Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

Ion traps for optical clocks

Elena Jordan[1,2], Group of Prof. Dr. Tanja E. Mehlstäubler[1,3]

[1]Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany

[2]Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), c/o Callinstr. 36, 30167 Hannover, Germany

[3]Leibniz Universität Hannover, Callinstr. 36, 30167 Hannover, Germany

quest

EPIC Online Quantum Technology Meeting on Atomic Clocks and Network Synchronization

06 October 2021

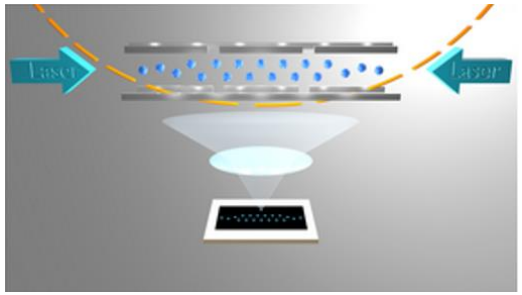
PTB – National Metrology Institute

PTB / Braunschweig + Berlin

~ 2200 employees

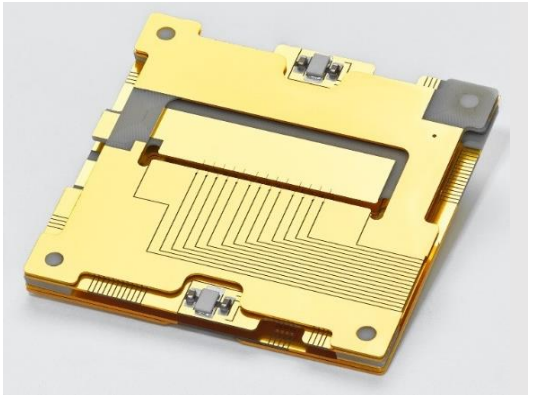
Founded 1887:
by Werner von Siemens & Hermann von Helmholtz

Quantum Clocks and Complex Systems



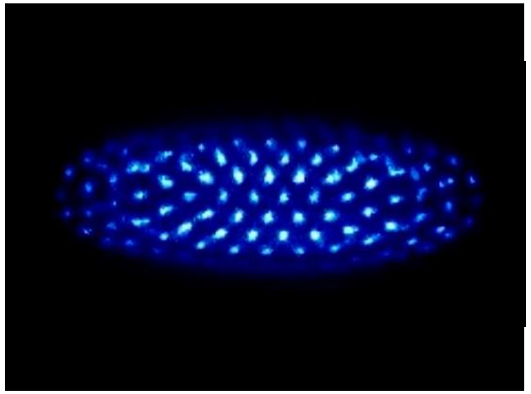
Optical Multi-Ion Clocks with $^{115}In^{+}$ and $^{172}Yb^{+}$

