Q 44: Laser Technology and Applications

Time: Thursday 11:00–13:00 Location: P 2

Q 44.1 Thu 11:00 P 2

Hybrid FDTD-transfer matrix framework for fast Bragg grating response modeling — •Yasmin Rahimof, Igor A. Nechepurenko, M. R. Mahani, and Andreas Wicht — Ferdinand-Braun-Institut (FBH), Berlin, Germany

Bragg gratings play a central role in integrated photonics because they enable fine control over reflection and transmission spectra. Numerical solvers such as the finite-difference time-domain (FDTD) method can capture their full electromagnetic behavior but quickly become impractical when simulating long or complex structures due to heavy computational demands. To overcome this limitation, we introduce a modeling strategy that derives a transfer matrix method (TMM) from short-segment FDTD simulations and then reuses it to predict the response of extended gratings. By composing transfer matrices obtained from short FDTD simulations, we can rapidly reconstruct spectra for gratings that are orders of magnitude longer than the original simulation domain. This method reproduces both reflection and transmission with errors consistently under 4% compared to full FDTD, while cutting computational time by more than an order of magnitude. Our study demonstrates that the TMM provides a reliable and scalable surrogate model, enabling efficient design exploration for structures ranging from tens to hundreds of grooves. The framework offers a powerful balance between accuracy and speed, making it particularly valuable for the development of large-scale photonic components.

Q 44.2 Thu 11:15 P 2

Tunable Pulsed UV Laser System for Laser Cooling of Relativistic Bunched Ion Beams — •Tamina Grunwitz[1,2], Benedikt Langfeld[1,2], and Thomas Walther[1,2] — [1]TU Darmstadt — [2]HFHF Campus Darmstadt

In contrast to established cooling methods (e.g. electron cooling), laser cooling promises to efficiently generate narrow longitudinal momentum distributions in relativistic bunched ion beams, even at large gamma factors. Therefore, laser cooling is the only planned cooling method for the upcoming heavy-ion synchrotron SIS100 at the FAIR facility, using three laser systems simultaneously.

In this talk, we present one of these laser systems, which delivers optical pulses with adjustable durations between 46 and 734 ps at repetition rates from 1 to 10 MHz. The systems achieves the high power output required for the laser cooling applications. By employing second-harmonic generation, the system can operate at wavelengths of both 514 nm and 257 nm, with maximum average output powers of 34 W (green) and 5 W (UV), respectively. Additionally, the system can be tuned continuously in its frequency over a range of 3.4 THz in the UV, making the laser system also suitable for laser spectroscopy applications.

Q 44.3 Thu 11:30 P 2

Ultrafast optical Kerr Gate at 1 GHz repetition rate with BBS glass and thin graphite films under focused illumination — •Amr Farrag[1], Assegid M. Flatae[1], Lenorah M. Stott[2], Alessandro Lagatti[3,5], Andrea Lapini[3,4], Doris Möncke[2], and Mario Agio[1,3,5] — [1]LaboratoryofNano-Optics, University of Siegen, 57072 Siegen, Germany — [2]Inamori School of Engineering at the New York State College of Ceramics, Alfred University, Alfred, NY, 14802, USA — [3]European Laboratory for Non-Linear Spectroscopy, 50019 Sesto Fiorentino, FI, Italy — [4]Dipartimento di Scienze Chimiche, della Vita e della Sostenibilità Ambientale, Università di Parma, 43124 Parma, PR, Italy — [5]Istituto Nazionale di Ottica (INO), Consiglio Nazionale delle Ricerche (CNR), 50019 Sesto Fiorentino (FI), Italy

Ultrafast optical detection is vital for quantum technologies and nanophotonics, yet sub-picosecond processes remain challenging to resolve, especially at the single-emitter level. Optical Kerr gating (OKG) offers high detection efficiency and broadband operation, making it a strong candidate for ultrafast single-photon measurements.

We demonstrate a 1-GHz OKG scheme using bismuth-borosilicate (BBS) glass and thin graphite films, requiring <1 nJ gate-pulse energy under focused illumination. Temporal resolutions of 175 fs (BBS) and 141 fs (graphite films) are achieved. BBS glass provides a high nonlinear coefficient and sub-ps response, whereas graphene-based graphite films deliver exceptionally strong nonlinearity and are promising for integration in future on-chip ultrafast optical platforms.

Q 44.4 Thu 11:45 P 2

Development of dynamic time over threshold method for signal processing in cavity ring-down spectroscopy — Konrad Kleineidam[1,2], Hideki Tomita[1], Takumi Mochizuki[1], Ryohei Terabayashi[1], •Erik Thiel[2], Klaus Wendt[2], Kenji Shimazoe[3], Hisashi Abe[4], and Norihiko Nishizawa[1] — [1]Department of Applied Energy, Nagoya University, Japan — [2]Institut für Physik, Johannes Gutenberg-Universität Mainz, Germany — [3]The University of Tokyo, Japan — [4]National Metrology Institute of Japan (NMIJ/AIST), Japan

Cavity ring-down spectroscopy (CRDS) is a highly sensitive technique for detecting elements and isotopes in gas samples by measuring the decay rate (i. e. ring-down rate) of transmitted laser light in a high-finesse optical cavity. Typically, a high-resolution data acquisition system is used to record the time-dependent change in signal and calculate the ring-down decay rate through exponential fitting, in order to measure the molecular number density inside the cavity. By injecting photons of different wavelengths, multiple molecules can be measured simultaneously by recording their respective ring-down rates. This study explores a simplified method for acquiring decay rates using dynamic time over threshold (dToT) analysis. This method relies on the discrete recordings of timing over two dynamically changing threshold voltages instead of the full curve recording by conventional ADCs. Preliminary results suggest that this approach can effectively determine the ring-down decay rate, offering a potentially lower-cost, faster and simpler alternative to the post exponential fitting process in CRDS measurements.

