Faculty of Physics
Warsaw University of Technology

X International Workshop

on

Nonlinear Optics Applications

Zakopane, Poland
September 23-26, 2009

X International Workshop

on

Nonlinear Optics Applications

organized by

Warsaw University of Technology

and

West Pomeranian University of Technology

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The International Workshops on Nonlinear Optics Applications have been organised since 1992 by *Warsaw University of Technology* and *West Pomeranian University of Technology*.

The purpose of the Workshop is to provide a forum for both senior and young scientists from different countries to present and discuss current research problems. The Workshop will deal with experimental and theoretical aspects of nonlinear optics applications, including nonlinear guided wave optics, optical solitons, optical switching and processing, nonlinear optical materials. Usually the main interest is focused on nonlinear guided wave optics, optical solitons in different media and their application for optical switching and processing. However, the workshop is widely open to related photonic phenomena such as magnetooptic effects and optical effects in complex materials

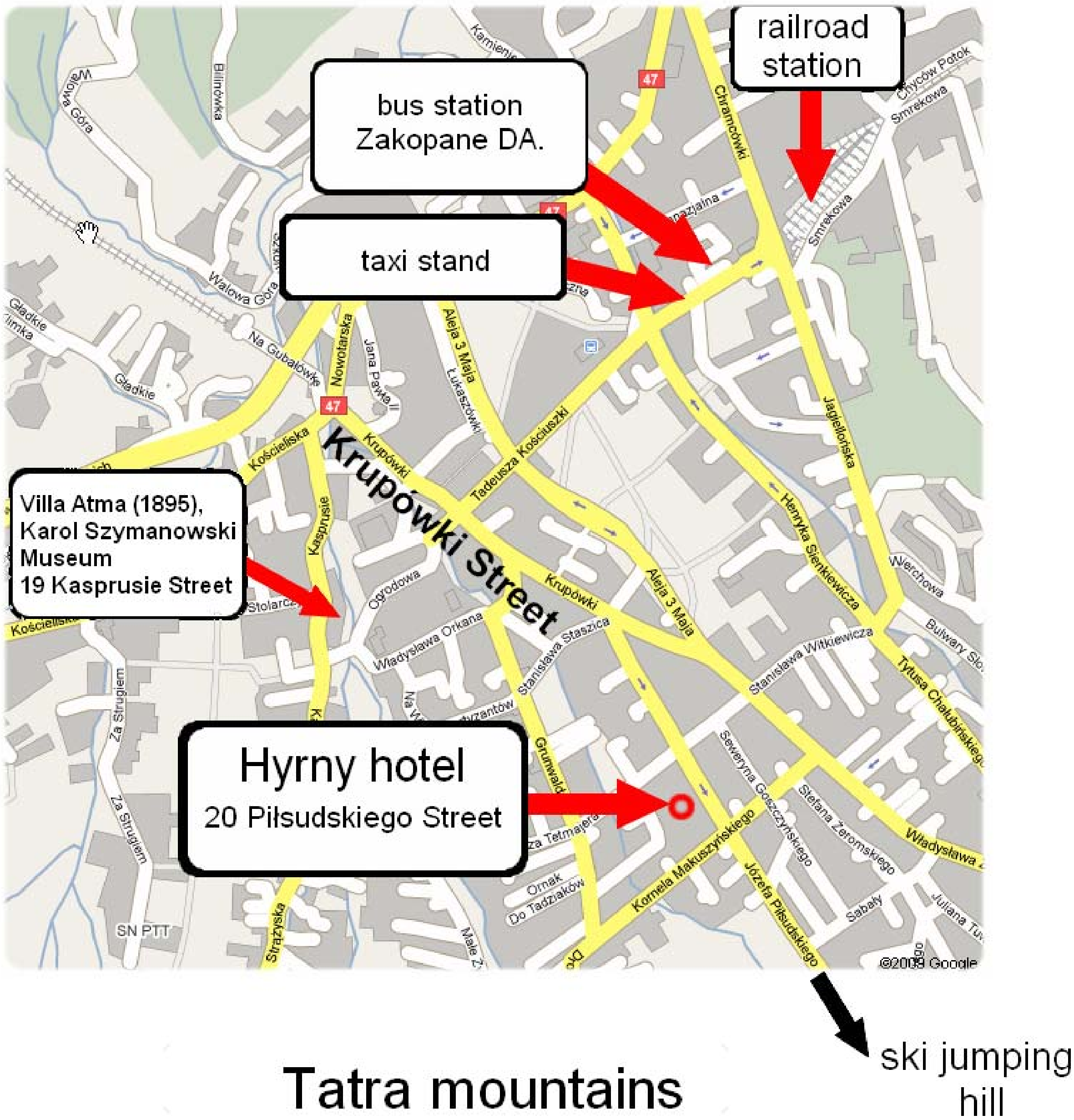
Previous workshops:

NOA 2007, Świnoujście, Poland, May 17-20, 2007
NOA 2005, Warsaw, August 31 - September 2, 2005
NOA 2004, Konstancin, June 17-20, 2004
NOA 2002, Łukęcin, September 5-8, 2002
NOA 2000, Grybów, June 8 - 11, 2000
NOA 1998, Międzyzdroje, August 31 - September 2, 1998
NOA 1996, Kazimierz Dolny, September 2-5, 1996
NOA 1994, Międzyzdroje, September 7-10, 1994
NOA 1992, Kociszew, December 14-16, 1992

This year's Workshop takes place in Zakopane, a picturesque town located in the foothills of the Tatra Mountains. First mention about the town is dated to the 17th century. Zakopane has nearly 30 000 inhabitants. Ski jumping World Cup is held there since 1980. There are 5 ski jumping hills (among them "Mała Krokiew" "Średnia Krokiew" and the most famous "Wielka Krokiew"). The main street of Zakopane is called Krupówki [pronounce kroopuvky]. There are many restaurants, cafes and shops. Zakopane is one of the most popular mountaineering and skiing resorts in Poland.

