Q 44: Laser Development and Applications

Time: Thursday 11:00–13:00 Location: f435

Q 44.1 Thu 11:00 f435

VECSEL system for quantum manipulation of trapped magnesium ions — •Till Rehmert[1,2], Maximilian J. Zawierucha[2], Jan Christoph Heip[2], Fabian Wolf[2], and Piet O. Schmidt[1,2] — [1]Leibniz Universität Hannover, Germany — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Optical pumped vertical-external-cavity surface-emitting lasers (VECSEL) have been demonstrated to be a promising technology for applications ranging from spectroscopy to quantum computing and quantum simulation [1]. VECSELs combine compact size and high optical power and the advantage of a wide wavelength coverage.

We present the steps towards a high power VECSEL system with an optical-to-optical effciency of approximately 30% and up to 6 watts of optical output power at 1121 nm. Furthermore, an overview of the spectral properties and the noise levels of frequency and intensity will be given.

A VECSEL system at this wavelength is a suitable light source for quantum logic spectroscopy with trapped magnesium ions, since it offers frequency quadrupled in the UV enough output power and a laser linewidth of tens of MHz for Doppler cooling, repumping and Raman transition.

[1] Burd et al, Optica Vol.3, No. 12 (2016)

Q 44.2 Thu 11:15 f435

Femtosecond writing of waveguides structures inside polymers. — •Dmitrii Perevoznik[1,2] and Uwe Morgner[1,2,3] — [1]Institute of Quantum Optics, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [2]Cluster of Excellence PhoenixD (Photonics, Optics, and Engineering - Innovation AcrossDisciplines), Hannover, Germany" — [3]Hannover, Germany" Laser Zentrum Hannover e.V., Hollerithalle 8, D-30419 Hannover, Germany

At present optical technology is one of the most rapidly developing areas of science and technology. Continuously increasing demands of the society for high-speed and reliable systems of information transmission have led to the development of waveguide optics and of methods for creation of waveguides in different media. Easiest way of creating waveguides and complex waveguide networks in different media is direct femtosecond writing. Writing waveguides in polymers is a just developing field, polymer materials are very cheap and have the potential to create complex structures inside the volume of the material. In polymers the refractive index increase is induced by material compression and stress-related effects which are caused by a quickly expanding plasma core. Once the modification is done, there is an area where material is compressed and the index increased. This area can be used as optical waveguide. In this work we want to demonstrate different waveguide structures which can be produced inside polymer materials.

Q 44.3 Thu 11:30 f435

Selective Hermite-Gaussian mode excitation in a laser cavity by external pump beam shaping — •Florian Schepers[1], Tim Bexter[1], Tim Hellwig[1], and Carsten Fallnich[1,2] — [1]Institute of Applied Physics, University of Münster, Germany — [2]MESA+ Institute of Nanotechnology, University of Twente, The Netherlands

An improved gain-shaping method for selective mode excitation is presented and its application for the excitation of higher-order Hermite-Gaussian modes is demonstrated in an end-pumped Nd:YVO4 laser. Using a digital micromirror device, the intensity distribution of the pump beam within the laser crystal could be shaped with a high degree of freedom. Thus, a broad variety of different gain distributions were achieved, enabling a highly selective mode excitation method based on gain shaping. In the presented experiment, the excitation of nearly 1000 different Hermite-Gaussian modes was demonstrated, increasing the number of excitable Hermite-Gaussian modes by at least a factor of five, compared to other excitation methods [1-3]. The excited modes include Hermite-Gaussian modes of high orders as, for example, the $HG_{25,27}$ mode. Furthermore, the electronic control of the gain profile, applied via the digital micromirror device, enabled automated measurements of the selective mode excitation. Here, a systematic study is presented to optimize the generated pump patterns with respect to the number of modes that could be excited.

[1] H. Laabs et al., Opt. Laser Technol. 28, 213-214 (1996)
[2] W. Kong et al., Opt. Lett. 37, 2661-2663 (2012)
[3] S. Ngcobo et al., Nat. Commun. 4, 2289 (2013)

Q 44.4 Thu 11:45 f435

High-Order and Multi-Line Transverse Mode Locking of an End-Pumped Solid-State Laser — •Florian Schepers[1] and Carsten Fallnich[1,2] — [1]Institute of Applied Physics, University of Münster, Germany — [2]MESA+ Institute of Nanotechnology, University of Twente, The Netherlands

Transverse mode locking (TML) was demonstrated for the first time by Auston [1] in 1968, generating a fast scanning beam in the transverse direction of the cavity by locking the phases of multiple transverse modes.

In this talk we demonstrate a three times broader beam scanning range in comparison to previous results [2] by implementing TML in an end-pumped solid-state laser using an acousto-optic modulator. This improvement was accomplished by both, a large effective open aperture of the gain medium and a line-shaped pump light distribution, providing gain for a high number of transverse modes and thus enabling an increase of the central mode number $\bar{n}$ of the TML-process from $\bar{n} = 4$ to $\bar{n} = 36$. Furthermore, we realized a beam that was scanning synchronously on multiple parallel lines by being operated on a single higher-order mode in the orthogonal direction of the TML-process.

