Q 10: Photonics I

Time: Monday 17:00–19:00 Location: E001

Invited Talk Q 10.1 Mon 17:00 E001

Maiman's ruby laser reborn as diode pumped cw laser — •Walter Luhs[1] and Bernd Wellegehausen[2] — [1]Photonic Engineering Office, Herbert-Hellmann-Allee 57, 79189 Bad Krozingen, Germany — [2]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany

In ninety sixty Theodore Maiman realized the first laser, a flashlamp pumped Ruby laser, which was the onset of a tremendous ongoing development of optics and quantum optics.

In the growing family of lasers, the Ruby laser however remained exotic, needing a population inversion with respect to the ground state. Although possible, cw operation was extremely difficult to achieve, and so the Ruby laser only found applications as a powerful pulsed system.

In 2019, we could first demonstrate cw laser oscillation of ruby in linear and ring resonators, pumped with 1 W 405 nm laser diodes, and achieve with Ruby crystals of 5 mm length stunningly low thresholds of below 100 mW and output powers up to 80 mW. Some of the ruby crystals used in this work can be traced back to the original material from Theodore Maiman, handed by himself to Herbert Welling, the German laser pioneer, for first experiments and then remained for more than 50 years in the basement of the institute.

Meanwhile, we realized ultra-compact and stable laser systems with resonators below 3 mm length, yielding narrowband tunable single frequency emission. Features of these systems are presented, and possible applications will be discussed.

Q 10.2 Mon 17:30 E001

Generation of ultrashort VUV pulses by frequency-tripling compressed high-energy pulses centered around 400 nm — •Nora Schmitt, Armin Azima, Marek Wieland, Mark Prandolini, and Markus Drescher — University of Hamburg, Institute for Experimental Physics, 22761 Hamburg, Germany

Generating ultrashort laser pulses in the vacuum ultraviolet spectral region (VUV, $\sim$100 to 200 nm) is key to studying an abundance of atomic and molecular transitions. Pump-probe experiments utilizing intense ultrashort laser pulses in this spectral region have successfully been realized and used to study the dynamics of several systems. However, the most widely used source in the VUV is the 5th harmonic of a Ti:Sa laser, which is centered around 160 nm, limiting the number of accessible transitions. In order to drive nonlinear transitions in this wavelength regime, alternative VUV generation schemes should provide pulse energies approaching μJ levels . In a novel approach, we generate pulses around 133 nm by frequency-tripling in a gas cell. The fundamental pulses, centered at 400 nm, are spectrally broadened in a stretched hollow core capillary fiber filled with helium and temporally compressed by a slightly detuned 4f-setup. For the 400 nm pulses, we obtain a pulse duration of 10 fs (FWHM) at 800 μJ pulse energy, evaluated by fringe resolved interferometric autocorrelation (FRIAC) measurements. Our simulations suggest that tripling these pulses in our geometry will yield a conversion efficiency in the order of 10^{-3}.

Q 10.3 Mon 17:45 E001

Tailored transverse field distributions in an enhancement resonator for high harmonic generation — •Tamila Rozibakieva[1], Stephan H. Wissenberg[2], Hans-Dieter Hoffmann[2], Constantin L. Häfner[2,3], Peter G. Thirolf[1], and Johannes Weitenberg[2,4] — [1]Ludwig-Maximilians-Universität München LMU — [2]Fraunhofer Institute for Laser Technology ILT — [3]Chair for Laser Technology LLT, RWTH Aachen University — [4]Max-Planck Institute of Quantum Optics MPQ

An enhancement resonator is a passive optical resonator, which is used for resonant enhancement of an optical power or intensity. Enhancement resonators are used in nonlinear processes such as high-harmonic generation (HHG), which requires high intensity (>10^13 W/cm^2) even at large repetition rates (>10 MHz). At Fraunhofer ILT, a VUV frequency comb is being set up for the excitation of the low-energy isomeric nuclear transition of 229-Thorium at LMU Munich as part of an ERC synergy project. The spectrum in the VUV frequency comb can be achieved via HHG in a Xe gas jet, in our case as the 7th harmonic of a driving laser at 1050 nm. A key challenge with enhancement resonators for HHG is the coupling of the harmonics out of the resonator. The talk will focus on an analysis of transverse modes that can be used to geometrically couple out high harmonics through a slit in a resonator mirror, for example the GH[1,0]-mode, the slit mode or a non-collinear resonator. It will be presented how a large spatial overlap with impinging Gaussian beam can be achieved for these modes. Funding: ERC Synergy project, Grant Agreement No. 856415.