Places to see:

- Ski jumping hills – (**Bronisława Czecha Street)** (nearly 500m from hotel)
- Villa Atma – The museum of Karol Szymanowski (Polish composer, pianist and educator) Built in 1895. (**19 Kasprusie Street)**
- Holy Family Church – Roman Catholic church founded in 1877. Built in the neo-Romanesque style (**Krupówki Street)**


railroad station
bus station Zakopane DA.
taxi stand
Villa Atma (1895), Karol Szymanowski Museum 19 Kasprusie Street
Krupówki Street
Hyrny hotel
20 Piłsudskiego Street
©2009 Google
ski jumping hill
Tatra mountains

Program

Wednesday, 23 September

18.00 – 20.00	registration
18.00 – 20.00	dinner

Thursday, 24 September

8.00 – 9.00	breakfast

Chairman: Gaetano Assanto

9.00 - 9.10	*opening of the workshop*
9.10 – 10.10	George Stegeman – „Complexity in discrete surfach soliton generation"
10.10 – 10.30	Piotr Lesiak – "Z-scan measurements of oriented Au nanoparticles suspension"
10.30 – 11.00	coffee break

Chairman: Bożena Jaskorzyńska

11.00 – 12.00	Gaetano Assanto – "Liquid Crystal Light Valves: a versalite platform for nematicons"
12.00 – 13.00	Noel Smyth – "Mathematical modelling of nematicon control"
13.00 – 14.00	lunch

Chairman: Noel Smyth

14.30 – 15.30	Bożena Jaskorzyńska – "Dielectric and plasmonic slot waveguides for sub-wavelength light confinement"
15.30 – 16.00	Piotr Berczyński – "Gaussian beam diffraction in nonlinear media of Kerr type"
16.00 – 16.30	coffe break

Chairman: Roberto Morandotti

16.30 – 16.50	Urszula Laudyn – "Properties of spatial solitons in chiral nematic liquid crystal cells"
16.50 – 17.10	Michał Kwaśny – "Discrete beam propagation in chiral nematic liquid crystals"
17.10 – 17.30	Filip Sala – "Numerical simulation of beam propagation in layer filled with chiral nematic liquid crystal"
17.30 – 17.50	Krzysztof Zegadło – "Analysis of beam propagation in optical fiber structures with high step index"
17.50 – 18.10	Waldemar Bajdecki – "Some aspects of the weather change"
18.10 – 19.00	dinner

Friday, 25 September

8.00 – 9.00	breakfast

Chairman: George Stegeman

9.00 – 10.00	Falk Lederer – "Cavity polariton solitons"
10.00 – 10.30	Jerzy Jasiński – "Evolution of supergaussian pulses in nonlinear /kerr media"
10.30 – 11.00	coffe breake

Chairman: Falk Lederer

11.00 – 12.00	Roberto Morandotti – "The dawn o nonlinear optics in the terahertz regime"
12.00 – 12.20	Katarzyna Rutkowska – "Control of nonlinear collapse in magnetooptical Kerr media"
12.20 – 12.40	Łukasz Michalik – "Depolarization of elliptically polarized light in complex

	birefringence structures”
12.40 – 13.00	Piotr Makowski – “Influence of the uncertainty of splice angles on the dynamics of all-fiber polarimetric sensors”
13.00 – 14.00	lunch

Chairman:Ewa Weinert-Rączka

14.30 – 15.30	Dumitru Mihalache – “Discrete spatiotemporal Ginzburg-Landau solitons: Collision scenarios”
15.30 – 16.30	Bouchta Sahraoui – “Azo-functionalized push pull systems for optical holography”
16.30 – 17.00	Yan Sheng – “Optical parametric processes in two-dimensional nonlinear photonic crystals”
18.00 – 19.00	dinner

Complexity in Discrete Surface Soliton Generation

S. Suntsov,[1] K. G. Makris,[1] D. N. Christodoulides,[1] G. I. Stegeman,[1*] R. Morandotti,[2] M. Volatier,[3] V. Aimez,[3] R. Arès,[3] E. H. Yang,[4] and G. Salamo[5]

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Discrete spatial solitons traveling along the interface between two dissimilar one-dimensional arrays of waveguides exhibit many interesting features. A Floquet-Bloch analysis predicted two families of interface solitons, each one with peaks on a different sides of the interface. Right at the interface, one soliton evolves from a linear mode at an array separation larger than a critical separation where-as the second soliton always exhibits a power threshold. These solitons exhibited different power thresholds which depended on the characteristics of the two lattices. For excitation of single channels near and at the boundary, the evolution behavior with propagation distance indicates that the solitons peaked near and at the interface experience an attractive potential on one side of the boundary, and a repulsive one on the opposite side. The power dependence of the solitons at variable distance from the boundary was found to be quite different on opposite sides of the interface and showed evidence for soliton switching between neighboring channels with increasing input power.