- improved signal to noise ratio
- shorter averaging time



Ion Trap Development

- precise
- compact
- scalable
- integrated



Many-Body Physics with Trapped Ions

- symmetry breaking phase transitions
- transport dynamics
- friction phenomena

User Facility „Ion Traps“

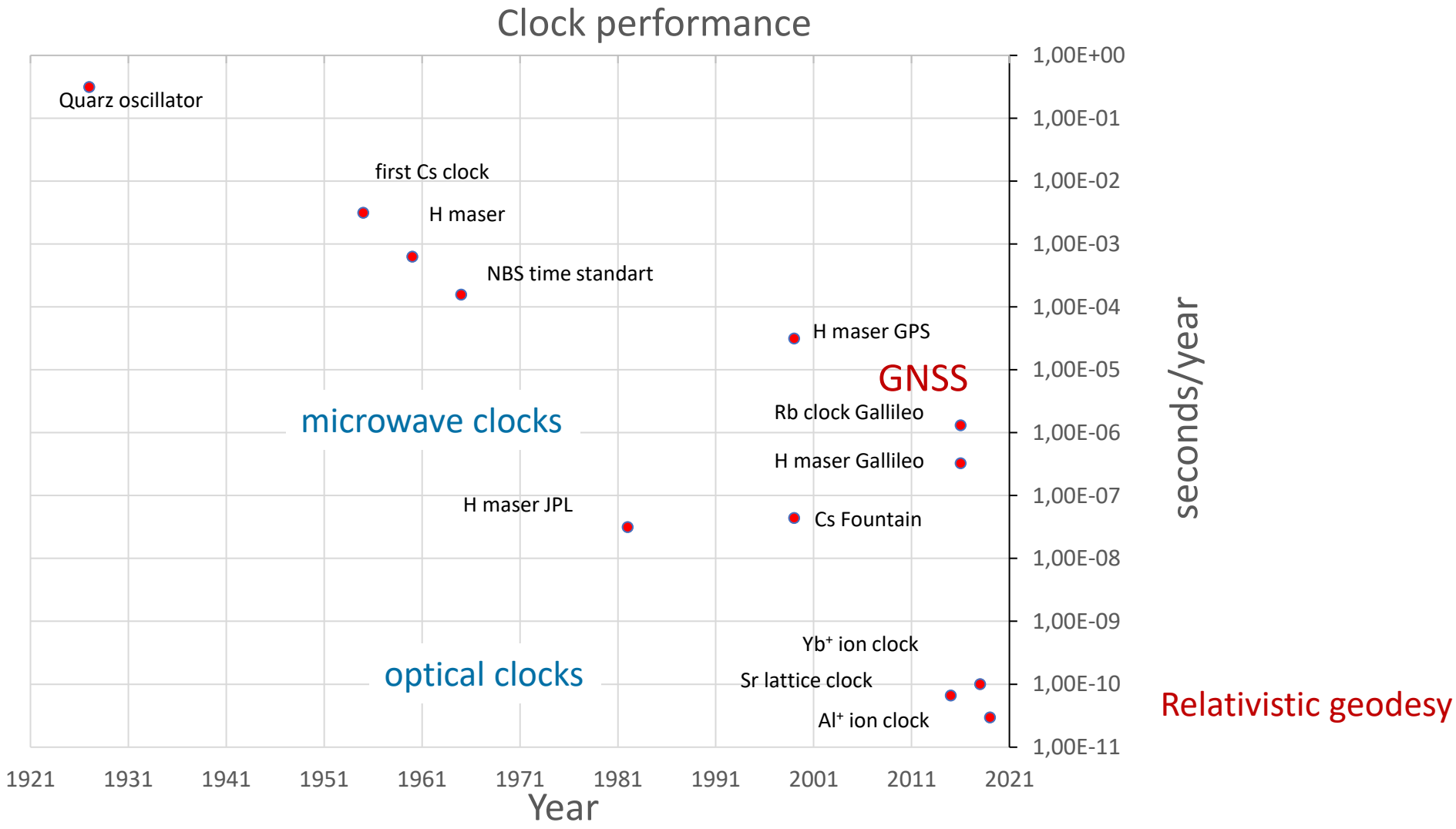
within PTB Quantum Technology Competence Center

