



# **XI International Workshop Nonlinear Optics Applications NOA 2011**

**Toruń, Poland, September 14-17, 2011**

**organised by  
Warsaw University of Technology  
and  
West Pomeranian University of Technology in Szczecin**

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Bouchta Sahraoui, George Stegeman, Andrey Sukhorukov

## **Workshop Secretary:**

Filip A. Sala

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

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. Usually the main interest is focused on nonlinear guided wave optics, optical solitons in different media and their application for optical switching and processing and nonlinear optical materials. However, the workshop is widely open to related photonic phenomena such as magnetooptic effects and optical effects in complex materials.

**Previous workshops:**

Kociszew, December 14-16, 1992  
Międzyzdroje, September 7-10, 1994  
Kazimierz Dolny, September 2-5, 1996  
Międzyzdroje, August 31 - September 2, 1998  
Grybów, June 8 - 11, 2000  
Łukęcin, September 5-8, 2002  
Konstancin, June 17-20, 2004  
Warsaw, August 31 - September 2, 2005  
Świnoujście, Poland, May 17-20, 2007  
Zakopane, Poland, September 23-26, 2009

This year's Workshop takes place in Toruń.



**Toruń** is an ancient city in northern Poland, on the Vistula River. Its population is more than 205,934 as of June 2009. Toruń is one of the oldest cities in Poland. The medieval old town of Toruń is the birthplace of the astronomer Nicolaus Copernicus.

The first settlement in the vicinity is dated by archaeologists to 1100 BC (Lusatian culture). During early medieval times, in the 7th-13th centuries, it was the putative location of an old Polish settlement, at a ford in the Vistula river.

The most interesting monuments are:

- Gothic churches:
  - The Cathedral of SS. John the Evangelist and John the Baptist, an aisled hall church built in the 14th century and extended in the 15th century; outstanding Gothic sculptures and paintings inside (Moses, St. Mary Magdalene, gravestone of Johann von Soest), Renaissance and Baroque epitaphs and altars (amongst them the epitaph of Copernicus from 1580)
  - St. Mary's church, a formerly Franciscan aisled hall built in the 14th century
  - St. James's church (often mistakenly called St Jacob's), a basilica from the 14th century, with monumental wall paintings and Gothic stalls
- The Old Town Hall, begun in 1274, extended and rebuilt between 1391 and 1399, and extended at the end of the 16th century; one of the most monumental town halls in Central Europe
- City fortifications, begun in the 13th century, extended between the 14th and 15th centuries, mostly demolished in the 19th century, but partially preserved with a few city gates and watchtowers (among them the so-called Leaning Tower) from the Vistula side.
- A 15th-century Gothic house (now a museum) where Copernicus was reputedly born
- Ruins of 13th-century Teutonic Knights' castle
- House at the sign of the Star (Polish: *Kamienica Pod Gwiazdą*), previously Gothic, briefly owned by Filip Callimachus, then rebuilt in the 16th century and in 1697, with a richly-decorated stucco façade and wooden spiral stairs
- Toruń has the largest number of preserved Gothic houses in Poland, many with Gothic wall paintings or wood-beam ceilings from the 16th to the 18th centuries

Source: <http://en.wikipedia.org/wiki/Toru%C5%84>

<b>WEDNESDAY 14.09.2011</b>			
18:00 - 22:00	<b>REGISTRATION</b>		
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10:20 - 11:05	Ulf Peschel	Temporal Discreteness in Fiber Transmission Lines	6
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## **Recent results on Nematicons**

Gaetano Assanto

University of Rome “Roma Tre”

# **Temporal Discreteness in Fiber Transmission Lines**

Christoph Bersch, Georgy Onishchukov and Ulf Peschel

University of Erlangen-Nuremberg

We transfer the concept of discreteness to the temporal domain using standard telecommunication equipment as fiber loops and electro-optic modulators. We apply a periodic phase modulation thus inducing an effective potential in time for optical pulses propagating in a re-circulating loop set-up. We experimentally demonstrate a modified dispersive spreading of pulses and investigate the formation and dynamics of discrete solitons in the time domain. We show that our set-up has many features in common with the quantum kicked rotor and that a chaotic dynamics occurs for strong phase modulation.