Z-scan measurement of oriented Au nanoparticle suspensions

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[2]Liquid Crystal Institute Kent State University

Typical negative index materials that have been developed today are obtained by combining two structured materials that show separately a negative dielectric permittivity and a negative magnetic permeability. Nanoparticles of alkali metals and noble metals copper, silver and gold show broad absorption bands in the visible region of the electromagnetic spectrum. The plasmon absorption band and the optical response can be changed by altering the nanoparticle size and shape.

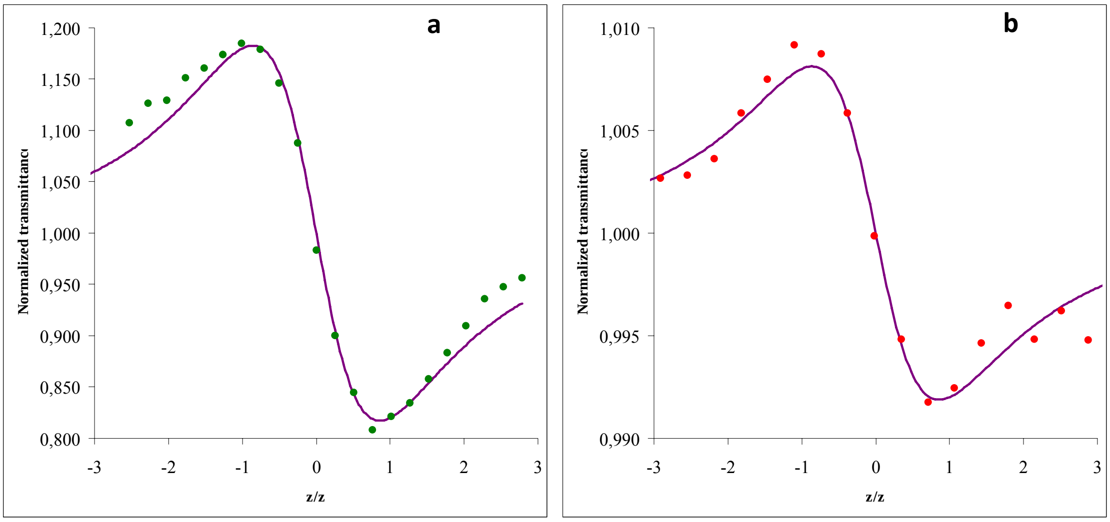

Fig. 1. Nonlinear refractive index measurements made for 543nm (a) and 633 nm (b)

The 1mm thick sample was built with nanoparticle suspension (concentration was 1 nanoparticle/μm^3 and 2.5 aspect ratio of rods) placed between two ITO glass plates. Gold nanoparticles were made at Liquid Crystal Institute and toluene was used as a liquid solvent. Linear absorption measurements give information about the structure of the nanoparticles, (peaks at 500 and 700 nm) and show that applying a field changes the magnitudes of these, indicating alignment. Typical z-scan close aperture results are shown in Figure 1. The solid line represents a theoretical fit. The nonlinear refractive index was observed for ms pulse time scale only. The peak - valley shaped closed-aperture curve exhibit **negative value** for the nonlinear index n_2.

Liquid Crystal Light Valves: a versatile platform for Nematicons

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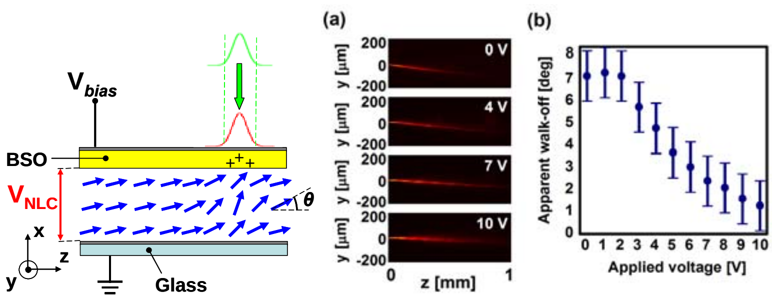
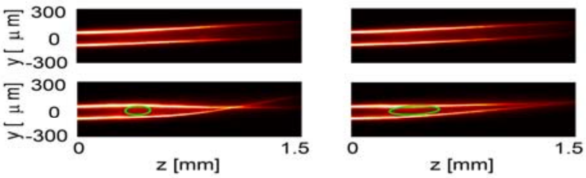
Spatial solitons in optics are one of the innovative routes all-optical for signal processing architectures.[1] The control of their trajectories is relevant in reconfigurable interconnects.[2] In nematic liquid crystals, recent progress on spatial solitons ("Nematicons") and their control include electro-optic and opto-optical deviation and interactions.[2-4]