[1] D. Auston, IEEE J. Quantum Electron. **4**, 471–473 (1968)
[2] C. Haug et al., IEEE J. Quantum Electron. **10**, 406-408 (1974)

Q 44.5 Thu 12:00 f435

Stimulated Raman Scattering Spectroscopy on Microplastic Particles with a Noncollinear Optical Parametric Oscillator — •Luise Beichert[1,2], Yuliya Binhammer[1,2], José Ricardo Andrade[1,2], and Uwe Morgner[1,2] — [1]Leibniz Uni Hannver, Institut für Quantenoptik, Hannover, Germany — [2]Cluster of Excellence PhoenixD, Hannover, Germany

Microplastics are widely spread in our global environment. We find them not only in our oceans and inland waters all over the world but also increasingly in our drinking water. Femtosecond Optical Parametric Oscillators are very suitable for microscopy and spectroscopy experiments due to their broadband tuning range at high output power. Noncollinear optical parametric oscillators (NOPOs) provide a good scalability in terms of output power, repetition rate and pulse energy. The instantaneous broadband frequency conversion combined with the special phase matching geometry in the nonlinear crystal enables a fast tunability without readjustment.

Here, we present an IR-NOPO with a fastly tunable output spectrum between 750 and 950 nm. It can adress Raman transitions in the range of 800-3500 cm^{-1} in less than 10 ms. We show SRS-spectra of different plastic particles in video rates.

Q 44.6 Thu 12:15 f435

Linewidth-reduced DBR laser for Raman sideband cooling — •Pooja Malik, Lukas Ahlheit, Wolfgang Alt, Maximilian Ammenwerth, Tobias Macha, Deepak Pandey, Hannes Pfeifer, Eduardo Uruñuela, and Dieter Meschede — Institut für Angewandte Physik, Wegelerstr. 8, 53115, Bonn, Germany

Raman sideband cooling is an established ground state cooling technique, especially suited for experiments involving one or few atoms. It uses a two photon Raman transition that is driven by two lasers phase locked at around the hyperfine splitting of the atomic species. This is implemented in our experiment with Rb87 atoms that are trapped inside a fiber Fabry-Pérot cavity for photon storage experiments [1]. One of the employed Raman lasers is a DBR laser that offers a mode hop free tuning range of hundreds of GHz. Phase locking is however hampered by the large intrinsic linewidth of some MHz. Here we show how this limitation can be overcome by using an external optical feedback reducing the linewidth of our DBR laser [2], while maintaining its GHz tuning range. By means of a delayed self heterodyne method supported by a numerical noise model [3], we identify different noise components and the Lorentzian linewidth below 30kHz. We demonstrate near ground state cooling of single atoms using this linewidth-reduced laser.

[1] T. Macha et al., arXiv:1903.10922v2 (2019)
[2] Q. Lin et al., Opt. Lett. 37, 1989-1991 (2012)

[3] W. Ma et al., Appl. Opt. 58, 3555-3563 (2019)

Q 44.7 Thu 12:30 f435

Argon Trap Trace Analysis: Radiometric dating of environmental samples with applied quantum technology — •Lisa Ringena[1], Julian Robertz[1], Maximilian Schmidt[1,2], Niccolo Rigi-Luperti[1], Florian Sandel[1], Jeremias Gutekunst[1], Arne Kersting[2], Yannis Arck[2], David Wachs[2], Annabelle Kaiser[2], Werner Aeschbach[2], and Markus Oberthaler[1] — [1]Kirchhoff Institute for Physics, Heidelberg, Germany — [2]Institute for Environmental Physics, Heidelberg, Germany

The measurement of the radioisotope ^{39}Ar opens a unique path towards dating of environmental samples from the last millennium, due to 269 years half-life, chemical inertness and well-known atmospheric concentration. However, its low relative abundance of ^{39}Ar/Ar $\sim 8 * 10^{-16}$ hinders the use of standard analysis schemes. Argon Trap Trace Analysis (ArTTA) enables detection by employing the isotopic shift in the resonance frequency of an optical dipole transition. The trapping of ^{39}Ar inside a magneto-optical trap grants perfect selectivity due to a multitude of resonant scattering processes. In the trap, single ^{39}Ar atoms are captured and counted, while the huge background of abundant isotopes remains unaffected. During the last years, the apparatus was successfully used to study groundwater, ocean, ice and lake water samples. A second machine for higher throughput is currently set up, the status of which will be presented. In respect of the original ArTTA dating apparatus, the state of the art regarding sample size limits and measurement uncertainty will be discussed.

Q 44.8 Thu 12:45 f435

Optical bend sensor based on micro-structured polymer optical fibres — •Lennart Leffers[1], Kort Bremer[1], Bernhard Roth[1], and Ludger Overmeyer[2] — [1]Hannover Centre for Optical Technologies, Leibniz Universität Hannover, Nienburger Straße 17, 30167 Hannover, Germany — [2]Institute of Transport und Automation Technology, Leibniz Universität Hannover, An der Universität 2, 30823 Garbsen, Germany

We investigate a highly flexible and elastic bend sensor based on polymer optical fibre (POF) with Bragg grating (BG) structures. The concept is very simple and relies on the inscription of BG structures eccentrically into a graded-index (GI) multi-mode (MM) POF via contact exposure with a phase mask and a KrF excimer laser in the UV. Depending on the deformation of the POF, the lattice constant of the inscribed BG is compressed or strained due to its position relative to the fibre core. This in turn will result in a red or blue shift of the Bragg wavelength, respectively. Therefore, with a single BG the deformation in one axis can be observed. Moreover, multiple BGs inscribed into the same POF at different positions would allow to determine the shape deformation of the POF relative to a reference frame. Consequently, this technology could form the basis for new applications in the areas of robotics, augmented reality or in medical diagnostics, for example, the monitoring of the neurological movement disorder *focal dystonia*.