Q 58: Precision measurements and metrology V

Time: Friday 11:00–12:30 Location: E 001

Q 58.1 Fri 11:00 E 001

Spektroskopie des optischen $^1S_0$-$^3P_0$ Uhrenübergangs von Magnesium nahe der magischen Wellenlänge — •Steffen Rühmann, André Kulosa, Dominika Fim, Klaus Zipfel, Temmo Wübbena, André Pape, Wolfgang Ertmer und Ernst Rasel — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany

Magnesium ist ein interessanter Kandidat für die Präzisionsspektroskopie in optischen Gittern [Katori, Nature 435, 321-324, 2005]. Es besitzt eine der geringsten Sensitivitäten auf die Schwarzkörperstrahlung, welche die Performance aktueller Neutralatomuhren limitiert. Wir berichten über die Speicherung von Magnesium in einem optischen Gitter bei der sogenannten magischen Wellenlänge, bei der die differentielle Frequenzverschiebung durch den AC-Stark-Effekt des stark verbotenen Uhrenübergangs $^1S_0$-$^3P_0$ in erster Ordnung unterdrückt wird. Dies erlaubt es erstmalig diesen Übergang direkt anzuregen. Erste Ergebnisse zur Spektroskopie werden präsentiert.

Q 58.2 Fri 11:15 E 001

Ultra-stable Cryogenic Optical Sapphire Cavities – Towards a Thermal Noise Limited Frequency Stability $< 3 \cdot 10^{-17}$ — •Moritz Nagel, Katharina Möhle, Klaus Döringshoff, Sylvia Schikora, Evgeny Kovalchuk, and Achim Peters — Humboldt-Universität zu Berlin, Institut für Physik, AG Optische Metrologie, Newtonstr. 15, 12489 Berlin

Many experimental and technical applications, e.g. optical atomic clocks, demand ultra-stable cavity systems for laser frequency stabilization. Nowadays, the main limiting factor in frequency stability for room temperature resonators has been identified to be the displacement noise within the resonator substrates and mirror coatings due to thermal noise. A rather straightforward method to reduce the influence of thermal noise is to cool down the resonators to cryogenic temperatures. Following this approach, we present a design and first measurements for an ultra-stable cryogenically cooled sapphire optical cavity system, with a prospective thermal noise limited frequency stability better than $3 \cdot 10^{-17}$.

Q 58.3 Fri 11:30 E 001

Coherence transfer for the generation of x-ray frequency combs — •Stefano M. Cavaletto[1], Zoltán Harman[1,2], Christian Buth[3], and Christoph H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]ExtreMe Matter Institute (EMMI), Darmstadt, Germany — [3]Argonne National Laboratory, Argonne, IL, USA

Optical frequency combs had a revolutionary impact on precision spectroscopy and metrology. The spectrum of a frequency comb, consisting of evenly spaced lines, is the result of an infinite train of femtosecond pulses produced in a mode-locked ultrafast laser. Recently, frequency-comb technology was extended to the extreme-ultraviolet spectral regime via high-harmonic generation in a femtosecond-enhancement cavity [1]. We propose an optical scheme to transfer the coherence of a driving, optical frequency comb to the radiation emitted by transitions of higher frequencies. The comb structure we predict in the emitted x-ray spectrum might eventually represent an alternative scheme for x-ray-comb generation, able to overcome the frequency limitations of present HHG-based methods.

[1] A. Cingöz et al., Nature 482, 68 (2012).

Q 58.4 Fri 11:45 E 001

Coherence-Enhanced Optical Determination of the ^{229}Th Isomeric Transition — •Sumanta Das, Wen-Te Liao, Christoph H. Keitel, and Adriana Pálffy — Max Planck Institute for Nuclear Physics, Heidelberg

The 7.8 eV isomeric transition in ^{229}Th [1] is a promising candidate for next generation frequency standards. The advantages of this nuclear transition are its very narrow width, the stability with respect to external perturbations and an accessible frequency within the VUV region. However, a direct measurement of the transition energy has not yet been possible, due to the weak fluorescence signal and the lack of an unmistakable signature for the nuclear excitation.

Here we investigate the effect of coherent light propagation on the excitation and fluorescence signal of the isomeric transition [2]. The transient superradiant behaviour for the nuclear fluorescence in a crystal lattice environment in the forward direction can be exploited to enhance the signal and reduce data collecting time. Furthermore, we put forward a quantum optics scheme based on quantum interference induced by two coherent fields coupling three nuclear levels as a novel way to identify the isomeric transition energy [2]. The proposed setup provides a clear signature for the nuclear excitation and an enhanced precision in the optical determination of the transition frequency compared to a direct fluorescence experiment using only one field.

[1] B. R. Beck *et al.*, Phys. Rev. Lett. 98, 142501 (2007).
[2] W.-T. Liao, S. Das, C. H. Keitel and A. Pálffy, Phys. Rev. Lett., in press (2012).

Q 58.5 Fri 12:00 E 001

An optical feedback frequency stabilized laser tuned by single-sideband modulation — •Johannes Burkart and Samir Kassi — Laboratoire Interdisciplinaire de Physique (LIPhy), UMR5588 CNRS/Université Joseph Fourier Grenoble, 38402 Saint Martin d'Hères, France

Stable, narrow and tunable laser sources are indispensable for molecular lineshape metrology.

Our novel approach consists in stabilizing a distributed feedback diode laser to an ultrastable V-shaped reference cavity by optical feedback self-locking. This limits the laser's frequency drifts to the order of a few hertz per second and reduces its linewidth by several orders of magnitude.

The second key innovation consists in shifting the laser frequency with millihertz precision using an integrated electro-optic Mach-Zehnder modulator. By successive laser locking to adjacent reference cavity modes this technique allows continuous frequency tuning over more than one terahertz.

Combined with cavity ring-down spectroscopy, this new setup will pave the way to an accurate determination of the Boltzmann constant as well as optical precision measurements of isotopic ratios for atmospheric and climate sciences.

Q 58.6 Fri 12:15 E 001

Optical Frequency Transfer over 1840 km Fiber Link - Bridging Continental Distances — •Stefan Droste[1], Katharina Predehl[1], Thomas Udem[1], Theodor W. Hänsch[1], Ronald Holzwarth[1], Sebastian Raupach[2], Filip Ozimek[2], Harald Schnatz[2], and Gesine Grosche[2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

The increasing performance of optical frequency standards calls for new methods of transferring highly stable optical frequencies. Well established satellite-based frequency dissemination techniques do not reach the required stability set by state-of-the-art frequency standards. Recently, a lot of work has been put into investigating fiber links as a possible medium for transferring optical frequencies. We established a fiber connection between the two institutes Max Planck Institute of Quantum Optics (MPQ) in Garching and the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig. In a loop configuration we transferred an optical carrier frequency at 194 THz over a 1840 km long fiber link. Doppler shifts introduced by the fiber link lead to a degradation of the optical signal. After applying a correction signal to compensate for the fiber noise we could demonstrate that optical frequencies can be transferred over nearly 2000 km with a stability and accuracy that surpasses the requirements for comparing modern optical frequency standards by more than one order of magnitude.