Here we discuss excitation and tunable propagation of nematicons in photoconductive light valves with nematic Liquid Crystals (LCLV), demonstrating a nonlinear setting where solitons can propagate while interacting with externally defined perturbations. We show that nematicons in LCLV can be effectively launched and deviated according to the applied voltage as well as to external beams illuminating the valve, thereby entailing complete control of the self-configured circuitry.[5-6] The LCLV consisted of a glass slide and a photoconductor slab (BSO), separated by 50μm and both coated with a layer of ITO in order to apply an external voltage. (Fig.1(Left)). All surfaces were coated with rubbing parallel to *y* at the input facet and at π/4 with respect to *z* on the valve plates. Nematicons were excited by a red beam focused to a waist of 4 to 6μm along **z**. When extraordinarily polarized, for powers ≥1.5mW the beam gave rise to a spatial soliton which could propagate for over > 15 Rayleigh lengths and at a walk-off ≈ 7°. Such angle could be reduced by varying the applied voltage, approaching 0° for V<10V, as shown in Fig. 1a-b. Using light at 532nm, we could illuminate the valve with isolated light spots and alter the soliton path point-wise and/or in the whole volume. Examples of nematicon paths deformable by an external beam are shown in Fig. 1(C).



(A) (B)



(C)

Fig. 1 (A) Sketch of an LCLV for nematicon excitation and control. (B) Nematicon steering versus applied voltage. The photos (a) show a 2mW nematicon in yz, the graph (b) is the measured apparent walk-off versus bias. (C) Reconfigurable X and Y junctions defined by the interaction of nematicons and external light-beams (in green).

We will illustrate the main properties of this setting for nematicon generation and processing, demonstrating a number of all-optical operations.

References

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Mathematical Modelling of Nematicon Control

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One of the goals of the study of nonlinear guided waves, or nematicons, in nematic liquid crystals is the possible development of optical devices in which they play a central role. To this end, new methods for the control of nematicons and their trajectories through their mutual interactions and through their interactions with non-uniform media, due to external electric fields for example, must be developed and understood. This seminar will discuss the mathematical modelling of the interaction of nematicons with each other and with non-uniform media as an aid to this understanding. The central role played by conservation laws in determining the trajectories of nematicons will be stressed. Emphasis will be placed on what is and what is not possible with mathematical modelling. Examples considered will include interacting nematicons of different wavelengths (colours), nematicons tunnelling out of a potential well and nematicons interacting with a dye-doped liquid crystal. It will be shown that at a mathematical level interacting nematicons possess a connection with the N body problem of Newtonian gravitation, but with differences arising from a Gaussian, rather than inverse distance "potential" and the diffractive radiation shed as nematicons evolve. Where possible, results and predictions of the mathematical modelling will be compared with experimental results. It is found that simple models can lead to results which agree with experimental results to within 4% to 10%.

Dielectric and plasmonic slot waveguides for sub-wavelength light confinement

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Gaussian beam diffraction in nonlinear media of Kerr type

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The paraxial complex geometrical optics (PCGO) is generalized for the case of Gaussian beam (GB) diffraction and self-focusing in nonlinear media of Kerr type. Ordinary differential equations for the beam amplitude and for complex curvature of the wave front are derived, which describe evolution of axially symmetric GB in Kerr type nonlinear medium. It is shown that PCGO readily provides the solutions of NLS equation obtained earlier from diffraction theory on the basis of the aberration-free approach. Besides reproducing classical results of self-focusing PCGO readily describes an influence of the initial curvature of the wave front on the beam evolution in medium of Kerr type including nonlinear graded index fiber.

Properties of spatial solitons in chiral nematic liquid crystals

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A lot of effort in recent years have been concentrated on the manipulation of light in nematic liquid crystals (NLCs). Due to the reorientational nonlinearity it is possible to generate self-trapped non-diffractive light beams for relatively low power, called nematicons [1,2]. They are light beams that do not spread because of the balance between diffraction and self-focusing , i.e. their size is unchanged during propagation. The properties of nematicons in liquid crystal cells in different geometries and configurations have been investigated comprehensively during last years [1-3]. However, solitons in chiral nematic liquid crystal in geometry where the incident light propagates perpendicular to the helical axis [4], have recently emerged a new area of research. The latter structure consists of molecules arranged in thin anisotropic layers, with the successive layer rotated through a small angle, leading to a spiral configuration.

In this work the propagation and interaction of spatial solitons in chiral nematic liquid crystal cell is considered. Such self-trapped beams were created due to the optical reorientation nonlinearity for a light power of a few tenths of milliwats at the distances of a few millimeters. We discuss the effect of initial beam focusing and relative input angle as well as time dependence on the interaction of nematicons. Additionally, we demonstrate that a weak signal beam can be guided in the channel formed by the nematicon. Furthermore, we extend those measurements by considering the impact of input polarization and external electric field (voltage) on the soliton propagation and soliton readdressing.

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Discreet beam propagation in chiral nematic liquid crystals

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Reorientational nonlinearity in nematic liquid crystals is a source of various phenomena, including the creation of spatial solitons [1,2]. In principle, the light beam propagation and nematicons creation in chiral nematic liquid crystals (ChNLCs) are similar to those in twisted nematics layer (TNs). The configuration with ChNLCs offers some new opportunities in comparison with standard nematic liquid crystal . This is connected with the fact, that the width of the guiding layer is not only determined by the width of the sample but also by the chirality pitch [3]. The orientation of ChNLC is determined by the anchoring conditions at the boundaries where the interaction with the cell walls introduces boundary orientation, as a consequence the refractive index varies across the sample from n_o (ordinary refractive index) to n_e (extraordinary refractive index). It is also possible to utilize multi-layers of ChNLCs for investigation of discrete diffraction in linear case and for propagation of discrete soliton as well as independent or interacting solitons in nonlinear regime. This work presents experimental and numerical results of possibility of discreet propagation in ChNLC.

