Q 8: Laser development and applications II

Time: Monday 14:00–16:00 Location: DO26 207

Q 8.1 Mon 14:00 DO26 207

Selection and control of laser modes in random media through spatial pump modulation — Nicolas Bachelard[1], •Stephan Burkhardt[2], Matthias Liertzer[2], Stefan Rotter[2], and Patrick Sebbah[1] — [1]Institut Langevin, ESPCI ParisTech CNRS UMR7587, Paris, France — [2]Institute for Theoretical Physics, Vienna University of Technology, Vienna, Austria

Random lasers emit radiation typically at many different frequencies and in many different directions at once. Recent work has addressed the question how random lasers can be "tamed" by making their emission spectrum and directionality externally tunable[1,2,3]. The key insight here is that this control can be conveniently exerted through the spatial profile of the pump beam that provides the external energy to the laser. Finding the optimal pump pattern, however, is difficult and requires an optimization procedure which does not give much insight into how a specific pump profile yields the desired laser emission. In this talk, I will elucidate the mechanisms behind the pump-control of random laser modes which is based on the spatial correlation between the applied pump profile and the lasing mode which it amplifies. Our findings are applicable not just to random lasers but for the design of lasers in general.

[1] N. Bachelard et al., Phys. Rev. Lett. 109, 033903 (2012).
[2] T. Hisch et al., Phys. Rev. Lett. 111, 023902 (2013)
[3] N. Bachelard et al.,arXiv:1303.1398 (2013)

Q 8.2 Mon 14:15 DO26 207

Stabile Multiwellenlängenemission eines Breitstreifendiodenlasers durch *spectral beam combining* — •Nils Werner, Christof Zink, Andreas Jechow, Axel Heuer und Ralf Menzel — Institut für Physik und Astronomie, Universität Potsdam, Karl-Liebknecht-Str. 24/25 14476 Potsdam

Mit einem externen *spectral beam combining* Resonator konnte ein einzelner, flächig kontaktierter Breitstreifendiodenlaser (BAL) zu einer stabilen Multiwellenlängenemission angeregt werden [1]. Durch die wellenlängenselektive Rückkopplung des Resonators bilden sich einzelne Lasermoden unter Selbstorganisation aus und verteilen sich gleichmäßig über die aktive Zone. Dies führt zu einer Nahfeldverteilung, die der eines Diodenlaserarrays ähnelt. Jeder dieser selbst organisierten Emitter lasert durch den Resonatoraufbau bei einer anderen Wellenlänge. Insgesamt wurden 31 einzelne Emissionslinien im Spektrum um die Zentralwellenlänge 774 nm realisiert. Die Emissionsspektren waren zeitlich stabil und hatten über den gesamten Pumpstrombereich eine spektrale Breite von 3.6 nm. Der verwendete BAL hat eine Emitterbreite von 1000 μm und besitzt keine Antireflexbeschichtung.

Für BALs ergeben sich durch das vorgestellte Konzept neue Anwendungsmöglichkeiten. Mit dem Design des Resonators kann die Anzahl der selbst organisierten Emitter und die Breite des Emissionsspektrums variabel eingestellt werden.

[1] Zink et al. Multi-Wavelength Operation of a Single Broad Area Diode Laser by Spectral Beam Combining. Photonics Technology Letters (2013 eingereicht)

Q 8.3 Mon 14:30 DO26 207

Characterization and laser operation of PLD grown Yb^{3+}: Y_2O_3 films — •Sven H. Waeselmann[1], Sebastian Heinrich[1], Kolja Beil[1], Katherine A. Sloyan[2], Robert W. Eason[2], Christian Kränkel[1,3], and Günter Huber[1,3] — [1]Institut für Laser-Physik, Universität Hamburg — [2]Optoelectronics Research Centre, University of Southampton — [3]The Hamburg Centre for Ultrafast Imaging

