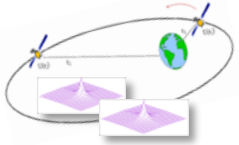
- Free-space optical systems for atomic manipulation in UHV; adhesive qualification
- Additive Manufacturing of functional ceramics and metal components for HV/UHV

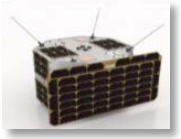


Cold atoms in space

Ultracold atoms for matter wave sensors, tests of quantum mechanics and quantum memories (in space)

- QUANTUS & MAIUS *collaboration led by LU Hannover*
- Test of quantum mechanics (Non-lin. ext., CSL)
- Atomic quantum memories





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M. Gündogan, J. Sidhu, V. Henderson, L. Mazarella, J. Wolters, D. Oi, and M. Krutzik, arXiv:2006.10636 (2020)
S. Vowe, C. Lämmerzahl, and M. Krutzik, Phys. Rev. A **101** (2020)
B. Wiegand, B. Leykauf, K. Döringshoff, Y Gupta, A. Peters, and M. Krutzik, AIP Review of Scientific Instruments **90** (2019)
J. Pahl, C. Grzeschik, A. Dinkelaker, J. Kluge, M. Schiemangk, A. Wicht, A. Peters, and M. Krutzik, Applied Optics **58** (2019)
V.Schkolnik, O. Fartmann, and M. Krutzik, IOP **29** (2019)
M. Christ, A. Kassner, R. Smol, A. Bawamia , A. Peters, M. Wurz , E. Rasel , A. Wicht and M. Krutzik, CEAS Space J (2019)

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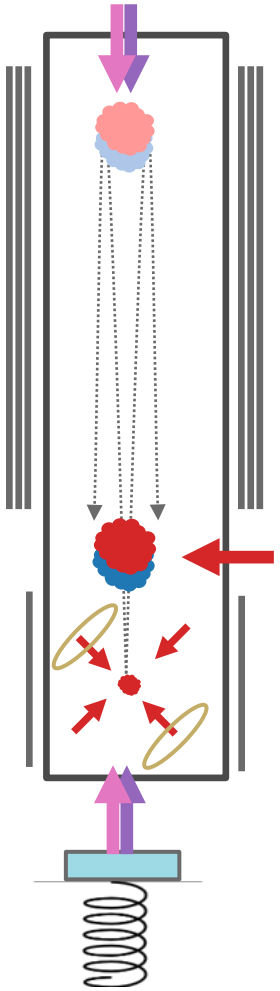
Gravimetric atom interferometer GAIN (Prof. Peters)