References:
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Numerical simulation of beam propagation in layer filled with chiral nematic liquid crystal

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Simulation of chiral nematic liquid crystals, which are anisotropic media, requires the use of full vector methods. One of them is FV-BPM (Full Vector Beam Propagation Method). For high light power densities also nonlinearity has to be taken into account. In present work application of FV-BPM to simulate light propagation as well as nonlinearity in cholesterics is shown. Simulations has been carried out for various values of incident beam full width half maximum, amplitude, pitch, elasto-optics coefficient and for different beam launching.

Analysis of beam propagation in optical fiber structures with high step index

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In recent years microstructural fibers play important role in photonics and nonlinear photonics. These fibers consist of solid pure silica core surrounded by an air hole lattice in the cladding. Such construction provides many interesting properties as ultra flattened dispersion, tailored mode area, broadband single-mode guidance, high numerical aperture, adjustable dispersion, high birefringence, large or ultra small effective areas, large nonlinearity, etc. There are a lot of applications of microstructural fibers as a tool in modern techniques and in psychical sciences. For that reason we need more and more precise methods to describe these structures. Standard Beam Propagation Method (BPM) is not proper on the bounds because this method solves scalar wave equation in homogenous medium without boundary conditions. In this work we deal with various approximate methods which make numerical simulations both faster and more effective. There are compared methods: BPM, improved BPM, Coupled Mode Theory (CMT) and Effective Refractive Index Method (Neff) for application in directional couplers consisted of two high-index cores.

Some aspects of the weather change

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During last years' it was taken more attention on new environment and human friendly technologies. Part of them are concentrated on exploration natural energy sources. Other ones are used to protect human life or to make them comfortable. The design phase of all applications must take into consideration planned work conditions and weather conditions.

Data from the faculties MeteoStation presented in this work, can be helpful for researchers and producers of new materials and apparatus e.g. in modern optoelectronics.

Cavity Polariton Solitons

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Polaritons are mixed states of photons and material excitations and are well-known to exist in many condensed matter, atomic and optical systems. We are dealing with a semiconductor microcavity, where polaritons exist due to mixing of quantum well excitons and resonant microcavity photons. In the strong coupling regime photons excite the medium and are re-emitted in a cascaded manner, which gives rise to so-called Rabi oscillations. This is in contrast with the more usual weak-coupling regime (typical for operation of vertical cavity surface emitting lasers (VCSELs), where the slow (nanosecond) carrier dynamics does not catch up with the fast (picosecond) photon decay. Thereby most of the photons leave the cavity as soon as they are emitted. In this regime the response to a pulse, resonating with a cavity mode, results in a single spectral peak. Thus any potential application of microcavity polaritons in optical information processing leads to a 2-3 orders of magnitude response time reduction relative to the VCSEL-like operating regimes.

Weak and strong coupling regime differ mainly in that in the latter case the dispersion curve exhibits two branches signaling mixing of light and matter excitations. Namely, additionally to the upper parabolic branch, which is largely a photonic one, the lower polariton branch appears. In our context the most relevant feature is that this lower branch exhibits an inflection point where the second order dispersion changes sign [Fig.1(a)]. It is worth noting that this effect is merely evoked by the strong photon-exciton coupling, hence it appears even in a homogeneous cavity and does not require any modulation as in the weak coupling regime. Whereas the existence of dark solitons [1] can be anticipated for the repulsive (defocusing) exciton-exciton interaction we demonstrate that the peculiar dispersion curve can be exploited for the formation of stable *bright* cavity polariton solitons [2] without requiring any periodic modulation in the cavity for dispersion control.

The widely accepted dimensionless mean-field model for excitons strongly coupled to the circularly polarized cavity photons is

$$\partial_t E - i(\partial_x^2 + \partial_y^2)E + (\gamma_c - i\Delta)E = E_p + i\Psi,$$
$$\partial_t \Psi + (\gamma_0 - i\Delta + i|\Psi|^2)\Psi = iE. \qquad (1)$$

Here E and Ψ are the averages of the photon and exciton creation or annihilation operators. Normalization is such that $(\Omega_R/g)|E|^2$ and $(\Omega_R/g)|\Psi|^2$ are the photon and exciton numbers per unit area. Here, Ω_R is the Rabi frequency and g is the exciton-exciton interaction constant. $\Delta = (\omega - \omega_r)/\Omega_R$ describes detuning of the pump frequency ω from the identical resonance frequencies of excitons and cavity, ω_r. Time t is measured in units of $1/\Omega_R$. γ_c and γ_0 are the cavity and exciton damping constants normalized to Ω_R. The normalized amplitude of the external pump E_p is related to the physical
incident intensity I_{inc} as $|E_p|^2 = g\gamma_c I_{inc}/\hbar\omega_0\Omega_R^2$.

The key of understanding for soliton formation is the linear dispersion relation of cavity polaritons, which follows from the linear version of Eq.[1].