Pulsed Laser Deposition (PLD) is a well established method to grow thin, single crystalline films. In this method the ionic particles in a laser induced plasma are deposited on the surface of a crystalline substrate. Due to the high energy of the ionic plasma particles epitaxial growth and high film quality can be achieved. Additionally the PLD allows for the growth of materials which are difficult or impossible to synthezise with conventional crystal growth methods. Thin films of 3 at. % Yb^{3+} doped Y_2O_3 were deposited on single crystalline Y_2O_3 substrates. In situ electron diffraction (RHEED) analysis has been used to investigate the crystal structure during film growth. The intensity oscillations of the observed RHEED reflexes imply layer by layer growth. The RHEED pattern of the 1 μm thick film indicates epitaxial film growth. In order to use PLD grown films as active thin disk material a film thickness of several ten μm is necessary for sufficent absorption of the pumplight. Laser operation was observed with a 30 μm thick Yb(5 at. %):Y_2O_3 film in a thin disk laser setup with 24 pumplight passes through the gain material. A maximum output power of 60 mW was achieved with 0.8 % outcoupling at a wavelength of 1033 nm.

Q 8.4 Mon 14:45 DO26 207

Timing Jitter Reduction of Mode-locked Quantum-Dot Lasers by Optical Feedback — •Oleg Nikiforov, Lukas Drzewietzki, Stefan Breuer, and Wolfgang Elsässer — Institute of Applied Physics, Technische Universität Darmstadt, Darmstadt, Germany

Investigations on the timing jitter (TJ) reduction of passively mode-locked monolithic quantum-dot (QD) semiconductor lasers by optical feedback (FB) allows to study the potential of QD lasers towards application as high-resolution photonic analog-to-digital converters or optical interconnects. Recently, the relevant mechanism of TJ reduction has been identified that is based on a statistical origin [1]. Here, we comprehensively study experimentally the effect of FB on TJ and pulse width as a function of FB strength and FB delay time and discuss the emission dynamics on the basis of a simple time-domain model. In addition, investigation on a multiple simultaneous FB configuration is presented. Thus, we provide a deeper insight into the underlying mechanism of TJ reduction and identify related ideal FB conditions. [1] L. Drzewietzki, S. Breuer and W. Elsäßer, Timing jitter reduction of passively mode-locked semiconductor lasers by self- and external-injection: Numerical description and experiments, Optics Express, Vol. 21, Issue 13, pp. 16142-16161 (2013)

Q 8.5 Mon 15:00 DO26 207

Generation of a Narrow-Bandwith Ultraviolet Frequency Comb for Quantum Control of $^9Be^+$ Ion Qubits — •Anna-Greta Paschke[1], Malte Niemann[1], Tino Lang[1], Marco Marangoni[2], Giulio Cerullo[2], and Christian Ospelkaus[1,3] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Politecnico di Milano — [3]PTB Braunschweig

A CPT test experiment based on a g-factor comparison between single trapped (anti-)protons is currently being designed in our group. The challenging spin-flip frequency measurement will be realized by transferring the (anti-)proton's spin state to a co-trapped $^9Be^+$-ion for readout, using quantum logic operations [1].

For the essential manipulation of $^9Be^+$, a narrow-bandwidth ultraviolet (UV) pulsed laser system has been designed. To keep the required UV power acceptably low, the spectral bandwidth as well as the spectral profile of the laser pulses need to be precisely controlled.

We report on selective spectral compression of broadband 626nm pulses in second-order nonlinear BiBO crystals to obtain the desired narrowband UV pulses. The method [2] uses the second harmonic generation process in presence of large group velocity mismatch to efficiently transfer the energy of broadband fundamental frequency pulses into narrowband second harmonic ones. Compared to [2] an extension of the wavelength range into the UV (313 nm) has been realized, additionally including the considerable influence of spatial walkoff.

