XIII International Workshop

Nonlinear Optics Applications

NOA 2015

Olsztyn, Poland, September 9-12, 2015

Zachodniopomorski
Uniwersytet
Technologiczny
w Szczecinie

XIII International Workshop

Nonlinear Optics Applications

NOA 2015

Olsztyn, Poland, September 9-12, 2015

organised by

Warsaw University of Technology

and

West Pomeranian University of Technology in Szczecin

Conference chairs:

Ewa Weinert-Rączka and Mirosław A. Karpierz

Scientific Committee:

Gaetano Assanto, Cornelia Denz, Bożena Jaskorzyńska, Wiesław Królikowski, Falk Lederer, Dumitru Mihalache, Fedor Mitschke, Roberto Morandotti, Ulf Peschel, Bouchta Sahraoui, George Stegeman†, Andrey Sukhorukov, Marek Trippenbach

Organizing Committee:

Ewa Weinert-Rączka, Mirosław A. Karpierz, Filip A. Sala

Olsztyn is a city on the Łyna River in northeastern Poland. Olsztyn is the capital of the Warmian-Masurian Voivodeship, and is a city with powiat rights. (Town rights: 1353)

Architecture:

- St. James's Cathedral
- Old Town Hall on the Market Square
- The Old Town
- The Gothic castle of the Bishopric of Warmia built during the 14th century.
- St. James's Cathedral (Polish: św. Jakuba, German: St. Jacob or St. Jakob).
- Old Town Hall on the Market Square – built in mid-14th century.
- The town walls and the Upper Gate (since the mid-19th century known as the High Gate).
- Neogothic church of the Holy Heart of Jesus, built during the years 1901–1902
- The Railway Bridge over the River Łyna gorge near Artyleryjska and Wyzwolenia streets, built during the years 1872–1873
- The Jerusalem Chapel, built in 1565
- Church of St. Lawrence, built during the late 14th century
- FM- and TV-mast Olsztyn-Pieczewo – 360 metres high, since the collapse of the Warsaw radio mast the tallest structure in Poland

Source: Wikipedia contributors. "Olsztyn." *Wikipedia, The Free Encyclopedia*. Wikipedia, The Free Encyclopedia, 5 Sep. 2015. Web. 7 Sep. 2015.

Parametric Cavity Polariton Solitons

Falk Lederer and Oleg Egorov

Institute of Condensed Matter Theory and Solid State Optics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

Abstract: We review the formation of 1D and 2D bright cavity polariton solitons in semiconductor microcavities. These solitons exist due to phase-matched parametric four-wave mixing in cases where the product of dispersion and nonlinearity has the 'wrong' sign.

OCIS codes: 190.5970, 190.6135

Currently, there is much interest in the nonlinear dynamics of half-light/half-matter quasi-particles (polaritons) being formed as a result of strong coherent light-matter interactions. One prominent example are *exciton cavity polaritons* in semiconductor microcavities. Their hybrid nature permits both easy excitation by photons and tight localization (optical sub-wavelength domain) due to the very small effective wavelength stemming from the exciton. Moreover, the intrinsic Coulomb interaction of excitons provides a very strong and fast repulsive (in the optical language - defocusing) nonlinearity which is by far faster and stronger than photonic nonlinearities in microcavities in the incoherent weak coupling regime. This might open the avenue for new applications in low-power all-optical schemes.

We have shown that parametric mixing is the nonlinear mechanism for the formation of *2D bright cavity polariton solitons* (CPS) although the nonlinearity is repulsive and dispersion can only be appropriately controlled in one direction [1]. This resembles much the scenario of quadratic soliton formation where for either sign of dispersion/diffraction bright solitons may emerge due the controllable phase modulation by three-wave mixing.

The aim of this contribution is to discuss in detail the formation process of two different *stable 2D bright CPSs* due to parametric mixing. The first kind of solitons is based on a hybrid mechanism where in one direction localization is due to self-phase modulation whereas localization in the perpendicular direction, where dispersion exhibits the 'wrong' sign, is due to parametric mixing. The second CPS type forms due to parametric mixing of polaritons from the upper (UP) and lower polariton (LP) dispersion branch.