# **Supercontinuum Generation, Enhancement by Feedback, and the Akhmediev Breather**

Fedor Mitschke, Christoph Mahnke

University of Rostock

The generation of supercontinuum in optical fibers will be discussed, with an emphasis on two aspects: the enhancement of the spectral broadening mechanism by feedback, and the generation of optical solitons from a broad pump pulse through a decay of an Akhmediev breather.

# Optical Frequency Conversion: Novel Integrated Devices and Applications

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Until today, the world of electronics has always been an inexhaustible source of resources to satisfy the continuous request for larger bandwidths in communication systems. Unfortunately the bit rate limit of electronic devices (around 50 Gb/s) will soon be reached, and scientists and engineers are now struggling for alternative solutions. Among them, all-optical signal processing appears to be one of the most viable approaches since it brings the promise to drastically increase the performances of transmission networks and, at the same time, to keep the associated costs low. However, in order to fulfill the goal of realizing all-optical agile communications systems and improve overall all-optical devices performances, it is mandatory to efficiently perform fundamental network operations such as optical switching, data storage, ultrafast modulation, etc. In particular, wavelength conversion is required to realize wavelength division multiplexing systems capable of substantially increasing the bit rate by channeling the information on different frequency carriers. Recently ultra-low CW pump power (5mW) wavelength conversion based on Four Wave Mixing (FWM) has been reported in silicon micro-ring resonators. Nevertheless, it is of paramount importance to study other material systems, since silicon is well known to suffer from two-photon absorption (TPA) that in turn induces free carrier losses and may affect the performance of silicon based devices. In this work we first demonstrated, by means of C-MOS compatible high index glass based micro ring resonators, efficient wavelength conversion by FWM using ultra-low continuous-wave pump power (<5 mW, @1553.38nm).

Our results are comparable to the highest values reported to date in silicon ring resonators, and in addition they combine the advantages of ultra-low optical loss (0.06 dB/cm) with the absence of two-photon absorption (near  $\lambda=1.5\mu\text{m}$ ). We believe that these achievements may bring us a step forward in the quest to create very efficient all optical communication networks.

Furthermore, the possibility of creating novel frequency at very affordable power levels could open up an host of different applications beyond their use in telecommunication networks. For example, integrated multiple wavelength laser sources may be considered of great importance for applications as high-precision broadband sensing and spectroscopy, molecular fingerprinting, optical clocks, and attosecond physics. Even if they have recently been demonstrated in silica and single crystal micro-toroid resonators using parametric gain, for applications in telecommunications and optical interconnects, analogous devices in a fully integrated, CMOS compatible platform still do not exist. While approaches such as silicon micro-ring resonators have been shown not to be ideal, other materials, such as Silicon nitride, have recently been proven to be a promising alternative platform for nonlinear optical on chip applications since they exhibits negligible saturation effects due to multi-photon absorption, and this enabled the demonstration of efficient multi-wavelength optical parametric oscillation in integrated ring resonators.

By using rings with a Q factor higher than 1000000, we succeeded in realizing a fully integrated, CMOS compatible, multiple wavelength source. We achieve CW optical “hyper-parametric” oscillation with a differential slope efficiency above threshold of 7.4% for a single oscillating mode out of a single port, a CW threshold power as low as 54mW, and a controllable range of frequency spacing from 200GHz to more than 6THz. The low loss, design flexibility, and CMOS compatibility of this device will enable multiple wavelength sources for telecommunications, computing, sensing, metrology and other areas.



# **BRW assisted directional coupler for widely tunable photonic components**

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Bragg Reflection Waveguide (BRW), also referred to as a defect waveguide in 1D photonic crystal (PhC), is known to have a number of attractive properties such as strong mode discrimination to maintain single-mode operation, support of interface (surface) modes, or large flexibility in dispersion tailoring. BRW can be also made tunable when its core is made of externally controllable material. However, the tunability rate is low. Much higher rates are provided by a directional coupler with BRW as one of the arms. We will discuss feasibility of using such BRW assisted couplers for widely tunable filters and lasers.