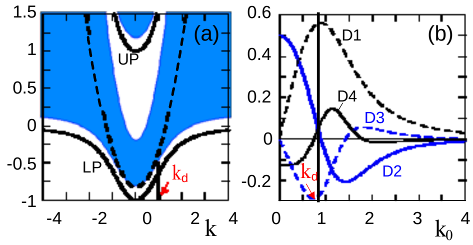

Figure 1: (a) Polariton dispersion: lower (LP) and upper(UP) branch in the strong coupling regime. The lower branch allows for the existence of dark (near the center) and moving bright solitons (beyond the inflection point). (b) Dispersion coefficients vs. inclination of the holding beam k_0

We show the formation of spatially localized polariton-solitons in the strong coupling regime. The microcavity polariton solitons reported here exhibit a picosecond excitation time and can be observed at pump powers a few orders of magnitude lower than those required in the weak coupling regime of semiconductor microcavities. Various stable and unstable dark solitons may be excited near the center of the lower branch of the dispersion relation whereas all bright solitons appear unstable there.

But, stable moving 1D cavity polariton solitons can form provided that the lower polariton dispersion is used beyond the inflection point. We also demonstrate the continuous transformation between cavity soliton polaritons shaped by the different dispersion orders, including the regimes where the influence of the usual second order dispersion is negligible.

Soliton existence and guiding mechanisms established here form the basis for future studies of soliton-polariton logic and processing schemes.

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Evolution of supergaussian pulses in nonlinear Kerr media

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In this work analytical calculations and numerical simulations, describing evolution of super-Gaussian pulses during propagation in saturable Kerr-like media without energy loss are carried out. Kerr nonlinearity is the most common nonlinear phenomenon, while super-Gaussian function is a good approximation that describes profile of pulses formed in different optical systems. Author's goal is to accomplish analytical calculations as far as possible, that is why variational method is used. The assumed trial function describe pulse with five changing parameters: height, width, order of supergaussian function together with phase and chirp. Four of the obtained Euler-Lagrange equations express directly pulse height, width, phase and chirp as function of supergaussian order. The last equation is equivalent to conservation of Hamiltonian of the system and gives first order differential equation expressing order as function of propagation distance. The solution of this equation is given by quadrature. For any constant order of supergaussian function solution is given by direct functions. Two cases of propagation are obtained – oscillations of all parameters for positive canonical energy and pulse spreading when energy is negative. The analogous cases are also observed when pulse change its order during propagation, however obtained quadrature cannot be expressed analytically. Nevertheless calculating it numerically we obtain complete description of supergaussian pulse evolution. We discuss various cases of pulse evolution as function of initial conditions. Numerical simulations are carried out to support and verify analytical calculations. The Nonlinear Schrödinger Equation is solved plane by plane. To obtain solution Runge-Kutta method with FTCS algorithm and transparent boundary conditions are used. On the basis of these simulations the trial function is chosen and the range of validity of analytical model is estimated.

The Dawn of Nonlinear Optics in the Terahertz Regime

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Until very recently the ultrafast nonlinear optical properties of most materials at terahertz (THz) frequencies have remained basically unexplored, primarily as a result of the lack of pulsed high-intensity THz sources as well as of suitable detections schemes. Strong sources suitable for exploring nonlinear THz interactions have recently become the subject of an increasing research effort [1-3]. This rapid advance in the generation of high intensity THz radiation is opening up new applications for the study of nonlinear THz-matter interactions [4-6], which are evidencing the capability of this new spectroscopy to characterize electronic and ionic nonlinearities. In principle, drift-velocity-based nonlinearities of free carriers in semiconductors can as well be explored in this way, since the low terahertz photon energy makes multiphoton interband effects negligible even in narrow-bandgap semiconductors. This has been proven here by studying the nonlinear transmission properties of a heavily-doped direct bandgap semiconductor thin film using terahertz open-aperture Z-scan. The large-aperture ZnTe optical rectification source used in this experiment is described in detail in [1]. In the specific configuration of this experiment, the source delivers picosecond terahertz pulses with frequency components up to about 3 THz, centered around 1 THz, with a pulse energy of 0.8 μJ at a repetition rate of 100Hz. The sample used here is a 500 nm-thick n-type InGaAs epilayer (carrier concentration of approximately 2 x 10^{18} cm^3) grown by metal oxide chemical vapour deposition on a lattice-matched, 0.5 mm thick semi-insulating InP substrate. The nonlinear transmission experiment is performed as follows: the sample is mounted on a translation stage and its position is scanned through the THz beam focus produced by an F/2 gold-coated off-axis parabolic mirror. The transmitted pulse is then detected using either coherent electro-optical sampling or direct pyroelectric energy detection. The setup, configured in this way, represents an open-aperture Z-scan [7], a technique well-developed in the visible and near infrared spectral regions, which has been widely used to perform optical nonlinear transmission experiments. When we measured the energy transmission through the sample, we found it varies as a function of the z position along the scan, with an incident THz pulse energy of 0.8 μJ (peak THz field ~ 200 kV/cm). In particular, we found a clear bleaching of the absorption at the focus of the terahertz beam. The same scan performed on the substrate alone does not return any evidence of the bleaching. This remarkable phenomenon is attributed to terahertz-electric-field-driven scattering of electrons into satellite valleys of the conduction band. In these satellite valleys, electrons acquire a significantly higher effective mass, reducing the conductivity of the sample and thus increasing the terahertz transmission. This behavior can be explained as follows. Free carriers in the Γ valley are accelerated by the terahertz electric field during its oscillations. When the carriers acquire enough kinetic energy to overcome the nearest intervalley separation, they may scatter into an upper valley (i.e. the L-valley) where the effective mass is higher and thus the THz transmission is enhanced. The electrons in this upper valley will then have a finite probability of scattering back to the Γ valley, resulting in a drop in the THz transmission with a time constant given by the L → Γ intervalley relaxation time. It is worth noting that this relaxation time is known to be about 3.1ps in InGaAs [8], which is consistent with the decay dynamics observed in our experiments. Recent simulations based on a standard Drude model, used to describe the collective motion of the electrons in the conduction band, have been found to be in good agreement with our experimental findings.