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

$$\begin{aligned}\partial_t E - i\left(\partial_x^2 E + \partial_y^2 E\right) + (\gamma_{\rm ph} - i\Delta - i\delta)E &= E_{\rm p}\exp\left(ik_{\rm xp}x\right) + i\Psi,\\ \partial_t \Psi - id\left(\partial_x^2 \Psi + \partial_y^2 \Psi\right) + (\gamma_{\rm ex} - i\Delta) + i|\Psi|^2)\Psi &= iE.\end{aligned} \tag{1}$$

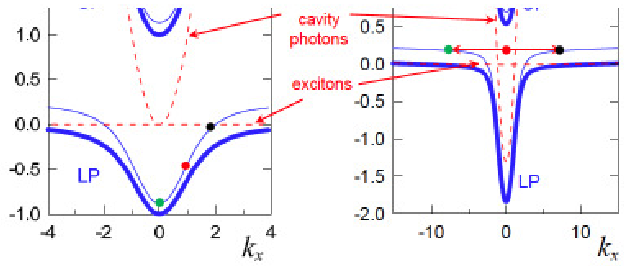


Fig. 1. Dispersion relation of cavity polaritons. Left: symmetric case: $\Omega_{\rm rex} = \Omega_{\rm rcav}$, i.e. $\delta = 0$; $d = 0$ (no exciton dispersion). Right: asymmetric case: $\delta = 1.3$; $d = 10^{-4}$. Dots designate the location of pump (red), idler (black), and signal (red). Thin blue line - nonlinear phase shift.

Here E and Ψ are the normalized averages of the photon and exciton creation or annihilation operators. $\Delta = (\Omega - \Omega_{\rm rex})/\Omega_{\rm R}$ and $\Delta + \delta = (\Omega - \Omega_{\rm rcav})/\Omega_{\rm R}$ describe the detuning of the pump frequency Ω from the exciton ($\Omega_{\rm rex}$) and cavity resonance frequency ($\Omega_{\rm rcav}$), respectively, and $\Omega_{\rm R}$ is the Rabi frequency. The exciton dispersion d which is much less (about 10^{-4}) than the photon dispersion has to be taken into account in the second case. $\gamma_{\rm ph}$ and $\gamma_{\rm ex}$ are the cavity and exciton damping constants normalized to Ω_R. E_p and k_{xp} are the normalized amplitude and wave vector of the external pump, respectively (for normalization details see [1,2]). From (1) the dispersion relation of linear cavity polaritons can be derived dropping both pump and nonlinearity. It is rotational symmetric but only shown for $k_y = 0$ in Fig. 1. It is evident that the LP branch has a non-parabolic shape. This has consequences for the required parametric mixing as well as for soliton formation.

First, we focus on the symmetric case ($\delta = 0$) and assume $\partial_x \equiv 0$ (localization in y). We recognize that the dispersion coefficient $\partial^2_{k_x}\Delta$ changes sign at the 'magic point' at the LB, thus beyond this point the dispersion can balance the repulsive nonlinearity and moving 1D bright solitons localized in x-direction may exist [1]. In addition, phase-matched parametric mixing of two pump polaritons at k_{xm} is feasible where both energy and momentum conservation $2\Omega(k_{xp}) = \Omega(k_{xs}) + \Omega(k_{xi})$, $2k_{xp} = k_{xs} + k_{xi}$ hold.

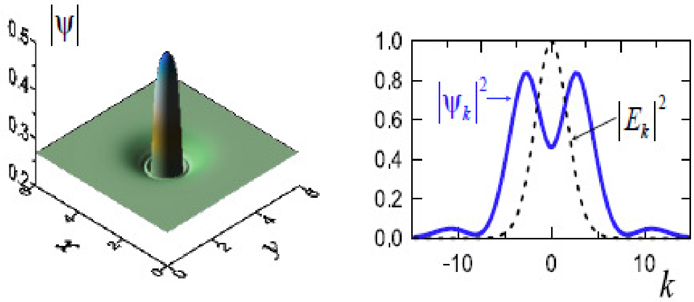


Fig. 2. Left: resting stable 2D bright parametric CPS ($\Omega_{rex} \neq \Omega_{rcav}$ and $\delta = 1.3$. right: excitonic and photonic soliton spectrum.

This parametric mixing leads to CPSs localized in the direction perpendicular (y) to the pump inclination [2]. It contains constituents at the required three frequency components. In a 2D setting combination of both effects leads to 2D moving bright CPS beyond the 'magic point' [1].