# Highly conjugated organometallic complexes as suitable candidates for molecular nonlinear optics applications

Bouchta Sahraoui

University of Angers MOLTECH ANJOU, CNRS UMR 6200, 2 Bd Lavoisier, 49045 Angers cedex

The non-linear optical properties of  $\pi$ -conjugated of organometallic complexes and their derivatives have recently gained particular interest due to their extended  $\pi$ -system and the strong electron donating character[1]. The knowledge of the nonlinear optical response, as well as the impact of the charge transfer on the nonlinearity is very important. Such systems can be used in a variety of applications particularly for molecular nonlinear optics applications. In this contribution nonlinear optical response of self-assembled molecular corners will be also presented as such class of molecular systems could be controlled with external stimuli, particularly using ultrafast light is of great importance for nanophotonics applications like optical computing, optical switching, because they could be used as building blocks for more complicated molecular systems. Sub molecular components, like rotaxanes, catenanes could be suitable and promising candidates for nonlinear optical applications [2]. In this talk nonlinear optical response of orthogonal tetrathiafulvalene-based bricks, which can be self-organized into orthogonal dimers, through metal assisted assembly with Pd(II) or Pt(II) salts will be also discussed. A Comparative study of the nonlinear optical response will be given

[1] Sahraoui, J. Luc, A. Meghea, R. Czaplicki, J.-L. Fillaut and A. Migalska-Zalas  
*Nonlinear optics and surface relief gratings in alkynyl-ruthenium complexes*  
Journal of Optics A: Pure and Applied Optics (Special Issue on Optics of Nanocomposite Materials), 11, 024005 (26pp), (2009)

[2] K. Iliopoulos, R. Czaplicki, H. El Ouazzani, J. Y. Balandier, M. Chas, S. Goeb, M. Salle, D. Gindre, B. Sahraoui,, *Physical origin of the third order nonlinear optical response of orthogonal pyrrolo-tetrathiafulvalene derivatives*, APL **97** 101104 2010

# Dipole limit in second-harmonic generation from L-shaped gold nanoparticles

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The optical response of metal nanoparticles is mostly due to their plasmon resonances. These resonances are sensitive to the exact size and shape of the structures, the dielectric environment, as well as their mutual ordering when arranged into a regular array. Besides the usual electric-dipole contributions to the optical responses, higher multipoles (magnetic dipoles and electric quadrupoles) can also contribute in such structures [1]. Small defects can also support localized plasmonic modes and thereby modify the optical response [2]. We have observed higher multipoles in second-harmonic generation (SHG) from gold nanoparticles, arising from the imperfection of the particles [3,4]. In this work, we provide additional support to this interpretation and show that higher multipole effects are suppressed by improved particle quality. The SHG measurements, performed at near-normal incidence ( $\sim 1^\circ$ ) with a Nd:Glass laser (200 fs, 1060 nm, 80 mW, 82 MHz), were done for square arrays of gold L-shaped nanoparticles (Fig. 1; 500 nm array period, L's linewidth 100 nm, length 250 nm and thickness 20 nm). Transmitted and reflected

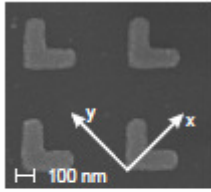


Fig. 1. SEM image of the investigated nanoparticles with coordinate system used.

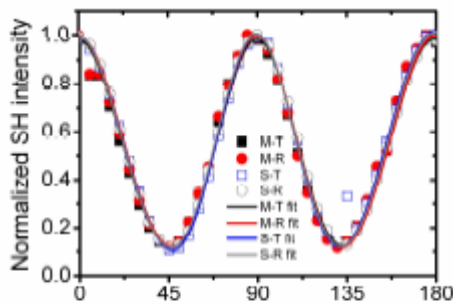


Fig. 2. Normalized transmitted (-T) and reflected (-R) SHG signals from an array of L-shaped gold nanoparticles, M- metal incidence, S- substrate incidence, symbols represent data from measurements, lines show theoretical fits.

