DF 2: Internal Symposium "Nonlinearities of Photonic Materials"

Time: Monday 10:00–13:00 Location: H11

Invited Talk DF 2.1 Mon 10:00 H11

Steuerung von Licht durch nichtlineare Brechungsindexänderungen - Perspektiven für den photonischen Chip — •Cornelia Denz, Bernd Terhalle, Christoph Bersch, Philip Jander und Jörg Imbrock — Institut für Angewandte Physik, Westfälische Wilhelm-Universität Münster

Die Optik bietet durch ihre inhärente Parallelität und höchste Ausbreitungsgeschwindigkeit bereits zahlreiche Vorteile in der Informationsverarbeitung. Die Realisierung vieler Funktionen verlangt jedoch Elemente, die Licht direkt schalten und parallel verarbeiten können. Nichtlineare optische Effekte können solche Funktionen durch die Wechselwirkung von Licht mit Materie erzeugen, ohne zusätzliche Umwandlung in elektronische Signale zu benötigen. So kann Licht sich selbst führen, speichern oder manipulieren und damit adaptive Komponenten erzeugen - eine viel versprechende Perspektive für komplexe photonische Systeme bis hin zur der Realisierung des optischen Chips.

Insbesondere das Potential zahlreicher nichtlinearer optischer Materialien, den Brechungsindex entsprechend der einfallenden Lichtverteilung zu ändern, bietet hier die Möglichkeit, bei geringsten Lichtleistungen Material bereits derart zu strukturieren, dass adaptive Wellenleiter, optische Schaltelemente oder optisch induzierte photonische Kristalle entstehen. Im Vortrag werden die Grundlagen zur Erzeugung dieser Elemente auf der Basis photorefraktiver solitärer Strukturen sowie die Erzeugung dieser Elemente und deren Steuerung und Kontrolle durch Lichtmodulation dargestellt.

DF 2.2 Mon 10:40 H11

Holographic polymer-dispersed liquid crystals for neutron optics — •Martin Fally[1], Irena Drevenšek-Olenik[2], Mostafa Ellabban[1], Klaus Pranzas[3], and Jürgen Vollbrandt[3] — [1]Fakultät für Physik, Universität Wien, Boltzmanngasse 5, A-1090 Wien, Österreich — [2]Faculty of Mathematics and Physics, University of Ljubljana, Jadranska 19 und and J. Stefan Institute, Jamova 39, SI 1001 Ljubljana, Slovenia — [3]GKSS Forschungszentrum, D-21502 Geesthacht, Germany

Holographic polymer-dispersed liquid crystals (H-PDLC) are electrically switchable photonic media with large potential for optical applications.

Here, we demonstrate that H-PDLC are not only interesting for nonlinear light optics but also for neutron optics. We report strong diffraction of cold neutrons from an only 30 micrometer thick holographic polymer-dispersed liquid crystal transmission grating [1]. The nonlinearty mechanism of this photonic material and the diffraction are discussed and compared to light optical experiments performed on the same sample[2]. We finally argue, why H-PDLCs are promising candidates for fabricating not only photonic crystals but also electrically switchable neutron-optical devices.

[1] M. Fally, I. Drevenšek-Olenik, M. A. Ellabban, K. P. Pranzas, and J. Vollbrandt, Phys. Rev. Lett. **97**, 167803 (2006)

[2] I. Drevenšek-Olenik, M. Fally, and M. Ellabban, Phys. Rev. E **74**, 021707 (2006)

DF 2.3 Mon 11:00 H11

Mechanisms of holographic grating formation in silver nanoparticle suspensions * — •Helge Eggert[1], James Adleman[2], Demetri Psaltis[2], and Karsten Buse[1] — [1]Institute of Physics, University of Bonn, Wegelerstr. 8, 53115 Bonn — [2]Department of Electrical Engineering, California Institute of Technology, Pasadena, CA 91125

