

Steffen Sauer

Lasertreiber

- [Laserdriver_Mg](#)
- Leiterplatten: <https://www.multi-circuit-boards.eu/index.html>
 - Login-Nummer: 162258
- 10 MHz Mail: 10mhz@iqo.uni-hannover.de
 - passwort: pAd98Y24
- [Metamirror](#)

Paper Sammlung

General

- Making optical atomic clocks more stable with 10–16-level laser stabilization
, V. Jiang et al., Nature Photonics **5**, 158-161 (2011)
- High-precision laser stabilization via optical cavities
, M. Martin and J. Ye
- [guidelines_for_developing_optical_clocks_with10_18fractional_frequency_uncertainty.pdf](#)

Relevant effects influencing frequency stability

Noise calculation

- 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)
- **Reduction of thermal noise limit**
 - **Higher-order mode locking:**
 - Thermal noise limited higher-order mode locking of a reference cavity
, X. Y. Zeng et al., arXiv:1801.05026v1 (2018)

Pound-Drever-Hall (PDH)

- Laser Phase and Frequency Stabilization Using an Optical Resonator
, R. W. P. Drever et al., Appl. Phys. B **31**, 97-105 (1983)
- EOM-Temperature

Vibration

- Simple vibration-insensitive cavity for laser stabilization at the 10^{-16} level
, J. Keller et al., Appl. Phys. **B 116**, 203–210 (2014)
- <https://journals.aps.org/pra/abstract/10.1103/PhysRevA.79.053829>

Residual amplitude modulation

- Reduction of residual amplitude modulation to 1×10^{-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

Temperature/CTE

- **ULE compensations rings:**
 - Tuning the thermal expansion properties of optical reference cavities with fused silica mirrors
, T. Legero et al., J. Opt. Soc. Am. B Vol. **27**, No. 5 (2010)

Spacer geometries / Cavity types

- **Vertical geometry:**
 - **Length: 2.5 cm:**
 - Compact, thermal-noise-limited reference cavity for ultra-low-noise microwave generation
, J. Davila-Rodriguez et al., Opt. lett. Vol. 42, No. 7 (2017)
 - **Length: 7 cm:**
 - Compact, thermal-noise-limited optical cavity for diode laser stabilization at 1×10^{-15}
, A. D. Ludlow et al., Optics Letters Vol. **32**, Issue 6, pp. 641-643 (2007)
 - **Length: 10 cm:**
 - A compact, robust, and transportable ultra-stable laser with a fractional frequency instability of 1×10^{-15}
, Q. F. Chen et al., REVIEW OF SCIENTIFIC INSTRUMENTS 85, 113107 (2014)
 - **Length: 48 cm:**

- 8×10^{-17} fractional laser frequency instability with a long room-temperature cavity
 , S. Häfner et al., Optical Letters Vol. **40**, No. 9 (2015)
- A strontium lattice clock with 3×10^{-17} inaccuracy and its frequency:
[a_strontium_lattice_clock_with_310_-17_inaccuracy_and_its_frequency.pdf](#)
- **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:**
 - **Length: 6 cm:**
 - **Length: 21 cm:**
 - 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)
 - <https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.118.263202>
- **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)

Measurement/characterization techniques of ultra-stable lasers

- Characterization of electrical noise limits in ultra-stable laser systems
 , J. Zhang et al., Review of Scientific Instruments 87, 123105 (2016)
- Phase noise characterization of sub-hertz linewidth lasers via digital cross correlation
 , X. Xie et al., Vol. 42, Issue 7, pp. 1217-1220 (2017)

Applications

- **Transportable cavities:**
 - Single-ion, transportable optical atomic clocks
 , Marion Delehaye & Clément Lacroûte, Journal of Modern Optics, 65:5-6, 622-639 (2018)
- **Lorentz invariance for the electron:**
 - Achim Peters: CORE
- **time:**
 - riehle.pdf

Noise

- [power spectral density of Brownian noise](#)
- Noise to frequency stability:
dawkins.pdf

Material-Konstanten

- [Mechanical Loss I](#)
- [Mechanical Loss II](#)

Coating

- **Crystalline coatings:**
 - Tenfold reduction of Brownian noise in high-reflectivity optical coatings
, Garrett D. Cole et al., Nature Photonics **7**, 644-650 (2013)
 - Anhang von Cole 2013
 - Optical performance of large-area crystalline coatings
, M. Marchito et al., Opt. Exp. 6114, Vol. 26, No. 5 (2018)

Doppelbrechung in kristallinen Spiegelschichten

- ada83.pdf
- bab92.pdf
- jew87.pdf
- Anhang des Cole 2013 Papers

RAM Optimierung

- zha14.pdf

Ab wann ist ein Spiegel ein Supermirror?

- Supermirrors: $R > 99.9999\%$ (<https://www.rp-photonics.com/supermirrors.html>)

Metamirror

- [Thermal noise of Etalon](#)

Transfer-Stabilität

- Providing 10–16 Short-Term Stability of a 1.5- μm Laser to Optical Clocks
, C. Hagemann et. al., IEEE Transactions on instrumentation and measurement, VOL. 62, NO. 6 (2013)
- <https://arxiv.org/pdf/1902.07012.pdf> Transfer-stability von Mehlistäubler zu Siliizum (über zwei Gebäude mit Ethernet-Kabel)

Kamm-Kamm-Vergleich/Frequenzkamm-Limitierung

- <https://arxiv.org/pdf/1910.04261.pdf>

Finesse Messung

- Ringdown von Cole:
supermirror-high-performance-near-and-mid-infrared-crystalline-coatings.pdf

Frequenzverdopplung

- S. Herbers:
oe-27-16-23262.pdf

Darkmatter

- Allgemein
derevianko_2016_j._phys._conf._ser._723_012043_1_.pdf
- Cavities
1808.00540.pdf
- clocks and cavities
eaau4869.full_1_.pdf
- Fiber links
srep11469.pdf
- GPS
s41467-017-01440-4.pdf

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