Raman beams

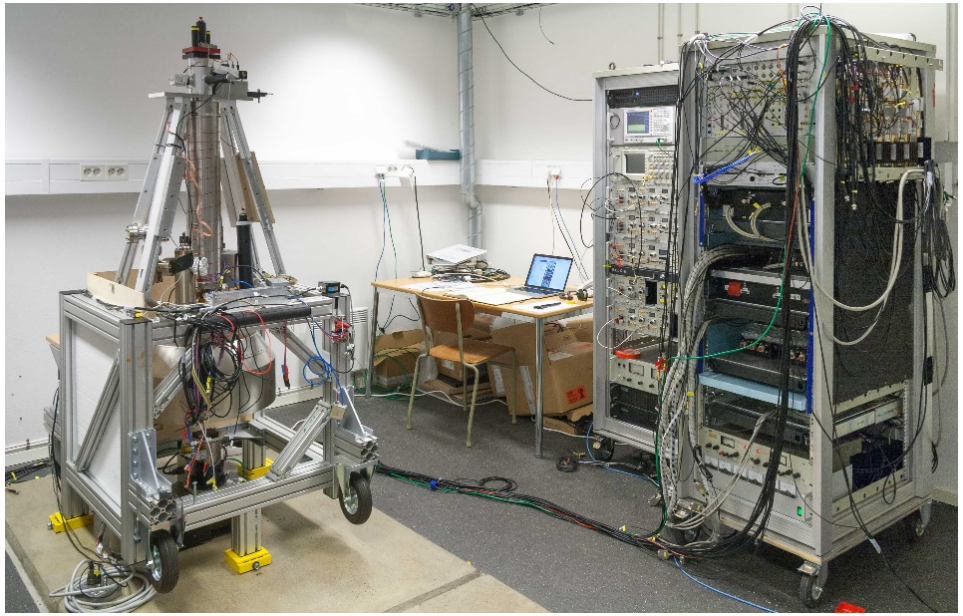
Interferometer zone

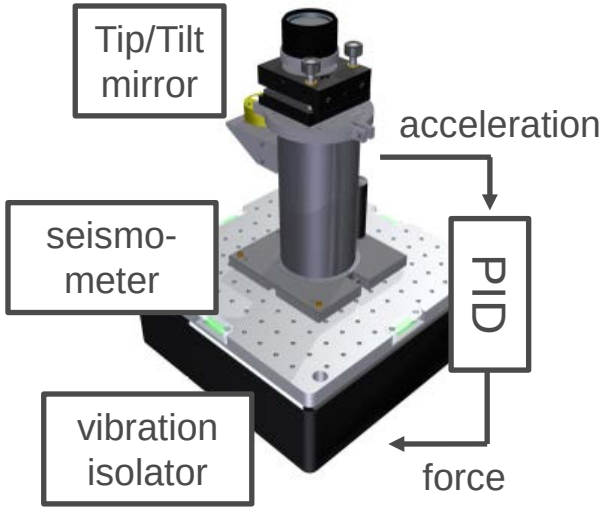
$h \approx 70\ \mathrm{cm}$
$T = 260\ \mathrm{ms}$

Preparation and detection

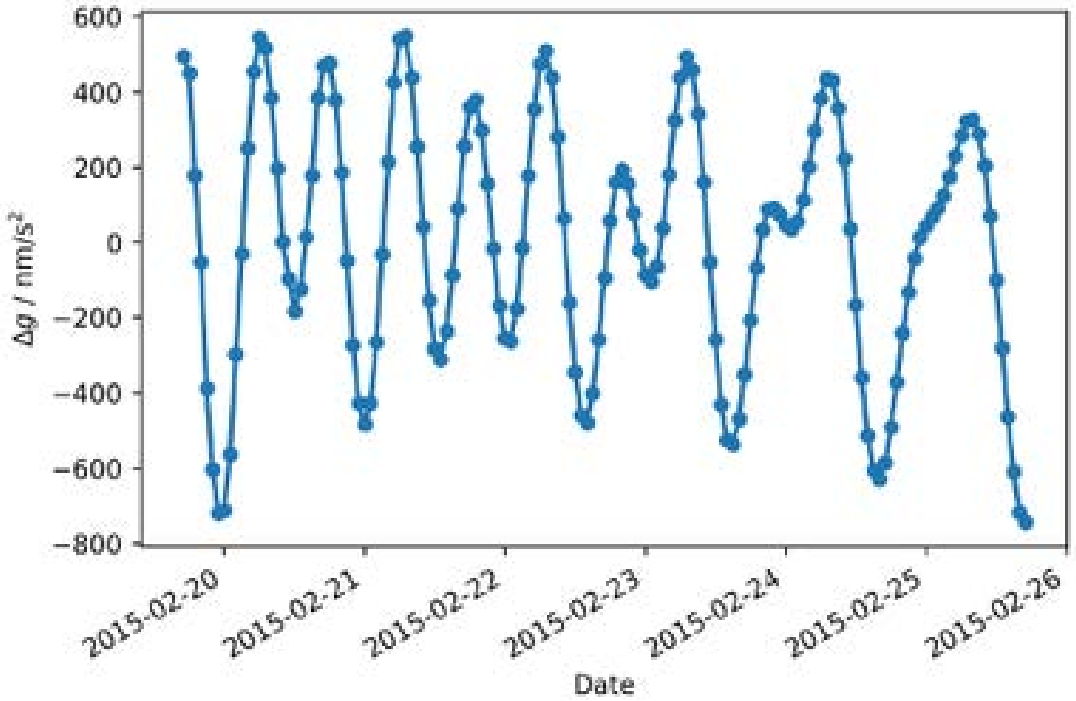
Magneto-optical trap

Vibration isolation





Gravimetric atom interferometer GAIN (Prof. Peters)



- Left: Tide signal at campaign in Onsala, Sweden
- **Accuracy of absolute gravity value**
  - Agreement with FG5:
    $$\Delta g = (63 \pm 37)\ \mathrm{nm}/s^2$$
  - Systematic error budget dominated by Raman wavefront aberrations
- Absolute, continuous gravity measurements with **long-term stability** of better than $\Delta g = \frac{0.5\ \mathrm{nm}}{\mathrm{s}^2}$

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