Eventually, we are looking for stable *resting* 2D bright CPS with $k_{xp} = k_{yp} \doteq k_p = 0$ and $\partial_y \equiv 0$. It has been shown that they are unstable if only the LP-branch is involved [1]. Now we consider the asymmetric case $\delta \neq 0$. Here the pump is localized close to the upper branch as shown in Fig. 1 (right). Now parametric mixing of two pump polaritons from the upper branch with signal (k_s) and idler ($k_i = -k_s$) polaritons from the lower branch ($2\Omega(0) = \Omega(k_s) + \Omega(-k_s), 0 = k_s - k_s$) yields the desired stable soliton as shown in Fig. 2.

We have shown that coherent parametric four-wave mixing leads to the formation of both 2D moving and resting CPS in domains of the dispersion relation where the incoherent phase modulation cannot balance dispersion [2,3].

References

1. O. A. Egorov , A. V. Gorbach, F. Lederer, and D. V. Skryabin,"Two-dimensional localization of exciton polaritons in microcavities," Phys. Rev. A **105**, 073903 (2010).
2. O.A. Egorov, D.V. Skryabin, and F. Lederer, "Parametric polariton solitons in coherently pumped semiconductor microcavities," Phys. Rev. B **84**, 165305 (2011).
3. O.A. Egorov and F. Lederer, "Formation of hybrid parametric cavity polariton solitons," Phys. Rev. B **87**, 115315 (2013).

The Dilemma of Optical Telecommunications: Nonlinearity to the Rescue

Fedor Mitschke

Institut für Physik, Universität Rostock, Rostock, Germany
fedor.mitschke@uni-rostock.de, *http://web.physik.uni-rostock.de/optik/*

Fiber-optic cables these days carry enormous amounts of data around the globe. The volume of this data traffic (approaching 10^{14} bits/second around the clock) keeps rising fast. As long as the conventional binary coding (in which either a light pulse or none is transmitted within one clock period) is kept, fibers are now pushed to their limit, and various data formats "beyond binary" are currently investigated. These involve a mix of phase, amplitude, and polarization modulation, and even space or mode multiplexing. The latter require special fibers, incompatible with the existing worldwide fiber network. It will be demonstrated that all these approaches suffer from limitations which are self-imposed because they all rely on the linear regime; i.e. the signal power is kept very low.

We will show that in the nonlinear domain many of these limitations disappear. With solitons and soliton molecules, a nonlinear transmission scheme "beyond binary" has been demonstrated already. On the other hand, it needs to be determined whether this format is robust in the presence of amplification and collision, and first preliminary data on these issues will be shown.

Complex Geometrical Optics and Collapse Effect.

Paweł Berczyński[1], Grzegorz Żegliński[2] and Sławomir Marczyński[3]

[1]Institute of Physics, West Pomeranian University of Technology in Szczecin,
Piastów 19, 70-310 Szczecin, Poland.
[2]Faculty of Electrical Engineering, West Pomeranian University of Technology in Szczecin, 26 Kwietnia 10, 71-126 Szczecin, Poland.
[3]Faculty of Mechanical Engineering, West Pomeranian University of Technology in Szczecin, Piastów 19, 70-310 Szczecin, Poland.

It is commonly accepted that classical self-focusing theory based on standard Nonlinear Schrödinger Equation (NLS) predicts catastrophic beam collapse. However, it was shown by Feit and Flack [1] and by Manassah and Gross [2] that the collapse is an artifact of standard approximation of slowly varying amplitude when we neglect the longitudinal component of wave vector depending on beam amplitude. It was shown in [3] that modification of NLS including term, which describes the change of the propagation constant in longitudinal direction improve the description of the beam propagation avoiding catastrophic collapse effect. In paper [3] authors present the numerical solutions of modified NLS showing the stable evolution of Gaussian beam (GB) intensity in the vicinity of collapse point. Following paper [3] we make an essential step further. Instead of complicated numerical solutions of modified partial-differential NLSE, we reduce at once the description of Gaussian beam to ordinary differential equations domain (ODEs) describing GB width, amplitude, wave front curvature and change of propagation constant along propagation direction. This way we derive using paraxial complex geometrical optics (CGO) set of ordinary differential-algebraic equations which let us simply describe the dynamics of GB width and evolution of propagation function (instantaneous propagation constant) using standard mathematical software like Matlab/Octave, Mathcad and Mathematica. New result achieved using CGO method relay on observation of absolutely different image of Gaussian beam wave motion in over-critical regime in Kerr type nonlinear medium. Namely, when we include into CGO description the change of propagation constant with amplitude like proposed in [3], we observe without collapse effect the pulsation waveguide. For clarity, we prove analytically the existence of the oscillating type of solutions in under-critical regime obtaining interesting mechanical analogy in the form of an oscillator type equation for GB width containing fractional nonlinearity. Using mathematical recipe in [4] the derived CGO equation takes a form of Rayleigh equation, which after some differential modifications possess an analytical solution in the form of first and second type of elliptic integrals. Moreover, except for stationary solution we prove using CGO method that total beam power of GB is not invariant in such nonlinear Kerr type paraxial wave motion but the power changes with propagation function. In our opinion, it is essential conclusion of this presentation.

