Steffen Sauer

Lasertreiber

- Laserdriver_Mg
- Leiterplatten: https://www.multi-circuit-boards.eu/index.html
  - Login-Nummer: 162258

Paper Sammlung

Cavity Paper

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

Overview Cavities

Relevant effects influencing frequency stability

- **Fundamental limit: Thermal noise limit**
  - 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)
- **Laser Lock: 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)
- Mercury (Paris) cavity:
    - Ultrastable lasers based on vibration insensitive cavities
    , J. Millo et al., PR A **79**, 053829 (2009)
    - Laser locking to the Hg199 □01−□03 clock transition with 5.4×10−15/√□ fractional frequency instability
    , J. J. McFerran et al., Optics Letters Vol. **37**, No. 17, 3477-3479 (2012)

Coating

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

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 $1\times10-15$
  , 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 $1 \times 10-15$
  , Q. F. Chen et al., REVIEW OF SCIENTIFIC INSTRUMENTS 85, 113107 (2014)
- **Length: 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)
  - 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

Measurement/characterization techniques

- 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

Noise

- power spectral density of Brownian noise

Material-Konstanten

- Mechanical Loss I
- Mechanical Loss II

Doppelbrechung in crystallinen 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 Mehlstäubler zu Siliizum (über zwei Gebäude mit Ethernet-Kabel)

Kamm-Kamm-Vergleich/Freuenzkamm-Limitierung

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

Finesse Messung

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