SHG signals were detected for sample and substrate side incidence of the fundamental beam when the polarization of the fundamental beam was modulated with a quarter-wave plate. The same polarization dependence (Fig. 2) for all detected signals indicates electric-dipole origin of the signals, whereas differences would show up if various multipoles would interfere [4]. The results point out that the SHG responses are strongly dominated by the dipole interaction. We have thus reached the desired dipole limit, which is a prerequisite for designing nonlinear metamaterials with engineered properties.

[1] G. Bachelier, I. Russier-Antoine, E. Benichou, Ch. Jonin, and P.-F. Brevet, *J. Opt. Soc. Am. B*, **25** (2008) 955–960.

[2] M.I. Stockman, D.J. Bergman, C. Anceau, S. Brasselet, and J. Zyss, *Phys. Rev. Lett.*, **92** (2004) 057402.

[3] S. Kujala, B.K. Canfield, M. Kauranen, Y. Svirko, and T. Turunen, *Phys. Rev. Lett.*, **98** (2007) 167403.

[4] S. Kujala, B.K. Canfield, M. Kauranen, Y. Svirko, and J. Turunen, *Opt. Express*, **16** (2008) 17196–17208.

# Influence of the magnetooptic effects on a light self-focusing in Kerr media

Katarzyna A. Rutkowska,<sup>1</sup> Jerzy Jasiński,<sup>1</sup> Boris Malomed,<sup>2</sup> Roberto Morandotti<sup>3</sup>

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Catastrophic self-focusing of the light beams (i.e. optical collapse) is one of the characteristic processes taking place in nonlinear bulk media. It may be observed in positive (self-focusing) Kerr medium in a case when optical power exceeds the critical value. It leads in turn to the material damage or/and significant changes in spatial beam profile (e.g. its filamentation). One of the challenges facing nonlinear optics is to gain a full control over nonlinear collapse, including possibility of its complete elimination (e.g. by reaching a stable light propagation in the solitary wave form).

To date, various mechanisms for the collapse management in bulk Kerr (-like) media have been suggested. They are theoretically described by suitable modifications of the nonlinear Schrödinger equation (NLSE), including these obtained by introduction of additional processes and phenomena in physical model [1].

In this work we show that optical birefringence may also act as a powerful tool allowing for the control of the light self-focusing. In particular, we propose to take advantage of a tunable interplay between the linear and circular birefringence, which may be achieved in practice via a specific combination of the Cotton-Mouton and the Faraday effects in magnetooptic medium. Our theoretical studies (based on numerical solving of the NLSE, as well as on the variational approximation) show that involvement of the optical birefringence, which gives us possibility to control the energy and phase transfer between beam polarization components, may significantly affect a dynamic of the optical beam collapse in bulk self-focusing medium. It leads to statement that suitably applied magnetic field (depending on its intensity and direction) may introduce changes in the high-power light beam propagation, including possibility of its (quasi-) stabilization [2-3].

[1] B.A. Malomed, et al., *J. Opt. B: Quant. Semicl. Opt.* **7**(5), R53–R72 (2005).

[2] K.A. Rutkowska, B.A. Malomed, R. Morandotti, *Opt. Exp.* **18**(9), 8879 (2010).

[3] Y. Linzon, K.A. Rutkowska, B.A. Malomed, R. Morandotti, *Phys. Rev. Lett.* **103**(5), 053902 (2009).

# **Modeling of light propagation in chiral and non-chiral nematic liquid crystal structures**

Filip A. Sala, Mirosław A. Karpierz

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In this work we present theoretical model describing light propagation in chiral and non-chiral nematic liquid crystal structures. To simulate light propagation we use Full-Vector Beam Propagation Method (FV-BPM) based on Maxwell equations without assumption on slowly varying envelope. Modeling of molecules alignment is based on the Frank-Oseen theory using two angles to describe molecule orientation. Our model describes as well chiral as non-chiral nematic liquid crystals. A short discussion on optimizing this model is also provided. In this talk numerical solutions of molecules reorientation are presented. We also show light propagation in chiral and non-chiral nematic cells presenting random phenomena e.g. discrete diffraction and walk-off.