[1] M. D. *Feit and J. A. Fleck*, Beam nonparaxiality, filament formation, and beam breakup in the self-focusing of optical beams, *J.* Opt*.* Soc*.* Am*. B 5,* 633, 12 *(1988*).
[2] Jamal T. Manassah and Barry Gross. Comparison of the paraxial-ray approximation and the variational method solutions to the numerical results for a beam propagating in a self-focusing Kerr medium. *Optics Letters*, Vol. 17, Issue 14, pp. 976-978, (1992).
[3] Nail Akhmediev, Adrian Ankiewicz and Jose Maria Soto-Crespo. Does the nonlinear Schrodinger equation correctly describe beam propagation?, March 15, Vol. 18, No. 6 . OPTICS LETTERS, (1993).
[4] A. D. *Polyanin* and V. F. Zaitsev, Handbook of Exact Solutions for *Ordinary Differential Equations*, Chapman & Hall/CRC Press, Boca Raton, (2003).

Guiding Discharges Around Obstacles and Arbitrary Trajectories

M. Clerici[1,2], Y. Hu[2,3], P. Lassonde[2], C. Milián[4], A. Couairon[4], D. Christodoulides[5], Z. Chen[6,3], L. Razzari[2], F.Vidal[2], F. Légaré[2], D.Faccio[1], R. Morandotti[2]

[1]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh EH14 4AS, UK
[2]INRS-EMT, 1650 Blvd. Lionel-Boulet, Varennes, Quebec J3X 1S2, Canada
[3]The MOE Key Laboratory of Weak Light Nonlinear Photonics, School of Physics and TEDA Applied Physics School, Nankai University, Tianjin 300457, China
[4]Centre de Physique Theorique, CNRS, Ecole Polytechnique, F-91128 Palaiseau, France
[5]College of Optics - CREOL, University of Central Florida, Orlando, Florida 32816, USA
[6]Department of Physics and Astronomy, San Francisco State University, San Francisco, California 94132, USA

Since the seventies the ability of laser pulses to trigger and guide electric discharges has attracted the interest of the scientific community [1]. Such interest has been supported by the large number of applications associated to electric discharges and by the possibility of lightening control [2–4]. Up to now, discharge control has been performed with Gaussian-like beams or filaments, and hence the discharge path always followed a straight line. Recently however, it has been pointed out that optical beams can propagate along trajectories different from straight lines. It has been shown for instance that Airy beams are featured by an intense peak that propagates along a curved trajectory [5–7].

Here we demonstrate that, exploiting the property of Airy beams to excite a curved plasma channel [5,6], it is possible to trigger an electric discharge along a curved trajectory, avoiding an obstacle placed in the line-of-sight of the two electrodes [see Fig. 1 (c) and (d)].

A further relevant feature of diffraction-free beams, such as the Airy and the Bessel beam is that of self-healing: if an obstacle blocks the intense part of the beam, this rebuilds itself along the propagation trajectory [7]. In Fig. 1 (d) we show such an effect for the Airy beam: an obstacle blocks the intense part of the beam at a certain position along its path and hence stops the gas ionisation (visible by the blue fluorescence). However, the curved plasma channel restores itself after nearly 1 cm. This property allows guiding the electric discharge on target even in case an obstacle blocks the intense part of the beam [see Fig. 1 (g)].

We shall discuss these results in details, comparing the case of Gaussian [Fig 1 (b), (e)], Airy and Bessel beams, and the associated numerical model based on the gas expansion laser-induced heating.