[1] Heinzen and Wineland, PRA 42, 2977 (1990)
[2] Marangoni *et al.*, Opt. Expr. 15, 8884 (2007)

Q 8.6 Mon 15:15 DO26 207

Curved Yb:YAG waveguide lasers for integrated optical devices — •Thomas Calmano[1], Sebastian Müller[1], Christian Kränkel[1,2], and Günter Huber[1,2] — [1]Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg

Waveguides are basic components for integrated optical devices. With the femtosecond (fs) laser writing technique waveguiding structures can be inscribed directly into a wide range of dielectric materials. By utilizing substrate materials doped with laser ions for the waveguide fabrication, active optical devices can be realized. These include lossless devices in which the losses are compensated by gain as well as waveguide lasers and amplifiers. Furthermore, this fabrication tech-

nique can be applied to rare-earth doped crystalline laser gain media, which exhibit excellent thermomechanical properties and a large gain due to high peak emission cross sections. In recent years we demonstrated highly efficient fs-laser written Yb:YAG waveguide lasers with slope efficiencies of nearly 80% and output powers of 1.06 W. However, for more complex optical devices, like beam splitters, couplers or ring lasers, curved structures are required. Here we report about our results on curved Yb:YAG waveguide lasers fabricated by the fs-laser writing technique. We could achieve slope efficiencies of 51% with waveguides with radii of curvature of 20 mm and more than 60% with structures with radii of more than 60 mm. Additionally, future perspectives and applications of curved Yb:YAG waveguide lasers will be discussed.

Q 8.7 Mon 15:30 DO26 207

VUV generation in a metal vapor filled hollow core fiber — •Andreas Koglbauer[1,2], Thomas Diehl[1,2], Patrick Bachor[1,2], Ruth Steinborn[1,2], Matthias Stappel[1,2], and Jochen Walz[1,2] — [1]Johannes Gutenberg-Universität Mainz, D-55099 Mainz — [2]Helmholtz-Institut Mainz, Johann-Joachim-Becher-Weg 36, 55128 Mainz

We present the first generation of continuous coherent vacuum ultraviolet (VUV) light by means of four-wave mixing in a mercury vapor filled hollow core fiber (HCF). Three fundamental laser beams at 254 nm, 408 nm and 540 nm are coupled into a vapor filled HCF with a bore diameter of 50 μm, where the sum-frequency generation to 121 nm takes place.

The use of a fiber allows a much longer interaction region, in contrast to the tight focussing regime. There it is restricted to a length comparable with the confocal parameter ($\sim$ 1 mm). Confining the light in a fiber sustains high intensities over a long range (several cm). This gives rise to a theoretical efficiency enhancement of the mixing process of $10^2 - 10^3$.

The presented measurements constitute a first important step towards an efficient VUV laser source.

Q 8.8 Mon 15:45 DO26 207

Frequenzstabilisierung zweier Lasersysteme auf angeregte Quecksilberübergänge bei 435,8 nm und 546,1 nm für Lasing Without Inversion — •Benjamin Rein, Johanna Heck und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, AG Laser und Quantenoptik, Schlossgartenstr. 7, D-64289 Darmstadt

Lasing Without Inversion (LWI) ermöglicht es durch die kohärente Anregung von atomaren Übergängen die Absorption auf dem Laserübergang zu unterdrücken. Durch diesen EIT ähnlichen Effekt genügen schon wenige angeregte Atome, um Lasertätigkeit zu erzielen. LWI lässt sich in Quecksilber bei 253,7 nm realisieren, wobei für die kohärente Anregung Laser bei einer Wellenlänge von 435,8 nm und 546,1 nm benötigt werden. An diese Laser werden hohe Anforderungen bezüglich der Linienbreite und Frequenzstabilität gestellt.

Realisiert werden die Laser durch frequenzverdoppelte External Cavity Diode Laser (ECDL), wobei für 435,8 nm ein Kaliumniobat-Kristall bzw. für 546,1 nm ein Lithiumniobat-Kristall als nicht-lineares Medium eingesetzt wird. Die optische Leistung der Fundamentalen wird im 435,8 nm System zusätzlich durch einen Trapezverstärker erhöht.

Die kurz-zeit Linienbreiten der Laser wurde mit einer Selbst-Heterodyn Messung zu 34,8 kHz für 435,8 nm bzw. 16,5 kHz für 546,1 nm bestimmt. Die absolute Frequenzstabilisierung erfolgt durch Polarisationsspektroskopie einer rf-Entladung in einer Quecksilberabsorptionszelle.