Q 44.5 Thu 12:00 P 2

On-axis Laser Ranging Interferometer for Grace-like Mission — •Daikang Wei — Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Hannover, Germany

The GRACE Follow-On mission's laser ranging interferometer (LRI) has demonstrated sub-nanometer precision for inter-satellite length tracking. We present a novel interferometric architecture for future GRACE-like missions, featuring an on-axis LRI that enables monoaxial transmission and reception of laser beams between two spacecraft. Our laboratory-scale prototype establishes a transponder-based laser interferometric link between two optical benches, with phase readout at a heterodyne signal of 7.3 MHz. Two independent active beam steering loops employ differential wavefront sensing (DWS) to co-align the transmitting (TX) and receiving (RX) beams. Under simulated angular jitters, the beam pointing stability is maintained below 10 $\mu\mathrm{rad}/\sqrt{\mathrm{Hz}}$ in the frequency range between 2 mHz and 0.5 Hz, and the fluctuation of the TX beam's polarization state induces a reduction of 0.14% in the carrier-to-noise-density ratio. Additionally, we investigate the tilt-to-length (TTL) coupling of the optical bench using dedicated rotations of the hexapod. Our results show that the on-axis LRI enables inter-spacecraft ranging measurements with nanometer accuracy, making it a potential candidate for future GRACE-like missions.

Q 44.6 Thu 12:15 P 2

Quantum-Correlated Biphotons for Two-Photon Absorption in Biomimetic Photoswitches — •Gonca Under and Oleg Kornilov — Max-Born-Straße 2A, 12489, Berlin, Germany

Spontaneous parametric down-conversion (SPDC) provides a reliable technique for generating quantum-correlated photon pairs, enabling various quantum sensing and spectroscopic applications. In this work, we demonstrate the generation and detection of biphotons produced via type-I SPDC and their characterization using a single-photon detection setup. The photon pairs are separated at a beam splitter and routed directly into two independent single-photon detectors, allowing coincidence-based identification of quantum-correlated events. After establishing the coincidence detection scheme, we couple the biphoton state into a single spatial mode to form a well-defined quantum optical probe intended for future two-photon absorption (TPA) experiments on novel biomimetic photoswitches. Owing to their non-classical correlations, such photon pairs can achieve two-photon excitation at optical powers significantly lower than classical limits, paving the way for sensitivity enhancements compared to classical illumination in quantum-enhanced spectroscopy.

Q 44.7 Thu 12:30 P 2

Heterodyne Interferometry for a Measurement of Vacuum Magnetic Birefringence — •Laura Roberts[1], Aaron Spector[2], and Todd Kozlowski[2] — [1]Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) and Leibniz Universität Hannover, 30167 Hannover, Germany — [2]Deutsches Elektronen Synchrotron DESY, 22603 Hamburg, Germany

Vacuum magnetic birefringence (VMB) is a long predicted consequence of quantum electrodynamics which describes the effect where an external magnetic field turns the vacuum into an anisotropic, polarizable medium. Despite more than 40 years of experimental effort, there has yet to be a direct laboratory detection of VMB due to its incredibly small amplitude. The Any Light Particle Search II (ALPS II) at DESY currently operates a string of 24 superconducting HERA dipole magnets, each generating a 5.3 T field, with an effective length of 212 meters, along with a high-finesse optical cavity whose eigenmode propagates through the magnet bore. The ALPS II infrastructure therefore can produce a vacuum birefringence 600 times larger than the previous best VMB search, making its future for VMB promising. We discuss an optical system to perform a measurement of VMB by sensing the differential frequency changes of two orthogonal fields stabilized to resonances of a 246 m long optical cavity whose eigenmode propagates through the ALPS II magnet string. In the following we present the results of implementing a prototype of this scheme on a 19 m cavity and discuss the prospects of the full scale experiment.

Q 44.8 Thu 12:45 P 2

Probing Vacuum Magnetic Dichroism with Precision Interferometry — •Aaron Spector[1] and Laura Roberts[2] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [2]Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) and Leibniz Universität Hannover, Hannover, Germany

An exciting new frontier in the search for physics beyond the standard model is emerging as experiments are using precision interferometry to probe the vacuum magnetic dichroism effect. Here, light propagating through a vacuum could experience additional polarization dependent optical losses in the presence of a magnetic field as some of its energy is transferred to hypothetical fields such as axion-like-particles, millicharged fermions, and dark matter "chameleons." In this talk, we propose a new method to test this effect by continuously characterizing the complex reflectivity of an optical cavity for polarization states aligned parallel and perpendicular to a modulated external magnetic field. Using this technique, it could be possible to disentangle the changes of conventional loss channels in an optical cavity, such as scattering and absorption at the mirror coatings, from sources induced by new physics interacting with the magnetic field. I will also discuss the discovery prospects of a setup utilizing the ALPS II infrastructure (24 HERA dipole magnets each providing 5.3 T magnetic fields for a length of 8.8 m) along with a 246 m long cavity and give a status report of a prototype setup implemented on a 19 m long cavity.