Q 40: Laser Development: Nonlinear Effects

Time: Wednesday 11:00–12:45 Location: K/HS2

Q 40.1 Wed 11:00 K/HS2

Record power levels in the mid-IR around 7 μm with a femtosecond OPO at 86 MHz — •Joachim Krauth[1], Suddapalli Chaitanya Kumar[2], Tobias Steinle[1], Andy Steinmann[1], Peter G. Schunemann[3], Kevin T. Zawilski[3], Majid Ebrahim-Zadeh[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart — [2]ICFO, Barcelona, Spain — [3]BAE Systems, Inc., Nashua, New Hampshire, USA

We demonstrate a high-power, mid-infrared, femtosecond optical parametric oscillator (OPO) based on Cadmium Silicon Phosphide, CdSiP2 (CSP) nonlinear crystal generating up to a record output power of 115 mW in the idler at wavelengths as long as 7 μm along with 480 mW of signal at 1209 nm. The OPO is configured as a singly resonant oscillator in an X-cavity design to operate at 86 MHz while it is synchronously pump by a Yb:KGW laser, providing up to 5 W of output power with 500 fs pulses at 43 MHz and operating at a central wavelength of 1029 nm. The generated signal and mid-infrared idler exhibit large spectral bandwidths of 9 and 310 nm, respectively. The signal pulses are measured to have pulse duration of 500 fs considering a sech^2 pulse shape. This stable, high power, mid-infrared OPO is useful for various applications including mid-infrared spectroscopy. A complete characterization of the OPO along with power scaling, stability and mid-infrared idler spectral measurements will be presented. We envision applications such as medical and vibration spectroscopy, neurosurgery, as well as detection of TNT and other chemical or biological materials with vibrational fingerprints in the 7 μm region.

Q 40.2 Wed 11:15 K/HS2

Difference frequency generation in the mid-IR at 80 MHz high repetition rate using a compact green-pumped soliton optical parametric amplifier — •Florian Mörz, Tobias Steinle, Andy Steinmann, and Harald Giessen — 4th Physics Institute and Research Center Scope, University of Stuttgart

We present a novel approach to generate mid-IR radiation at high repetition rates by using amplified solitons as a seed source for difference frequency generation in GaSe. A 3.4 times higher DFG output power is observed when compared to a non-amplified soliton seed. About 0.35 mW of idler power is generated at 5.4 μm wavelength. The power is currently limited by strong dispersion effects.

The solitons are generated in a tapered fiber and further amplified in a green-pumped OPA. By using a NIR 4 W Yb:CALGO laser source with a pulse width of 80 fs, the often reported soliton instability is negligible. The solitons exhibit a wavelength drift of only 1% over 2 hours. A 10 mm long PPLN crystal is used in the OPA, which is pumped by the frequency-doubled Yb laser and seeded by the solitons. Our system is extremely stable, compact and has a footprint of less than 0.5 m^2. The OPA gain could be increased about 3 times by applying spectral-focusing for SHG instead of frequency doubling in a standard LBO crystal.

We give an outlook concerning future applications of the MIR DFG system and present further steps to increase the green-pumped OPA gain, to further stabilize the solitons and to compensate for the dispersion effects.

Q 40.3 Wed 11:30 K/HS2

A Simplified Scheme for Generating Narrow-Band Mid-Ultraviolet Laser Radiation — •Guy Almog[1,2], Matthias Scholz[2], Waldemar Weber[2], Patrick Leisching[2], Wilhelm Kaenders[2], and Thomas Udem[3,1] — [1]Ludwig-Maximilians-Universität, Geschwister-Scholl-Platz 1, 80539 Munich, Germany — [2]TOPTICA Photonics AG, Lochhamer Schlag 19, 82166 Graefelfing (Munich),Germany — [3]Max-Planck Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

We report on the development and characterization of continuous, narrow-band, and tunable laser systems that use direct second-harmonic generation from blue and green diode lasers with an output power level of up to 11.1 mW in the mid-ultraviolet. One of our laser systems was tuned to the mercury $6^1S_0 \rightarrow 6^3P_1$ intercombination line at 253.7 nm. We were able to perform Doppler-free saturation spectroscopy on this line and to lock our laser to the transition frequency on long time scales.

Q 40.4 Wed 11:45 K/HS2

Efficient and Broadband Frequency Generation by Composite Crystals — •Genko Genov[1], Andon Rangelov[2], and Nikolay Vitanov[2] — [1]Institute of Applied Physics, Technical University of Darmstadt, Hochschulstrasse 6, 64289 Darmstadt, Germany — [2]Department of Physics, St. Kliment Ohridski University of Sofia, 5 James Bourchier blvd, 1164 Sofia, Bulgaria

Composite pulse sequences have been used for several decades in nuclear magnetic resonance, and lately, in quantum information processing. Novel universal broadband composite pulses have been introduced recently that perform robust population transfer and compensate errors in any experimental parameter and for any pulse shape [1]. These sequences were also experimentally implemented for efficient and robust rephasing of atomic coherences in doped solids.