- standardized characterization of ion traps

www.quantummetrology.de/quaccs

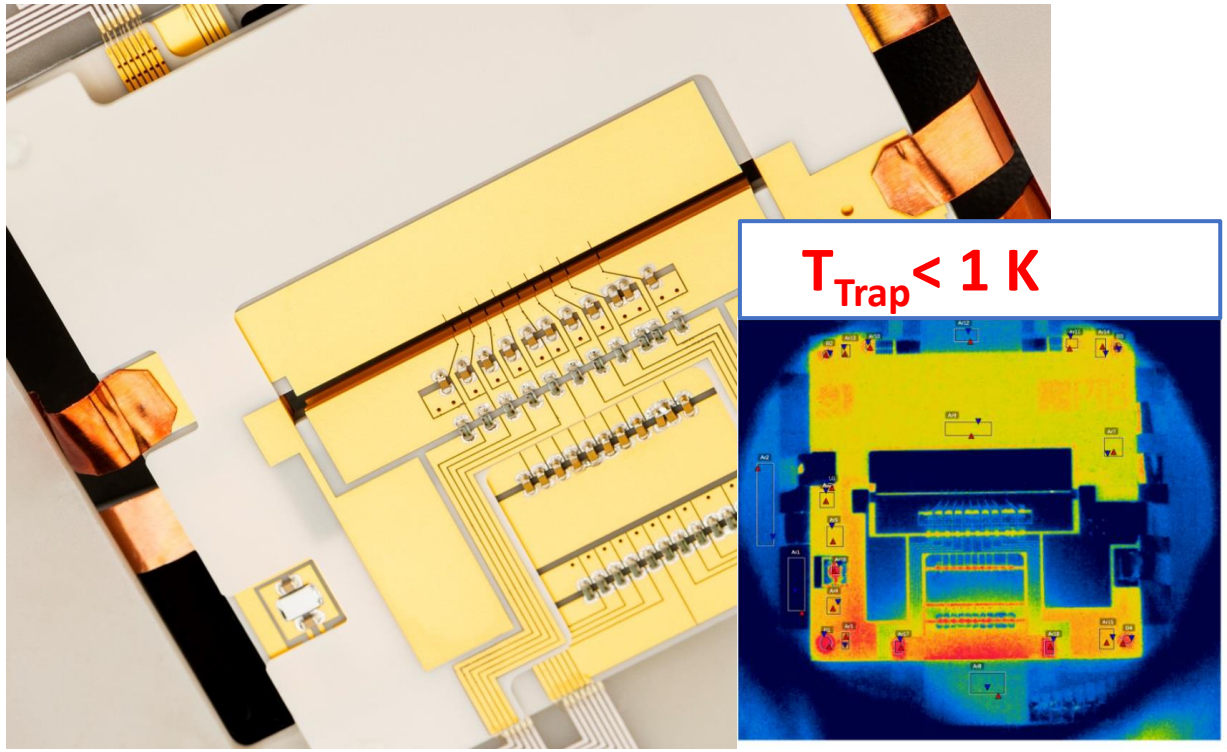
Clock performance

References:
[N. F. Ramsey, JOURNAL OF RESEARCH of the National Bureau of Standards Vol. 88 (1983), https://www.esa.int/Applications/Navigation/Galileo/Galileo_s_clocks (10/2021)



Relativistic geodesy

Ion traps for optical clocks



Keller *et al.* PRA (2019) Nordmann *et al.* (2020)

- Temperature stability
- Micromotion compensation
- Multi-ion operation

Yb-ions trapped at Uni Siegen (2020)

Current projects and partners

- **IDEAL - integrated diamond ion trap**

Diamond Materials – Advanced Diamond Technology
PTB
GRIN TECH – Gradient Index Optics Technology
Laser nanoFab
NANEO®
DAUSINGER+ GIESEN GMBH
IQ – Institut für Quantenoptik
Bundesministerium für Bildung und Forschung

- **EVAQS advanced vacuum technologies**

allectra – A future with vacuum
JGU
L-ptek – FIBER OPTIC LIGHT GUIDES AND SENSORS
PTB
JOHANNES GUTENBERG UNIVERSITÄT MAINZ
Bundesministerium für Bildung und Forschung

ATIQ – quantum computer

infineon
BLACK Semiconductor
Fraunhofer
PTB
Leibniz Universität Hannover
Technische Universität Braunschweig
Bundesministerium für Bildung und Forschung

… just to name a few

- **QVLS – quantum computer**

SARTORIUS
Max-Planck-Institut für Gravitationsphysik Albert-Einstein-Institut
NIEDERSACHSEN METALL
QubeDot
DLR – Institut für Satellitengeodäsie und Inertialsensorik
Technische Universität Braunschweig
PTB
Leibniz Universität Hannover
VolkswagenStiftung

Towards a „Clock on a chip“

- use synergies with quantum computers
- develop a compact, robust „optical clock on a chip“
- Our part: Ion trap with integrated photonics

Looking for

- UHV compatible components: fibers, connectors, …
- Integrated optical switches
- Fiber to chip connectors
- Miniaturized single photon detectors

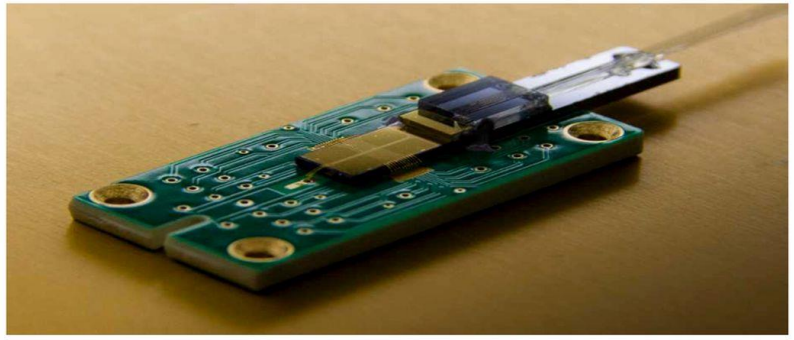


Image: ETH Zürich website

Similar efforts:

Sandia National Laboratories

Ivory et al., arXiv:2011.12376v2, (2021).
Setzer et al., arXiv:2105.01235v2, (2021)