Colloidal suspensions of metal nanoparticles have interesting thermal and nonlinear-optical properties. The high third-order nonlinearity of metal nanoparticles at wavelengths close to the surface plasmon resonance makes such suspensions attractive, e.g., for optical switching applications. However, the optical response of these materials is still not completely understood, especially on the nanosecond time scale. To study silver nanoparticle suspensions, holographic experiments are conducted: Holographic gratings are recorded utilizing interfering nanosecond pulses. The diffraction efficiency is measured with continuous-wave light. An instantaneous response together with a longer lasting but also transient grating are observed: The nanoparticles absorb the pump light and heat up, which yields a response on the time scale of the laser pulse duration. Heat is transferred to the solvent, and a delayed thermal grating appears. The final decay time constant of this grating depends quadratically on the period length of the interference pattern and has a typical value of 1 ms for grating spacings of several micrometers. This are indications for thermal gratings.

*Financial support by the DFG (BU 913/17) and by the Deutsche Telekom AG is gratefully acknowledged.

DF 2.4 Mon 11:20 H11

On the way to μJ THz pulses by optical rectification — •Eberhard Riedle[1], Balázs Bartal[2], Ida Z. Kozma[1], Andrei Stepanov[3], Gábor Almási[4], Jürgen Kuhl[5], and János Hebling[2] — [1]LMU München, Germany — [2]Dept. of Exp. Physics, Univ. of Pécs, Hungary — [3]Inst. of Spectroscopy, Russian Acad. of Science, Troitsk, Russia — [4]Dept. of Informatics in Physics, Univ. of Pécs, Hungary — [5]MPI for Solid State Research, Stuttgart, Germany

We investigate the energy scaling of sub-ps THz pulses generated by tilted pulse front excitation. With 150fs-long 500μJ pump pulses at 800nm THz energies up to 240nJ were achieved [1]. For a 1.2mm^2 pump area, the conversion efficiency of pump to THz energy had a maximum of 5x10^{-4} at 300μJ pump energy. This amounts already to a quantum efficiency of above 10%. For comparison, the maximum attainable THz pulse energy was limited to 2.1nJ at 32μJ pump energy in a line focusing geometry. To illustrate the very different type of development of the THz pulse inside the electro-optical crystal, model calculations were performed for both geometries and found to be in good agreement with the experiments. Comprehensive simulations predict that the tilted pulse front excitation allows further up-scaling of the THz pulse energy by using a larger pump spot size, still stronger pump pulses and cooling of the nonlinear crystal [2]. These measures should increase the THz energy into the μJ regime and the quantum efficiency to 50%. We also find an optimal pulse duration and crystal length for maximum resulting electric field and the potential for simple tuning of the THz center frequency.

[1] A. G. Stepanov, et al. Opt. Express 13, 5762-5768 (2005).
[2] B. Bartal et al., Appl. Phys. B (2006) DOI: 10.1007/s00340-006-2512-7

DF 2.5 Mon 11:40 H11

Optical excitation of space-charge waves in semi-insulating materials — •Mikhail Petrov[1], Valeriy Bryksin[1], Michaela Lemmer[2], and Mirco Imlau[2] — [1]Ioffe Physico-Technical Institute, St. Peterburg, Russia — [2]Department of Physics, University of Osnabrück, Germany

The application of an electric field to a semi-insulating (SI) crystal can create conditions for the existence of definite space-charge wave eigenmodes. Specific properties of these waves (dispersion law, quality factor) depend on intrinsic properties of the SI material (carrier mobility and lifetime, trap concentration, Maxwell relaxation time). Because these materials are typically good photoconductors, a proper illumination of the crystal can generate the desired space-charge waves with corresponding wave vector and eigenfrequency. This report is devoted to the discussion of a broad spectrum of the effects caused by optical excitation of space-charge waves. Some of these effects have direct analogs in nonlinear optics (for instance, complete rectification of space-charge waves reminds of optical rectification in nonlinear optics). The experiments have been performed in photorefractive crystals of the sillenite family (BSO, BTO, BGO) and SI semiconductors (CdTe:Ge, SiC, InP:Fe). New prospects of the investigations are discussed. They are the interaction of optically generated space-charge waves with magnetic field and investigation of space-charge waves in pseudo-two-dimensional structures when a crystal is illuminated with light that is absorbed in a thin surface layer of the crystal.