In conclusion, terahertz ultrafast nonlinear spectroscopy has proven to be an effective method for the characterization of drift-velocity-based nonlinearities in semiconductors. Transmission changes due to intervalley scattering processes have been observed over picosecond time scales. The high-field electronic transport dynamics that can be deduced from these studies is of great interest for better understanding the standard operating conditions of state-of-the-art ultrafast semiconductor devices.

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Control of nonlinear collapse in magnetooptical Kerr media

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Theoretical and experimental demonstration of light collapse control in magnetooptical bulk Kerr media is presented. The tunable interplay between magnetically induced linear and circular birefringence is achieved via a combination of the Cotton-Mouton and the Faraday effects. The nonlinear Schrödinger equation (NLSE) arises in various physical contexts in many branches of science, describing wave propagation in nonlinear media [1,2]. In general, the solutions of the NLSE relate to important phenomena, such as stable localized waves (e.g. solitons) and wave singularities (e.g. shock waves and wave collapse), strongly depending on the problem dimensionality [1,2]. In particular, nonlinear collapse that can be observed in physical systems described by high-dimensional NLSE-like models (including light propagation in bulk self-focusing Kerr media) has attracted a significant amount of attention [1-6]. A considerable effort has been dedicated to the possibility of controlling optical collapse (e.g. to prevent its negative effects, that can lead in turn to material damage). Various physical mechanisms for the management of the collapse have been suggested and described by suitable modifications of the NLSE [7]. One of the possible methods allowing the control of light self-focusing involves optical birefringence, which gives the possibility to control the energy and the phase transfer between the beam polarization components. Our numerical studies, as well as the associated experimental results show that the combined contribution of linear and circular birefringences can affect the dynamic of optical beam collapse in bulk self-focusing media. In our case, a tunable interplay between the linear and circular birefringence is realized through a combination [8] of the Cotton-Mouton [9] and the Faraday [10] effects. We find theoretically that the acceleration, the deceleration, or even the suppression of the collapse can be obtained for specific values of the magnetically induced birefringences [11]. We also show experimentally that the specific birefringence required for the collapse management can be achieved in a transparent magnetooptical (MO) Yttrium Iron Garnet (YIG) crystal via the application of an external magnetic field [11]. This cubic dielectric crystal is highly transparent for optical signals in the near-infrared and exhibits large MO transmission coefficients, owing to its ferromagnetic phase [9-10, 12]. In particular, we observed experimentally a controllable decrease of the threshold power for the collapse as a function of the magnetic field [11]. Our study offers new possibilities for prospective applications and future fundamental research in magnetically assisted nonlinear optics.

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Depolarization of elliptically polarized light in complex birefringence structures

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Depolarization of linearly and circularly polarized light in birefringent media has been investigated experimentally for several years [1-3]. Modified Mueller-Stokes formalism with help of the depolarization matrix has allowed to predict all results of such research. In case of more complex structure of birefringent medium like Lyot depolarizer [4] or temperature compensated optical fiber polarimetric sensor [5] the modified Mueller-Stokes formalism requires additional improvements. In the paper we present results of research on depolarization of elliptical polarized light passing through complex birefringence structures. We also discuss an additional modification of the depolarization matrix in order to have better theoretical tool for designing temperature compensated polarimetric fiber-optic sensor working as strain sensor of composite material.

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Influence of the uncertainty of splice angles on the dynamics of all-fiber polarimetric sensors

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Fiber splices play a substantial role in sophisticated all-fiber polarimetric sensor systems. Joining segments of highly birefringent (HB) fiber with a specific axes orientation enable to set the position of the sensor segment, control the degree of polarization (DOP) of the passing light and perform the temperature or other harmful influences compensation [1]. In these cases the 45^o and 90^o splices are used. For these specific angles methods of calculation DOP of partially coherent light are well known. Such calculations are necessary due to the fact that in HB fiber the polarization degree fading diminishes sensor dynamics [2].

In this paper we present a novel approach in calculation of the polarization degree changes of light passing through any-angle HB fiber splices. Derived method utilizes the modified Mueller-Stokes propagation formalism with the depolarization matrix [3]. The theoretical analysis is performed in the context of simple two segment HB fiber polarimetric sensor with the 90^o splice. The splice gives the temperature or depolarization compensation. The presented model enables to consider any deviation of the splice angle and calculate the influence of this angle on the dynamics of the sensor.

