# Q 10: Ultrakurze Pulse: Erzeugung I

Zeit: Montag 14:00–15:45 Raum: VMP 8 R206

Q 10.1 Mo 14:00 VMP 8 R206

**Effect of feedback on femtosecond supercontinuum generation: numerical investigation on nonlinear dynamics** — •Michael Kues, Nicoletta Brauckmann, Till Walbaum, Petra Gross, and Carsten Fallnich — Institut für Angewandte Physik Westfälische Wilhelms-Universität, Münster, Deutschland

Since the development of photonic crystal fibers (PCFs), numerous investigations have been made to improve the phase stability and coherence of supercontinua generated in PCFs. As a possible method to achieve this goal, we investigate the effect of feedback on supercontinuum (SC) generation in PCFs. For this, we numerically study the supercontinuum evolution in a ring cavity synchronously pumped with fs-pulses from a titanium:sapphire laser. The generalized nonlinear Schrödinger equation is solved numerically using a split-step Fourier algorithm, and feedback is employed by superimposing the calculated SC with the following pump pulses. Here, we present results of these simulations, which exhibit a strong influence of feedback on the SC evolution. Depending on input parameters, a convergence of consecutive SC spectra to a steady state can be observed, as well as period doubling, limit cycles, and chaos. Finally, we include noise in our simulations in order to pave the way for an experimental demonstration. From these results, we expect a parameter range where the phase stability as well as the coherence should be improved.

Q 10.2 Mo 14:15 VMP 8 R206

**Femtosecond supercontinuum generation in a feedback cavity: Experimental investigations on nonlinear dynamics** — •Nicoletta Brauckmann, Michael Kues, Till Walbaum, Petra Gross, and Carsten Fallnich — Institut für Angewandte Physik Westfälische Wilhelms-Universität, Münster, Deutschland

Supercontinuum generation is a highly nonlinear optical phenomenon where narrow bandwidth light becomes spectrally broadband due to, e.g., self-phase modulation, four-wave mixing, soliton fission and Raman scattering. For a high degree of pulse-to-pulse coherence in supercontinua typically short pulses with only a few tens of femtoseconds are used. Currently we are investigating how an optical feedback allows to relax the experimental conditions for low-noise supercontinuum generation. In our experimental feedback system, the supercontinuum is generated in a photonic crystal fiber within a ring cavity. This leads to an interaction of the supercontinuum with the following pulses of the titanium:sapphire pump laser. Here, we present the nonlinear dynamical behaviour of this system which includes, e.g., regimes of period doubling, which means that the system state is not reproduced after every cavity roundtrip, but after every second roundtrip. In our experiments, we also observe system state reproductions after three and four roundtrips and more complex regimes of operation up to chaos. With our investigations we want to identify regimes of operation where parts of supercontinuum show improved pulse-to-pulse coherence related to self-stabilisation mechanisms.

Q 10.3 Mo 14:30 VMP 8 R206

**Investigation and optimization of continuum generation in crystals - white-light beyond sapphire** — •Maximilian Bradler, Peter Baum, and Eberhard Riedle — Lehrstuhl für BioMolekulare Optik, LMU München

Focusing intense ultrashort pulses into nonlinear media leads to one of the most fascinating phenomena in ultrafast optics - white-light generation. The resulting supercontinua are used for many applications such as optical parametric amplification, femtosecond spectroscopy or CEP measurements. The standard bulk material for white-light generation is sapphire, which allows the generation of a high quality single filament. We now find that sapphire is not always the best choice. We report a comprehensive investigation and the optimization of femtosecond continuum generation in single crystals of several common laser host materials. The absolute spectral energy density, pulse-to-pulse stability, pump threshold and beam profile are studied in dependence on the crystal thickness, focusing conditions, pump pulse energy and pump wavelength. Lower thresholds, plateau-like visible and infrared spectra and higher infrared photon flux as compared to conventional materials are found in yttrium aluminum garnet (YAG), yttrium vanadate (YVO4), gadolinium vanadate (GdVO4) and potassium-gadolinium tungstate (KGW). We discuss the particular advantages of each material and show the potential of the new crystals for advanced applications.

Q 10.4 Mo 14:45 VMP 8 R206

**Erzeugung von intensiven, ultrakurzen Laserpulsen durch Weißlichtfilamentation in Argongas - Simulation und Experiment** — •Robert Irsig[1], Nguyen Xuan Truong[1], Thomas Fennel[1], Tilo Döppner[2], Josef Tiggesbäumker[1] und Karl-Heinz Meiwes-Broer[1] — [1]Institut für Physik, Universität Rostock, Universitätsplatz 3, 18051 Rostock — [2]Lawrence Livermore National Laboratory, Livermore, CA 94551 USA

Durch die Fokussierung von kurzen, intensiven Laserpulsen (40 fs, 2.5 mJ) in eine mit Argon gefüllte Gaszelle werden Weißlichtfilamente erzeugt. In diesen Filamenten kommt es durch Selbstphasenmodulation zu einer spektralen Verbreiterung der Pulse. Die Ionisation des Gases und nichtlineare Effekte wie Self-Steepening führen zu einer Verringerung der Pulslänge [1].
Es wird gezeigt, wie die Filamente experimentell durch Variation von Gasdruck und Fokuslänge beeinflußt werden können. In einer Simulation wird die Propagation der Laserpulse im Filament durch Lösung der nichtlinearen Schrödingergleichung beschrieben. Der Einfluß von Selbstphasenmodulation, Self-Steepening und Plasmabildung wird diskutiert.