Supported by the DFG (projects GRK 695 and 436 RUS 17/15/07)

DF 2.6 Mon 12:00 H11

Hybrid materials with nonlinear optical properties — •Dominik Schaniel[1], Susanne Lisinski[2], Lorenz Ratke[2], and Theo Woike[3] — [1]I. Physikalisches Institut, Universität zu Köln, Zülpicher Strasse 77, 50937 Köln — [2]Institut für Materialphysik im Weltraum, DLR, Linder Höhe, 51170 Köln — [3]Institut für Mineralogie, Universität zu Köln, Zülpicher Strasse 49b, 50674 Köln

Aerogels and xerogels are used as host matrices for a variety of guest materials. Due to their broad transparency range of 350-2500 nm they are especially interesting for the design of novel nonlinear photonic materials. E.g., silica-aerogels are synthesized in a sol-gel process leading to a porous network of SiO_2 particles with diameters of 3-5 nm and pore sizes in the range of 10 nm. Embedding micro- to nanoparticles of oxidic electrooptic materials or single photoactive molecules novel hybrid materials with nonlinear optical properties can be produced. We show first results on silica aerogels with embedded $KNbO_3$ and $BaTiO_3$ particles, where we investigated the efficiency of second harmonic generation as a function of particle size and particle density. Further prospects of such hybrid materials are discussed.

DF 2.7 Mon 12:20 H11

Bound soliton pairs in photonic crystal fiber — •Przemyslaw Szarniak, Alexander Podlipensky, Nicolas Joly, Chris Poulton, and Philip Russell — Max-Planck Research Group (IOIP), University of Erlangen-Nuremberg, Guenther-Scharowsky Str. 1/Bau 24, 91058 Erlangen, Germany

We demonstrate experimentally, for the first time to our knowledge, the formation of bound pairs of solitons in highly nonlinear PCF. The pairs are generated by break-up of higher order solitons, and each member of each pair experiences a different soliton self-frequency shift (SSFS), leading to a decrease in the temporal and spectral spacing between the soliton pair as the input power increases. This eventually results in the formation of a trapped pair of solitons when the spacing becomes sufficiently small. We observe that the trapped soliton pair continues to propagate along the PCF with constant frequency spacing and time delay, while the central frequency of the pair shifts to lower frequencies due to the SSFS. We also present the results of numerical calculations that confirm the experimental observations.

DF 2.8 Mon 12:40 H11

Measurement of linear and nonlinear band structures of 1D photonic crystals — •Detlef Kip, Jürgen Wisniewski, and Christian Rüter — Institut für Physik und Physikalische Technologien, Technische Universität Clausthal, 38678 Clausthal-Zellerfeld

Arrays consisting of parallel aligned optical channel waveguides that are evanescently coupled due to the overlap of guided modes are an example of one dimensional photonic crystals. As such they can be analysed using the Floquet-Bloch approach. Due to the periodicity the linear transmission spectrum is split into bands of allowed extended Floquet-Bloch modes divided by forbidden gaps. In a nonlinear array the propagation dynamics may be altered, and nonlinear effects like modulational instabilities of Floquet-Bloch modes and energy localization, i.e., the formation of discrete solitons, occurs. So far nonlinear one dimensional waveguide arrays have been fabricated using various materials including polymers, III/IV semiconductors, or LiNbO3 and considerable work has been accomplished to study the linear and nonlinear light propagation in these systems. Recently we demonstrated that a prism coupling method can be used to measure the linear band structure and to excite pure Floquet-Bloch modes of a one dimensional periodic medium. Here we show that in a nonlinear waveguide array this method can be applied to study the temporal evolution of the propagation constant of an excited Floquet-Bloch mode and to directly measure the band structure modified by the induced nonlinear index changes.