A 8: Precision Measurements I (joint session Q/A)

Time: Monday 17:00–19:00 Location: HS 1221

A 8.1 Mon 17:00 HS 1221

Search for variations of fundamental constants with highly charged ion clocks — •Luis Hellmich[1,2], Ullrich Schwanke[1,2], Steven Worm[1,2], and Lakshmi Kozhiparambil Sajith[2,3] — [1]Humboldt-Universität Berlin — [2]DESY Zeuthen — [3]MPIK Heidelberg

The measurement of the variation of fundamental constants would be strong evidence for new physics. In particular, many different theories predict the variation the fine-structure constant α. Atomic clocks are a highly precise tool of measuring variations of α, as the clock transitions may change with α.

We are aiming to compare a Sr-lattice clock as a reference to a highly charged ion (HCI) clock. HCI clocks are expected to have extremely high sensitivities to α-variations. We show how such a setup could set new limits on variations of fundamental constants. Furthermore, we estimate with Monte-Carlo simulations and real data how those limits translate to constraints on scalar dark matter models and models with Lorentz-invariance violation.

A 8.2 Mon 17:15 HS 1221

A strontium optical clock based on Ramsey-Bordé spectroscopy — •Amir Mahdian[1], Oliver Fartmann[1], Ingmari C Tietje[1], Martin Jutisz[1], Conrad L Zimmermann[2], Vladimir Schkolnik[1,2], Marc Christ[2], and Markus Krutzik[1,2] — [1]Humboldt-Universität zu Berlin, Institut für Physik — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Berlin

We are developing a Ramsey-Bordé based optical atomic clock where the long-term stability relies on interrogating a stream of strontium atoms. Our choice of the clock transition is the $5s^2\ ^1S_0 \rightarrow 5s5p\ ^3P_1$ intercombination line of Sr at 689 nm, targeting an Allan deviation as low as 2×10^{-15} between 100 s and 1000 s, and 10^{-15} for longer interogation times.

Following an overview of our atom interferometer's current status, the latest developments in the power and frequency stability of the relevant lasers and a different readout mechanism will be presented. Additionally, I showcase the observation of Ramsey-Bordé fringes, accompanied by numerical simulations to aid in interpreting the signal. Moreover, I discuss the stability comparison of our atomic beam clock vs a Rb two-photon frequency reference.

This work is supported by the German Space Agency (DLR), with funds provided by the Federal Ministry for Economic Affairs and Climate Action (BMWK) under grant number DLR50WM1852, and by the German Federal Ministry of Education and Research (BMBF) within the program quantum technologies - from basic research to market under grant number 13N15725.

A 8.3 Mon 17:30 HS 1221

Electronic Bridge schemes in ^{229}Th doped LiCAF — •Tobias Kirschbaum[1], Martin Pimon[2], and Adriana Pálffy[1] — [1]Julius-Maximilians-Universität Würzburg, Germany — [2]Technische Universität Wien, Austria

Large band gap crystals such as CaF_2 or $LiCaAlF_6$ (LiCAF) are an ideal inert host for the nuclear clock candidate ^{229}Th. Among others, these crystals are transparent with respect to the clock transition at $\approx$ 8 eV and a large number of nuclei can be interrogated at the same time [1]. However, DFT calculations indicate that doping of ^{229}Th in these crystals leads to the formation of localized electronic states in the band gap, so-called defect states [2]. Due to their vicinity to the nuclear transition energy, these can be used for effective nuclear excitation via the Electronic Bridge mechanism, as we could show for the case of Th-doped CaF_2 crystals [2,3].

Here, we investigate theoretically different driven Electronic Bridge schemes for ^{229}Th doped LiCAF crystals and present the corresponding excitation rates. These schemes enable a more efficient nuclear excitation/deexcitation compared to direct photoexcitation. The results are discussed in conjuncture with the design of a solid-state nuclear clock.

[1] G. A. Kazakov *et al.*, New J. Phys. **14**, 083019 (2012).
[2] B. S. Nickerson *et al.*, Phys. Rev. Lett **125**, 032501 (2020).
[3] B. S. Nickerson *et al.*, Phys. Rev. A **103**, 053120 (2021).

A 8.4 Mon 17:45 HS 1221

Large ring lasers in geodesy and seismology — •Simon Stellmer[1], Jannik Zenner[1], Andreas Brotzer[2], Jan Kodet[3], Heiner Igel[2], and Karl Ulrich Schreiber[3] — [1]Universität Bonn — [2]LMU München — [3]Geodätisches Observatorium Wettzell und TU München

The rotation of Earth is not as constant as it may seem. On the contrary, it is modulated through various processes at a large range of frequencies. Traditionally, these variations are measured by astronomical techniques such as VLBI, but there is a new kid on the block: large ring lasers have matured to a level that allows for continuous monitoring of variations in the Earth rotation rate at the level of 10^{-8} and below. We will give an overview on the three large ring lasers currently operated in Germany, latest advances and technology development, as well as applications and future perspectives.