Discrete spatiotemporal Ginzburg-Landau solitons: Collision scenarios

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We overview recent systematic results of collisions between discrete spatiotemporal dissipative Ginzburg-Landau solitons in one-dimensional waveguide arrays and in two-dimensional photonic lattices. Depending on the values of the kick (collision momentum) and of the nonlinear (cubic) gain, the following generic collision scenarios were put forward: (a) soliton merging, (b) creation of an extra soliton (soliton "birth"), (c) soliton bouncing, (d) soliton spreading, and (e) quasi-elastic (symmetric) interactions.

Azo-functionalized push pull systems for optical holography

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Organic azo-functionalized molecules constitute an attractive class of materials that have inspired various fields of investigations due to their Cis Trans photoisomerization that can lead to a wide rang of potential applications such as in optical data storage, biology and so on. In the field of nonlinear optics, electronic conjugation of the molecules is often involved to improve molecular hyperpolarizibilities of nonlinear optical molecules. Therefore, incorporating diazo double bound in push pull structure may lead to additional properties and an enhancement of optical nonlinearities.

The aim of this work is to study the photo-ordering ability and nonlinear optical properties of some selected families of organic azo-dye compounds: azo-azulenes, carbazoles and azo-azo-benzenes. These systems are designed as charge transfer structures. Second and third order nonlinear optical properties where investigated by means of Maker fringes and degenerate four waves mixing in picosecond regime. The experimental results show larger NLO responses respect to the references (quartz, carbon disulfide). Moreover, the photo-induce surface relief grating investigated by the degenerate two waves mixing shows one and two dimensional periodic structure.

Key words:

Push-pull systems, nonlinear optical properties, photo-induced ordering, surface relief grating.

Optical parametric processes in two-dimensional nonlinear photonic structure with short-range ordered domains

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Optical parametric processes are of importance for creating coherent sources at new frequencies where the conventional lasers perform poorly or are unavailable. As is well-known, optical dispersion of crystals gives rise to different phase-velocities between interacting light waves with different frequencies. Then, efficient parametric process requires phase compensation for optical dispersion of crystals. This can be achieved in nonlinear photonic structure (NPS) with a constant linear refractive index but a modulated nonlinear quadratic [or $\chi^{(2)}$] response, where the phase-velocities mismatch is compensated by an appropriate reciprocal vector of $\chi^{(2)}$ structure. Such technology is called quasi-phase-matching (QPM). Though initially the concept of QPM was restricted to one-dimensional periodic NPS, it has been generalized to one-dimensional totally randomized structures, allowing phase matching broadband parametric processes at the price of reduced conversion efficiency [1].

Here we report on the design and fabrication of reversed domains in a short-range ordered manner by placing randomly oriented basic units on a square lattice [Fig. 1 (a)]. The corresponding reciprocal space is characterized not only by its discrete diffraction peaks, but also by the continuous RVs distribution as homocentric rings [Fig. 1 (b)]. Then continuous nonlinear process is available as long as its wave vector mismatch falls within the region of continuous RV. In experiment the broadband tunable SHG was observed covering the visible range [Fig. 1 (c)]. The conversion efficiency was ~12% in the red and yellow wave bands, much higher than the recorded in totally randomized NPC. Moreover, scarcely any drop of the efficiency occurred even though the incident direction or sample temperature varies over a large range (50□ and 18°).

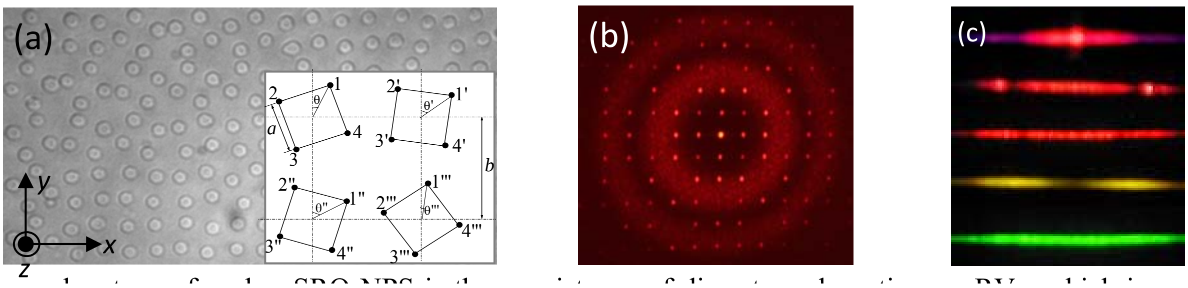

Fig. 1. (a) Micrograph of the poled LiNbO3 crystal with short-range order. The inset illustrates how the short-range order NPS is created. First, the basic unit is a square with side length of *a* with reversed domains denoted with 1, 2, 3 and 4. Second, a 2D lattice of period *b* is built by placing the basic units in each lattice point. Finally, we randomly rotate each basic unit around its own center. (b) Linear diffraction pattern of the short-range ordered NPS, consisting $G_{m,n}$ 2D square array and Gc homocentric rings. (c) SH images selected at some wavelengths.

the first step of SHG is phase matched by discrete RV ($G_{0,1}$) and the second one of sum frequency mixing is attributed to the continuous RVs (G_c). As the ratio of $G_{0,1}$ to G_c can be adjusted freely by proper design of the NPC, cascaded THG can be achieved at any given wavelength in the transparency range of the crystal. In experiment we have made a LiNbO3 sample in which 12% THG at 526.7 nm was achieved.

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