Q 10.4 Mon 18:00 E001

Femtosecond Fast Tunable Ultraviolet Radiation through Non-collinear Sum-frequency Mixing in a Visible NOPO — •Fridolin Geesmann[1], Robin Mevert[1,2], David Zuber[1,2], Han Rao[1,2], and Uwe Morgner[1,2,3] — [1]Institute of Quantum Optics, Leibniz Universität Hannover, Hannover, Germany — [2]Cluster of Excellence PhoenixD (Photonics, Optics, and Engineering-Innovation Across Disciplines), Hannover, Germany — [3]Laser Zentrum Hannover e.V., Hannover, Germany

We report on a rapidly tunable non-collinear optical parametric oscillator (NOPO), which simultaneously delivers femtosecond pulses in the visible and ultraviolet wavelength range. The system is pumped by the third harmonic of a Yb based MOFA system, which is focused into a BBO crystal to generate the visible pulses via a DFG process. A KDP crystal is placed in a second focus of the NOPOs ring cavity for further frequency conversion. Thereby, ultraviolet wavelengths were reached through non-collinear sum-frequency mixing of the visible pulses with residual infrared pump radiation. With this approach, two synchronized outputs were realized, delivering fast tunable pulses from 449-690 nm and 340-413 nm with output powers up to 232 mW and 59 mW, respectively. By replacing the visible output coupler with an HR mirror, even higher power in the UV of up to 90 mW was achieved. In addition, the quick tuning of the two outputs was shown over their entire wavelength range with a frequency of 43.9 Hz. Even higher tuning speeds can be expected by using a different piezoelectric actuator, as this has been the limiting factor so far.

Q 10.5 Mon 18:15 E001

Towards intracavity optical parametric amplification of a Ti:sapphire laser oscillator — •Robin Mevert[1,2], Jintao Fan[1,2], Fridolin Jakob Geesmann[1,2], Han Rao[1,2], David Zuber[1,2], Tino Lang[3], and Uwe Morgner[1,2,4] — [1]Leibniz Universität Hannover, Institute of Quantum Optics, Hannover, Germany — [2]Leibniz Universität Hannover, Cluster of Excellence PhoenixD (Photonics, Optics, and Engineering-Innovation Across Disciplines), Hannover, Germany — [3]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germ — [4]Laser Zentrum Hannover e.V., Hannover, Germany

Nowadays, Ti:sapphire oscillators still play a major role as a typical work horse for the generation of femtosecond laser pulses in the near-infrared since its broadband emission range can support pulse durations in the sub-10fs range. Unfortunately, power scaling of Ti:sapphire lasers is limited by the thermal lensing effect inside the Ti:sapphire crystal as well as the additional gain-narrowing effects. On the other hand, synchronously-pumped femtosecond optical parametric oscillators (OPOs) in the near-infrared are easily power scalable since there are only nonlinear absorption effects inside the gain material. This fact is utilized nowadays in optical parametric amplifiers which are often used to amplify the output power of a Ti:Sapphire laser. However, the main drawback is the drastic decrease in repetition rate towards the kHz range which causes additional obstacles for later applications such as high-harmonic generation. In this work, we investigate the possibility to use the parametric gain of a BBO-crystal to amplify the Ti:sapphire laser inside a single cavity.

Q 10.6 Mon 18:30 E001

Jitter comparison of gain-switched diodes — •Simon Angstenberger, Tobias Steinle, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

Gain-switched diodes are a cost-efficient and widely used approach to seed flexible amplifier chains. However, the timing jitter of the gain-switching process limits the implementation in applications with critical timing on the tens of picosecond scale. We compare different diode concepts, namely a Fabry-Perot (FP) laser diode and a distributed feedback (DFB) laser diode. We find that the timing jitter for the FP diode is significantly lower, when driven with the same electronic driver. Furthermore, we investigate the influence of optical feedback by means of a fiber Bragg grating (FBG) on the jitter performance. Eventually, a comparison is made of the obtained values to a fiber laser for reference.

Q 10.7 Mon 18:45 E001

Optimization of photonic multilayer structures to increase upconversion efficiency — •Fabian Spallek[1,2], Stefan Yoshi Buhmann[2], Thomas Wellens[1], and Andreas Buchleitner[1,3] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg — [2]Institut für Physik, Universität Kassel — [3]EUCOR Centre for Quantum Science and Quantum Computing, Albert-Ludwigs-Universität Freiburg

The efficiency of solar silicon solar cells can be substantially improved by widening the spectral operating window by means of upconversion materials [1]. These convert two low-energy photons into one photon with higher energy [1]. Embedding the upconverter material in photonic dielectric nanostructures allows to influence the interplay of absorption and emission rates, energy transfer processes, local irradiance and local density of (photonic) states which in turn determines the overall efficiency.

We utilize methods from macroscopic quantum electrodynamics to calculate the influence of multilayer nanostructures on spontaneous emission and absorption rates in the upconverter. This allows us to propose specific designs optimized for upconversion efficiency [2]. Lastly, we take into account manufacturing errors and compare indicators for the achievable upconversion luminescence and quantum yield of our optimized design to existing, experimentally implemented Bragg structures.

[1] C. L. M. Hofmann et al., Nat. Commun. **12**, 14895 (2021)

[2] F. Spallek et al., J. Phys. B: At. Mol. Opt. Phys. **50**, 214005 (2017)