A 8.5 Mon 18:00 HS 1221

Quantum Memory Enhanced Velocimetry — •Yagiz Murat[1], Arash Ahmadi[1], Mustafa Gündoğan[1], and Markus Krtutzik[1,2] — [1]Humboldt Universität zu Berlin, Institut für Physik — [2]The Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik

Optical interferometry is crucial in motion sensing. Recent progress has utilized electromagnetically induced transparency (EIT) to measure the velocity of a moving medium, leveraging Fizeau's light-dragging effect. This novel approach opens new possibilities for quantum optical methods in velocimetry, Our work is centered around EIT-based quantum memories. Light storage is realized by tuning a probe and a control field to the Zeeman-split levels of the D1 transition line of cesium atoms ($F = 4 \rightarrow F' = 3$). By monitoring the phase difference of the beating signal of the probe field with a reference field, before and after storage of the probe field, displacement of the cesium vapor cell can be measured down to the nanometer scale. This work contributes to the frontiers of quantum optics and motion sensing, promising advancements in precision measurements. This work has been funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under grant number 448245255.

A 8.6 Mon 18:15 HS 1221

Suppression of scattered light through tunable coherence in Sagnac-Speed-Meters — •Leonie Eggers, Daniel Voigt, and Oliver Gerberding — Universität Hamburg, Institut für Experimentalphysik, Germany

As scattered light noise is a dominating limitation for the sensitivity of gravitational wave detectors, we investigate the use of tunable coherence as a new concept to suppress scattered light.

Tunable coherence is realised by phase modulation following a pseudo-random sequence, which artificially shortens the coherence length of stable continuous wave lasers to the centimeter scale. While Sagnac-Speed-Meter topologies provide a potential alternative for the currently used Michelson-interferometers for future gravitational wave detectors, they suffer from the same limitations through scattered light, as well as the effect of light backscattering from the mirrors and coupling into the counter-propagating beam. We are investigating the use of tunable coherence in Sagnac-Speed-Meters to suppress scattered light through simulations and a tabletop experiment. We are presenting our recent findings on using tunable coherence in Sagnac-Speed-Meters.

A 8.7 Mon 18:30 HS 1221

Investigating a Tensegrity structure as a possible multi DoF inertial sensor — •Ben Becker, Oliver Gerberding, and Artem Basalaev — IExP, Hamburg, Germany

One of the continued challenges for gravitational wave detectors is the advancement of inertial sensors to improve the active isolation of the mirrors. Towards that end we are investigating tensegrity structures as a possible multi degree of freedom inertial sensor. Tensegrity structures are disconnected multi body structures held together by tensioned wires. They offer the option of tuning their mechanical properties by changing the moment of inertial as well as the wire tension. We've simulated a model tensegrity using Ansys multibody dynamics and analyzed its mechanical response to excitation. We compare the direct simulation result with the results of a simulated readout scheme. This readout scheme will be realized on a real tensegrity model for further comparison. We've observed and fitted the transfer functions of the system to get a more thorough understanding with regards to its invertibility and thermal noise. The tensegrity shows distinct transfer function with regimes of linear response for most relevant degrees of freedom. Therefore it should indeed be viable as an inertial sensor.

A 8.8 Mon 18:45 HS 1221

Full spatio-temporal description of Non-linear interference based on cascaded Spontaneous Parametric Down-Conversion. — •Carlos Sevilla[1,2], Purujit Chauhan[1,2], and Fabian Steinlechner[1,2] — [1]Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Albert-Einstein-Str. 7, 07745 Jena, Germany — [2]Abbe Center of Photonics, Friedrich-Schiller-University Jena, Albert-Einstein-Str. 6, 07745 Jena, Germany

Non-linear interferometers are a powerful tool for quantum state engineering and applications in quantum sensing with enhanced phase sensitivity [1]. The typical configuration uses a cascade of non-linear processes such as spontaneous parametric down-conversion (SPDC) combined with spatial or spectral dispersion. This architecture has been widely used, but only few studies have addressed the complete spatiotemporal correlations of the output state of a nonlinear interferometer. Here we extend our results on the spatiotemporal description of SPDC based on the spectral dependence of Laguerre-Gauss modes [2] to the output spatio-temporal state of nonlinear interferometers. For this, we take into consideration realistic parameters such as phase difference between the three fields, the optical system which might induce spatial transformation, and polarization rotations inside then nonlinear interferometer. Furthermore, we show experimental results validating our predictions. References:[1] Bernard Yurke et al. Phys. Rev. A 33, 4033 (1986). [2] A. Ferreri et al. Quantum 5,461 (2021). [3] C. Sevilla-Gutiérrez, et.al. Spectral Properties of Transverse Laguerre-Gauss Modes in Parametric Down-Conversion. arXiv:2209.01913