

# Atomic clocks

---

## General

---

- Optical atomic clocks  
, N. Poli et al., arXiv:1401.2378v2 (2014)
- Optical atomic clocks  
, A.D. Ludlow et al., Reviews of modern physics **87** (2015)
- Fritz Riehle, Frequency Standards, WILEY-VCH Verlag GmbH & Co. KGaA, 2004

## Elements

---

- Best Clock so far (Stand 11/2016)  
<http://www.nature.com/nature/journal/v506/n7486/pdf/nature12941.pdf>  
doi:10.1038/nature12941
- Systematic Evaluation for this <http://www.nature.com/articles/ncomms7896.pdf>
- Best Clock Comparison so far (Stand 11/2016) Comparison of Two Independent Sr Optical Clocks with  $1 \times 10^{-17}$  Stability at  $10^3$  s:  
[physrevlett.109.230801.pdf](http://arxiv.org/abs/1603.02026)
- **Mercury:**
  - Comparing a mercury optical lattice clock with microwave and optical frequency standards  
, R. Tyumeney et al., arXiv:1603.02026v2 [physics.atom-ph] 13 Nov 2016

## Cavities

---

### Summary of the best cavities

- Mercury (Paris) cavity:
  - Ultrastable lasers based on vibration insensitive cavities  
, J. Millo et al., PR A **79**, 053829 (2009)
  - Laser locking to the Hg199  $^1S_0 - ^3P_0$  clock transition with  $5.4 \times 10^{-15}/\sqrt{\nu}$  fractional frequency instability  
, J. J. McFerran et al., Optics Letters Vol. **37**, No. 17, 3477-3479 (2012)

## General

- Making optical atomic clocks more stable with 10–16-level laser stabilization  
, V. Jiang et al., Nature Photonics **5**, 158–161 (2011)

## Relevant effects influencing frequency stability

- **Vibration:**

- Simple vibration-insensitive cavity for laser stabilization at the  $10^{-16}$  level  
, J. Keller et al., Appl. Phys. **B 116**, 203–210 (2014)

- **Thermal-Noise:**

- Thermal-Noise Limit in the Frequency Stabilization of Lasers with Rigid Cavities  
, K. Numata et al., PRL **93**, 250602 (2004)
- Thermal noise in optical cavities revisited  
, T. Kessler et al., J. Opt. Soc. Am. B Vol. **29**, No. 1 (2012)

- **Residual amplitude modulation:**

- Reduction of residual amplitude modulation to  $1 \times 10^{-6}$  for frequency modulation and laser stabilization  
, W. Zhang et al., Optics Letters Vol. **39**, No. 7 (2014)
- Investigation and cancellation of residual amplitude modulation in fiber electro-optic modulator based frequency modulation gas sensing technique  
, Z. Li et al., Sensors and Actuators B **196**, 23–30 (2014)
- Residual amplitude modulation in interferometric gravitational wave detector  
, K. Kokeyama et al., J. Opt. Soc. Am. A Vol. **31**, No. 1 (2014)
  - Residual Amplitude Modulation in Interferometric Gravitational Wave Detectors  
, K. Kokeyama et al., aXiv:1309.4522v1 [gr-qc] 18 Sep 2013

## Length

- **7 cm:**

- Compact, thermal-noise-limited optical cavity for diode laser stabilization at  $1 \times 10^{-15}$   
, A. D. Ludlow et al., Optics Letters Vol. **32**, Issue 6, pp. 641–643 (2007)

- **10 cm:**

- A compact, robust, and transportable ultra-stable laser with a fractional frequency instability of  $1 \times 10^{-15}$   
, Q. F. Chen et al., REVIEW OF SCIENTIFIC INSTRUMENTS **85**, 113107 (2014)

- **48 cm:**

- $8 \times 10^{-17}$  fractional laser frequency instability with a long room-temperature cavity  
, S. Häfner et al., Optical Letters Vol. **40**, No. 9 (2015)

## Mirror layers

- **Crystalline coatings:**

- Tenfold reduction of Brownian noise in high-reflectivity optical coatings  
, Garrett D. Cole et al., Nature Photonics **7**, 644–650 (2013)

## Other geometries

- **Cubic geometry:**

- Force-insensitive optical cavity  
, S. Webster et al., Optics Letters Vol. **36**, Issue 18, pp. 3572-3574 (2011)
    - PTB took the NPL-design and updated it for a better longterm stability (see Häfner PHD-thesis, Chapter 4.2)

- **Cryogenic single-crystal optical cavities:**

- Ultrastable laser with average fractional frequency drift rate below  $5 \times 10^{-19}/s$   
, C. Hagemann et al., Optics Letters Vol. **39**, No. 17 (2014)
    - A sub-40-mHz-linewidth laser based on a silicon single-crystal optical cavity  
, T. Kessler et al., Nature Photonics Vol. **6**, 687-692 (2012)

## Applications

- **Transfer of stability:**

- Providing 10–16 Short-Term Stability of a 1.5- $\mu$ m Laser to Optical Clocks  
, C. Hagemann et. al., IEEE Transactions on instrumentation and measurement, VOL. 62, NO. 6 (2013)

# Application of Clocks

- Realization of a timescale with an accurate optical lattice clock:  
optica-3-6-563.pdf

From:

<https://iqwiki.iqo.uni-hannover.de/> - IQwiki

Permanent link:

<https://iqwiki.iqo.uni-hannover.de/doku.php?id=groups:mg:otherclocks&rev=1479402988>

Last update: **2016/11/17 17:16**