## Nematicon-nematicon interactions in a cell with adjustable nonlinearity

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Spatial solitons in nematic liquid crystals (nematicons) are shape-preserving wave packets where, due to the reorientational nonlinearity, diffraction is compensated by the self-focusing effect[1,2] The attractive interaction and collisions between nematicons[3] strongly depends on the nonlocal perturbation in director distribution caused by the gaussian-shaped beam, by means of mechanisms such as heating, diffusion, thermophoresis and molecular reorientation in nematic liquid crystals[4,5] (NLCs). This work contains numerical and experimental studies of nematicon-nematicon interactions in a NLCs sample with adjustable nonlinearity and a fixed value of nonlocality. Controlling parameters as power, separation distance and molecules reorientation by the comb-shaped electrodes system enables distinguishing between impact of nonlinearity and nonlocality on solitary-waves interactions. Both, numerical and experimental results are in very good agreement with a model accounting for the anisotropic nature of the NLCs.

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- [2] G. Assanto, M. Peccianti, and C. Conti, Opt. Photonics News 14, 44 (2003).
- [3] G. Stegeman and M. Segev, *Science* 286, 1518 (1999).
- [4] C. Conti, M. Peccianti, and G. Assanto, *Phys. Rev. Lett.* 92, 113902 (2004).
- [5] G. Assanto and M. Karpierz, *Liq. Cryst.* 36, 1161 (2009).

# **All optical measurement of Frank elastic constants based on nonlinear self-diffraction**

Bartłomiej W. Klus, Mirosław A. Karpierz

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Liquid crystals have a lot of interesting optical properties. The most important of them are an optical birefringence and sensitivity for external electric and magnetic field which can reorient anisotropic molecules. These structures have many applications in telecommunication and liquid crystal display. They are also unique medium to be used in nonlinear optics.

Most important parameters of liquid crystals are optical birefringence, electrical anisotropic and Frank elastic constants. Frank elastic constants ( $K_{11}$ ,  $K_{22}$ ,  $K_{33}$ ) determine forces (external fields) necessary to reorient molecules in liquid crystals.

To this time absolute majority of methods to analyze Frank elastic constants use external electric or magnetic fields. The method based on nonlinear self-diffraction is as easier as traditional method with external electric and magnetic field to analyze  $K_{22}$  which is difficult to observe in liquid crystal cells with external field. In this work we present results of measurements of Frank elastic constants in a few different nematic liquid crystals.

# **Frequency Dispersion of the Kerr Effect in Molecular Media**

George Stegeman

Chair Professor, College of Engineering King Fahd University of Petroleum and Minerals, Dammam  
Saudi Arabia

Professor Emeritus, College of Optics and Photonics, University of Central Florida

Frequently in the literature the Kerr effect is assumed to be (1) independent of frequency and (2) to have the same sign, at all frequencies. In this talk the frequency dispersion of the Kerr effect for both symmetric and asymmetric molecules will be examined using the quantum mechanical sum over states model. The general formula is complicated and requires knowledge of the molecular states and the transition dipole moments between them. A simple model based on two states, a ground state and one excited state is used to obtain trends in asymmetric molecules with permanent dipole moments, and a three state model as used for symmetric molecules. Both approaches have proven effective to date in a number of materials.



# Plasmon – Controlled Optical Properties of Nanostructures

Sebastian Maćkowski

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Plasmon excitations in metallic nanoparticles are effective means for controlling the optical properties of nanostructures [1-4]. Recent work has demonstrated that the emission and absorption of light-harvesting complex, peridinin-chlorophyll-protein can be enhanced by coupling to inhomogeneous distribution of silver islands [1-3], while fluorescence and absorption of the Photosystems can increase by attaching gold nanoparticles [5-6]

During the presentation I will describe how plasmon excitations in tailored metallic nanoparticles can be used for controlling the optical properties of light-harvesting systems both in the visible and the infrared spectral regions. The concept can be easily extended towards other fluorescent molecules and nanoparticles containing rare earth ions.

In the case of the latter system, preliminary optical imaging results will be shown, where we can observe up-conversion fluorescence of individual nanosized fluorophores containing rare earth ions. Such systems, due to significant energy separation between absorption and emission could provide a way to deconvolute plasmon effect on these two processes.