[1] G. Stibenz, N. Zhavoronkov, and G. Steinmeyer, Opt. Lett. 31, 274 (2006)

Q 10.5 Mo 15:00 VMP 8 R206

**Quasi-hydrodynamic spatio-temporal shaping in filamentary propagation of femtosecond pulses** — •Carsten Bree[1,4], Ayhan Demircan[1], Stefan Skupin[2], Luc Berge[3], and Günter Steinmeyer[4] — [1]Weierstraß-Institut für Angewandte Analysis und Stochastik — [2]Max-Planck-Institut für Physik komplexer Systeme — [3]CEA-DAM, DIF, Arpajon, France — [4]Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie

Filament self-compression is a remarkably simple new way for generating intense laser pulses with sub-10 fs pulse duration. Despite the experimental simplicity, the physical situation in femtosecond filaments is quite involved. In fact, the filamentary dynamics is governed by a complex interplay of about ten linear and nonlinear optical effects. We will show, however, that the formation of short pulses in the filamentary channel can already be well understood in a reduced model that isolates three major mechanisms. In particular, this model implies vanishing flow of energy between adjacent temporal slices of the pulse. In this quasi-hydrodynamic scenario, a pronounced self-induced pinching of the photon density is observed, leading to the characteristic spatio-temporal inhomogeneity of filamentary pulses. We will show, both by analytical arguments and numerical simulations that it is this spatial concentration of energy that gives rise to the experimentally observed self-compression. In addition, we show that the experimentally observed asymmetric temporal shape of self-compressed pulses, consisting of a small leading subpulse followed by an intense trailing pulse, can be understood within the framework of our analytical model.

Q 10.6 Mo 15:15 VMP 8 R206

**Self-healing mechanism of compressed femtosecond filaments** — •Stefan Skupin[1], Luc Bergé[2], and Günter Steinmeyer[3] — [1]Max-Planck-Institut für Physik komplexer Systeme, Dresden — [2]CEA-DAM, DIF, F91297 Arpajon, France — [3]Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie

In self-generated filaments, femtosecond pulses experience strong spatial and temporal shaping effects. The dynamical balance between Kerr self-focusing and plasma-induced defocusing gives rise to a self-guiding mechanism, which involves a complex time dependent radial energy flow (dynamical spatial replenishment). This energy flow strongly links spatial and temporal dynamics.

One of the most surprising properties of femtosecond filaments is on-axis self-compression, i. e., pulse shortening in the center of the beam during filamentary propagation. For examining the self-compression regime, experimental set-ups use windowed cells, allowing for careful optimization of the pressure that gives rise to maximum self-compression. Here we will investigate numerically the influence of these exit windows on pulse propagation, which distort the spatio-temporal shape of the exiting pulse considerably and seem to destroy self-compression. However, upon subsequent propagation in, e. g., the atmosphere, a self-healing mechanism takes place. We find that again, as the self-compression mechanism itself, this self-healing process is a result of a time dependent radial energy flow.

Q 10.7 Mo 15:30 VMP 8 R206

**Fourfold self-compression of 120-fs pulses in a white-light filament** — •J. Bethge[1], G. Stibenz[2], P. Staudt[2], H. Redlin[3], S. Düsterer[3], C. Brée[4,1], A. Demircan[4], and G. Steinmeyer[1] — [1]Max-Born-Institut, Berlin — [2]Angewandte Physik und Elektronik GmbH (APE), Berlin — [3]Deutsches Elektronen-Synchrotron (DESY), Hamburg — [4]Weierstraß-Institut für Angewandte Analysis und Stochastik (WIAS), Berlin

Self-compression in whitelight filaments has opened remarkable new opportunities for compressing energetic pulses from a few ten femtosecond duration down into the sub-10 fs range [1]. Other than hollow fiber compressors, filament compression is neither limited by optical damage to the guiding structure nor does it require external dispersion compensation. However, so far self-compression has only been demonstrated with rather short input pulses. Moreover, this scheme was found to work only in a small parameter range and showed an increased sensitivity towards fluctuations of the input pulses. We use a 10 Hz Ti:sapphire laser system with 3.5 mJ pulse energy at the DESY FLASH facility. Using this laser we demonstrate a fourfold self-compression from 120 fs before filamentary propagation into 30 fs pulses after the filament, clearly indicating the universality of the self-compression mechanism in filaments. The self-compression measured with LX-SPIDER complies with the predictions of an improved analytical model [2].

[1] C. P. Hauri, et al., Appl. Phys. B **79**, 673 (2004).
[2] C. Brée, et al., submitted to Phys. Rev. Lett. (2008).