Q 8: Laser Systems – Optical Methods (joint session K/Q)

Time: Monday 11:00–12:45 Location: HS XI ITW

Invited Talk Q 8.1 Mon 11:00 HS XI ITW

Hochleistungs-UKP-Laser für die Fertigung — •Arnold Gillner — Lehrstuhl für Lasertechnik RWTH Aachen Steinbachstrasse 15, 52074 Aachen

Ultrakurzpulslaser mit Pulsdauern von einigen 100 fs bis ps ermöglichen in der industriellen Fertigung neue Bearbeitungsansätze mit bisher unerreichter Genauigkeit. Durch die weitgehende Trennung von Energieabsorption und Materialablation ist der Energieeintrag in den Werkstoff minimal, sofern einige wichtige Randbedingungen berücksichtigt werden. Insbesondere kann es bei hohen Pulswiederholraten zu thermischer Akkumulation kommen und bei hohen Pulsenergien zu Plasmaabschirmung und Beeinflussung des eingehenden Laserstrahls. Als Lösung bieten sich Hochgeschwindigkeits-Scansysteme mit Geschwindigkeiten über 1000 m/s oder Multistrahl-Bearbeitungssysteme mit mehreren 100 Teilstrahlen an, um die eingestrahlte Laserenergie im optimalen Arbeitspunkt zu nutzen. Dieser Arbeitspunkt wird im Wesentlichen von der optischen Eindringtiefe bestimmt, höhere Energiedichten führen mit ballistischen Elektronen zu tieferen Orten der Energiedeposition. Detaillierte Analysen der Wechselwirkung über Pump-and-Probe sowie über hochenergetische Röntgenstrahlung am DESY zeigen dynamische Wechselwirkungsverhältnisse, die es gilt, durch schnelle Strahlformung zu beherrschen. Im Ergebnis steht mit Ultrakurzpuls-Lasern im kW-Bereich ein neues Werkzeug für die Präzisionsfertigung zur Verfügung.

Q 8.2 Mon 11:30 HS XI ITW

Electronically tunable fiber-feedback optical parametric oscillator with intracavity Echelle grating stretcher — •Florent Kadriu, Michael Harteker, Tobias Steinle, and Harald Giessen — University of Stuttgart 4th Physics Institute

Tunable light sources in the near-IR are often limited by tuning speed, stability, and reproducibility due to the physical movement of optics. Fiber-feedback optical parametric oscillators (FF-OPOs) offer broad tuning in the IR with high stability. Thus, ideally static optics are required for ultrafast and reproducible tuning. We present a gain-switched diode-based FF-OPO using an intracavity echelle grating stretcher for temporal-dispersion wavelength tuning. This approach enables four distinct tuning ranges corresponding to four grating orders, achieving a theoretical tuning rate of 500 kHz, a narrow linewidth below 1 nm, and 2 pm wavelength reproducibility. This concept can be transferred to other grating types and spectral ranges and is ideal for applications in infrared narrowband AM/FM spectroscopy.

Q 8.3 Mon 11:45 HS XI ITW

Advancements in large ring laser gyroscopes for geodesy and seismology — •Jannik Zenner[1], Andreas Brotzer[2], Heiner Igel[2], Karl Ulrich Schreiber[3,4], and Simon Stellmer[1] — [1]Physikalisches Institut, Rheinische Friedrich-Wilhelms-Universität, Bonn, Germany — [2]Department of Earth and Environmental Sciences, Ludwig-Maximilians-Universität, Munich, Germany — [3]Research Unit Satellite Geodesy, Technical University of Munich, Munich, Germany — [4]School of Physical Sciences, University of Canterbury, Christchurch, New Zealand

This winter marks the 100 year anniversary of the Michelson-Gale-Pearson experiment, the first interferometric measurement of Earth's rotation. Ring laser gyroscopes have matured considerably and are now able to continuously monitor Earth's rotation rate at a 10^{-8} level. This opens the possibility to detect subtle earth rotation variations driven by diverse geophysical processes across a wide spectrum of frequencies, which have traditionally only been detected by astronomical techniques. We will highlight the technological advancements in ring laser technology and future perspectives.

Q 8.4 Mon 12:00 HS XI ITW

Sub-two-cycle pulses at 1600 nm and in the mid IR from an ultralow-noise fiber-feedback optical parametric oscillator system at 76 MHz — •Johann Thannheimer, Abdullah Alabbadi, Tobias Steinle, and Harald Giessen — University of Stuttgart

We achieve fiber-based self-compression down to sub-two optical cycles (9.5 fs) at 1600 nm with an average power of 620 mW (8.2 nJ) and a 76 MHz repetition rate. A commercial Yb-based pump laser is used to drive a fiber-feedback optical parametric oscillator. The frequency converted pulses are amplified to the Watt scale with an optical parametric amplifier and coupled into a 42-mm-long common single mode fiber. The fiber realizes ultracompact grating-free single stage compression to sub-two optical cycles. An added intra-pulse difference frequency generation stage converts the shot-noise limited few-cycle pulses to tunable ultra-broadband mid-infrared radiation. Beside ultrafast metrology via electro optic sampling, this system is particularly suited for mid-infrared spectroscopy.

Q 8.5 Mon 12:15 HS XI ITW

Laser Ranging for Satellite Gravimetry: GRACE-FO and beyond — •Malte Misfeldt[1,2], Vitali Müller[1,2], Gerhard Heinzel[1,2], Kai Voss[3], and Kolja Nicklaus[3] — [1]MPI für Gravitationsphysik, Hannover — [2]IGP, Leibniz Universität Hannover — [3]SpaceTech Immenstaad GmbH

The Laser Ranging Interferometer (LRI) aboard the GRACE Follow-On (GRACE-FO) mission represents a groundbreaking advancement in satellite geodesy. Designed as an experimental addition to the established microwave ranging system, the LRI employs laser interferometry to measure inter-satellite distance variations with nanometer-scale precision. The enhanced sensitivity enables improved tracking of Earth's gravity field variations, offering refined insights into critical climate change processes such as polar ice mass loss. The LRI's successful deployment and operation have set a new benchmark for the accuracy and resolution of space-based gravity measurements.

This presentation will discuss the key technologies of the LRI. As evolved LRI instruments will be the primary payload in future satellite gravimetry missions, we will highlight lessons learned from several years of successful operation in orbit and their relevance to the design. Finally, we will address the new challenges in transitioning the LRI from a technology demonstrator to a primary payload. These include meeting stricter performance requirements, enhancing robustness for long-term operation, and adding a new sub-unit to measure the laser's wavelength in-orbit to better than 25ppb.

Q 8.6 Mon 12:30 HS XI ITW

The LISA space mission — •Lennart Wissel — Max Planck Institute for Gravitational Physics — Leibniz University Hannover

The LISA observatory is a large ESA-lead mission that will unlock the yet unaccessible millihertz regime of gravitational waves. It will be launched in the mid-2030s and consists of three spacecraft on a heliocentric orbit, each shielding free-falling test masses acting as geodesic reference points. The triangular formation utilises heterodyne interferometers to measure the variations in light travel times between the test masses across 2.5 million km distances to picometer precision.

This talk gives an overview of the mission concept, highlights its technological challenges, its current status, and finishes with an outlook for the exciting timeline ahead.