Financial support from the WELCOME program '*Hybrid nanostructures as a stepping-stone towards efficient artificial photosynthesis*' awarded by the Foundation for Polish Science is gratefully acknowledged.

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- [4] P. Anger, P. Bharadwaj, L. Novotny (2006) *Phys. Rev. Lett.* 96, 11302.
- [5] I. Carmeli, I. Lieberman, L. Kravetsky, Z. Fan, A.O. Govorov, G. Markovich, S. Richter, (2010) *Nano Lett.* 10, 2069.
- [6] J.B. Nieder, R. Bittl, M. Brecht (2010) *Angew. Chem. Int. Ed.*, 49, 1.

# **Circularly polarized few-cycle optical solitons: Recent theoretical studies**

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We give a brief overview of recent studies of theoretical models put forward for the adequate description of temporal dynamics of circularly polarized (vectorial) few-cycle optical solitons in both long-wave- and short-wave approximation regimes beyond the framework of slowly varying envelope approximation. Assuming that the frequency of the transition is far above the characteristic wave frequency (i.e., the so-called long-wave-approximation regime), by using the multiscale analysis we showed that propagation of few-cycle pulses, taking into account the wave polarization, is described by the nonintegrable complex modified Korteweg–de Vries equation. In the short-wave-approximation regime, by using the reductive perturbation method, we derived from the Maxwell-Bloch-Heisenberg equations the governing evolution equations for the two polarization components of the electric field in the first order of the perturbation approach and we showed that propagation of circularly-polarized few-optical-cycle solitons is described by a system of coupled nonlinear equations. This nonlinear system reduces, in the scalar case, to the standard sine-Gordon nonlinear equation describing the dynamics of linearly polarized few-cycle pulses in the short-wave-approximation regime. The robustness of circularly-polarized few-cycle solitons and their generic instability scenarios were also studied in detail in both long-wave- and short-wave-approximation regimes.

# **Light bullets in media with effective saturable nonlinearity of cubic-quintic type**

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Propagation of spatio-temporal solitons - light bullets – is described by the nonlinear Schrödinger equation with three transverse and one longitudinal coordinate. In the paper evolution of such bullets along the infinite axially-symmetric graded-index medium with effective saturable nonlinearity is considered. We assume the effective nonlinearity to be a mean nonlinearity over the neighbourhood of the field peak. As a result, the field of the bullet can be written as a product of two components - the transverse one satisfying the optical Schrödinger equation in the linear graded-index medium and the longitudinal component satisfying the nonlinear equation in medium with a certain effective nonlinearity. To describe saturation the nonlinearity of cubic-quintic type is assumed.

Analytically, the evolution of light bullets is described by variational method. Taking the trial function containing six bullet parameters – field height, spatial and temporal width, phase propagation factor and spatial and temporal curvature we can obtain the set of six Euler-Lagrange equations. The resulting set can be reduced to two coupled second order differential equations describing evolution of bullet's spatial and temporal width. The above equations were solved exactly for the stationary case giving all bullet's parameters as function of its power. We analyze the obtained solution both for the Kerr and cubic-quintic nonlinearity. We show how these solutions depends on effectiveness coefficient.

The nonstationary Euler-Lagrange have no exact, analytic solutions. Nevertheless, assuming small oscillations around the stationary values we can obtain certain approximate solutions. There are two types of such solutions – the oscillating and exponentially decaying ones. But the resulting oscillations are quite complex – they are superpositions of two normal vibrations – everyone with its own frequency. We obtain the explicit expressions for the normal frequencies as a function of bullet's power. The relation between the amplitude of both components depends on initial conditions.

The solutions obtained by means of variational method are compared with numeric solutions obtained by FD-BPM method. The results are quite similar – we obtain a few types of oscillations being superpositions of vibrations with two different frequencies. We found the numeric period of oscillation – it differs from that one obtained by variational method only by 1%. The effectiveness coefficient gives more flexibility to adjust parameters of numeric and analytic solutions. The best fitting obtains taking the effectiveness coefficient about 0.8-0.9 .