We introduce another interesting application that uses an analogy with the universal composite pulses: composite crystals for efficient broadband sum and difference frequency generation [2]. This technique delivers high efficiency and robustness to parameter variations, e.g., when the phase matching condition is not fulfilled. It is a viable alternative to the adiabatic approaches because it requires much lower input intensity and shorter nonlinear crystals. It also works both with continuous-wave and pulsed lasers, as well as in the linear and nonlinear regimes of depleted and undepleted pump, respectively.

[1] G. T. Genov, D. Schraft, T. Halfmann, N. V. Vitanov, Phys. Rev. Lett. 113, 043001 (2014). [2] G. T. Genov, A. A. Rangelov, N. V. Vitanov, J. Opt. 16, 062001 (2014).

Q 40.5 Wed 12:00 K/HS2

Extra-narrow linewidth, stable and widely tunable extracted single laser line — •Hassanain Al-Taiy, Stefan Preussler, and Thomas Schneider — Technische Universität Braunschweig, Institut für Hochfrequenztechnik, Schleinitzstraße 22, 38106 Braunschweig, Germany

A high-quality laser source became indispensable for many different applications like high-resolution spectroscopy and coherent optical communications. Therefore, an extra-narrow linewidth, stable and widely tunable extracted source of coherent radiation is demonstrated and experimentally implemented. The extracted single line is achieved by utilizing the polarization pulling assisted stimulated Brillouin scattering as an optical filter and amplifier with a bandwidth of 10-30 MHz. Therefore, one spectral comb line out of a femtosecond-fiber laser with a repetition rate of 100 MHz is selected and amplified, whereas all other lines are suppressed. The fine tuning is performed by an additional modulation, while the course tuning is achieved via the selection of a different line out of the fiber laser. The relative stabilization is done via a measurement of the repetition rate and a corresponding adaptation of the modulation. First proof of concept results show possible linewidths below 1 Hz and an SNR of 47 dB with a tunability of more than 100 nm and a relative stability of $\pm$160 mHz over 5 h.

Q 40.6 Wed 12:15 K/HS2

Feedback coupling of quantum dot microlasers — •Janik Wolters[1], Leon Messner[1], Elisabeth Schlottmann[1], Sören Kreinberg[1], Steffen Holzinger[1], Christian Schneider[2], Sven Höfling[2,3], Martin Kamp[2], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Berlin, Germany — [2]Technische Physik, Wilhelm Conrad Röntgen Research Center for Complex Material Systems, Universität Würzburg, Würzburg, Germany — [3]Present address: SUPA, School of Physics and Astronomy, University of St Andrews, United Kingdom

Semiconductor micropillar cavities with a few tens of embedded quantum dots under time delayed optical feedback are ideal to study the transition from semiclassical to quantum mechanical nonlinear systems. In addition, these structures are expected to have manifold applications, e.g. in cryptography or high bit-rate random number generation.

We established a way to maximize the incoherent optical feedback of nanophotonic systems while leaving options to change phase, polarization and feedback rate. In our experiments, we observe feedback-induced changes, mainly in the second order autocorrelation function of the emitted light and the input-ouptut characteristics.

Our results pave the way to further studies of nonlinear laser dynam-

ics beyond the Lang-Kobayashi model, towards the quantum regime.

Q 40.7 Wed 12:30 K/HS2

Erzeugung vakuum-ultravioletter Strahlung durch Vierwellenmischen in einer mit Quecksilberdampf gefüllten Hohlfaser — •Thomas Diehl[1,2], Andreas Koglbauer[1] und Jochen Walz[1,2] — [1]Johannes Gutenberg-Universität Mainz, D-55099 Mainz — [2]Helmholtz-Institut Mainz, Johann-Joachim-Becher-Weg 36, 55128 Mainz

Für zukünftiges Laserkühlen von gefangenen Anti-Wasserstoffatomen und Rydberg-Anregung von gefangenen $^{40}Ca^{+}$-Ionen in einer Paulfalle wird eine kontinuierliche und kohärente Laserlichtquelle im vakuumultravioletten Bereich um 122 nm benötigt. Eine etablierte Methode zur Erzeugung solcher Strahlung ist Vierwellenmischen in Metalldämpfen.
Durch nicht-entartetes Summenfrequenzmischen in Quecksilber mit stark fokussierten Gaußstrahlen konnte die bislang effizienteste kontinuierliche Laserlichtquelle bei dieser Wellenlänge durch Ausnutzen atomarer Resonanzen im nichtlinearen Medium realisiert werden [1]. Eine weitere Effizienzsteigerung lässt sich durch den Einschluss des nichtlinearen Mediums und der fundamentalen Laserlichtfelder in eine Hohlfaser erreichen. Damit lässt sich die Wechselwirkungszone des nichtlinearen Prozesses von ca. 1 mm auf mehrere cm ausdehnen. Dies führt zu einer theoretischen Effizienzsteigerung von mehr als zwei Größenordnungen.
Es werden der aktuelle Stand und die bisher erzielten Ergebnisse des Experiments vorgestellt.
[1] Phys. Rev. Lett. 109, 063901 (2012)