# Lyot depolarizer in terms of the theory of coherence – description for broadband light

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An original coherence-based [1,2] description of the bulk version of the Lyot depolarizer [3] dedicated to broadband light emitted from a point source is proposed in opposition to the quasi-monochromatic approach given in early works by Burns [4] and Mochizuki [5], usually cited by researchers in the topic as well as manufacturers of commercial depolarizers. The derived depolarization formula is discussed analytically and a geometrical interpretation of its structure is provided. The results of the numerical analysis show that the proposed description, when applied to any configuration of a two-segment Lyot-like depolarizer, is fully equivalent with the Mueller-Stokes calculus for broadband light. Additionally, following this consistency the range of accuracy of the approximate coherence-based solutions [4,5] has been verified. It has been found that the commonly used quasi-monochromatic models provide very accurate predictions even in case of light with spectrum of an arbitrary width, provided that the spectral density distribution is a regular peak. It has been also pointed out, however, that in some situations the approximate models can lead to non-physical predictions even for narrow and regular spectra.

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# Complex Geometrical Optics of Nonlinear Inhomogeneous Fibres of Kerr type

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We present the Gaussian beam (GB) evolution in nonlinear fibres of Kerr type with special attention to the influence of initial curvature of the wave front and to fibres' refractive profile. The analysis is performed in the framework of complex geometrical optics (CGO). This method reduces the problem of Gaussian beam (GB) evolution in nonlinear and inhomogeneous media to the solution of ordinary differential equations, which can be easily solved either analytically or numerically. It is shown that CGO approach radically simplifies modeling of nonlinear phenomena in fibres as compared with standard method of nonlinear optics such as the variational method approach. It is shown that CGO readily provides the solution of Nonlinear Schrödinger Equation (NLS) for nonlinear medium of Kerr type obtained using self-focusing theory on the basis of the aberration-free approach. It is shown that CGO method also supplies the solution of NLS for self-focusing fibre with focusing permittivity profile and provides number of new results. The discussion on the interplay between the nonlinear (self-focusing/self-defocusing) and linear (focusing/defocusing) components of the total permittivity demonstrates the new possibilities to limit the collapse phenomenon in nonlinear fibres of Kerr type taking into account the effect of initial beam divergence.

## Nonlinear properties of polymer-dispersed liquid crystals

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Polymer-dispersed liquid crystals (PDLC) are heterogeneous structures in which small liquid crystal droplets (from tens of nanometers up to dozen micrometers) are embedded in a solid polymer matrix [1]. Their properties are interesting because of interaction on the surface between the liquid crystal and polymer cavity. LC droplets in polymer matrix are oriented arbitrary. They can be ordered by the application of external electric field. It allows obtain almost transparent state. This PDLC is also doped with nanocrystallites of nonlinear material – LCBO. Reorientation of the LC molecules by the electric field can also have influence on the nonlinear properties of such material. It can cause aligning the nonspherical crystallites along one direction. Hence nonlinear properties of PDLC with LCBO depend not only on concentration of nonlinear molecules but also on driving electric field. In this work we present the results of measurements of second- and third-order nonlinear susceptibility in such structures.

# The Beam Propagation Method with exact boundary conditions

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The development of optical devices and structures like microstructural fibers, slot waveguides, buried waveguide, photonic nanowires and diffractive elements based on a high step of refractive index require accurate analysis of field distributions. This knowledge is significantly important when the polarization is considered.

There are lots of methods used to analyze inhomogeneous media using approximations like the graded index [1], the staircase index [2] or the average index [3]. In the structure with a high step index the solutions received from these methods are not accurate enough. More accurate methods were presented by C. Vassallo [4] and Hung-Chun Chang [5, 6] but implementation is complicated. In this work it is shown a simple and effective method to analyse rectangular media with a high step index. It is presented a comparison of classical Beam Propagation Method with Beam Propagation Method with Exact Boundary Conditions for the planar waveguides. It is also shown an influence of a high step of refractive index for the distribution field in a structure with a rectangular shape. The analysis of this structure can be treated like diffraction in a thick aperture. The obtained distributions from two methods have an influence on the observed beam shape and dimensions in a far field diffraction.

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