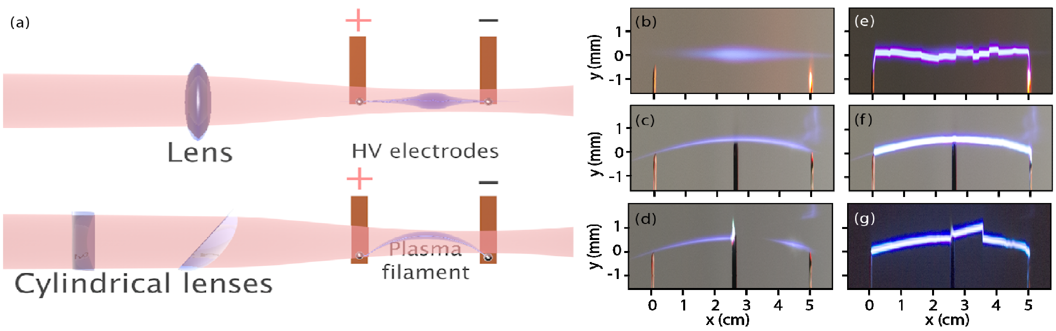


Fig. 1 (a) Schematic of the experiment. In the upper case, a Gaussian beam is focused with a lens between two electrodes. A discharge occurs then along a straight line. In the lower case, an Airy beam generates a curved conductive channel between two electrodes and the discharge occurs along a curved trajectory**.** (b) Fluorescence induced by a Gaussian and an Airy (c) beam propagating in air, respectively. When an obstacle partially blocks the Airy beam its intense peak reforms (self-healing) (d). (e) Discharge guided by the Gaussian pulse. Note the segmented nature of the discharge. (f) and (g) are the curve discharges guided by an Airy beam without and with an obstacle in the beam paths. Note that the vertical scale in all the figures is 8 times the horizontal one.

References

[1] D. W. Koopman, "Channeling of an Ionizing electrical streamer by a laser beam," J. Appl. Phys. **42**, 1883–1886 (1971).
[2] X. M. Zhao and J. C. Diels, "Femtosecond pulses to divert lightning," Laser Focus World **29**, 113 (1993).
[3] F. Vidal, D. Comtois, H. Pépin, T. Johnston, C. Chien, A. Desparois, J. Kieffer, B. La Fontaine, F. Martin, F. A. M. Rizk, H. P. Mercure, and C. Potvin, "The control of lightning using lasers: properties of streamers and leaders in the presence of laser-produced ionization," Comptes Rendus Phys. **3**, 1361–1374 (2002).
[4] J. Kasparian, R. Ackermann, Y.-B. André, G. Méchain, G. Méjean, B. Prade, P. Rohwetter, E. Salmon, K. Stelmaszczyk, J. Yu, A. Mysyrowicz, R. Sauerbrey, L. Woeste, and J.-P. Wolf, "Electric events synchronized with laser filaments in thunderclouds," Opt. Express **16**, 5757–5763 (2008).
[5] P. Polynkin, M. Kolesik, J. V Moloney, G. a Siviloglou, and D. N. Christodoulides, "Curved plasma channel generation using ultraintense Airy beams," Science **324**, 229–232 (2009).
[6] J. Kasparian and J. Wolf, "Laser beams take a curve.," Science **324**, 194–195 (2009).
[7] J. Broky, G. a Siviloglou, A. Dogariu, and D. N. Christodoulides, "Self-healing properties of optical Airy beams," Opt. Express **16**, 12880–12891 (2008).

Influence of the ion implantation on the absorption spectrum in the semiconductor quantum wells (MQW)

Eliza Miśkiewicz, Marek Wichtowski, Ewa Weinert – Rączka

Telecomunications & Photonics Department,
Faculty of Electrical Engineering,
West Pomeranian University of Technology in Szczecin

Semi-insulating GaAs – AlGaAs multiple quantum wells (SIMQW) comprise a special class of photorefractive materials as they have very high sensitivity and short response time. They show the highest photorefractive response for photon energies close to the exciton transitions [1],[2]. Due to the strong photoabsorption near the excitonic resonance, SIMQW samples are usually designed as thin films.

The GaAs/AlGaAs multiple quantum well structure operating in Franz-Keldysh geometry, with an external electric field applied along the layers of quantum wells, is one of the most popular systems[1],[2],[3],[4]. In this setup applying the high external electric field leads to ionization of excitons, shortening their life time. This phenomenon manifests itself in the absorption spectrum as the broadening and decreasing of the peaks corresponding to excitonic transitions and is thus called electroabsorption [3].
In this paper are presented the results of the absorption and electroabsorption spectra measurements in SIMQW structures. The experiment shows the dependence of changes in the exciton peaks amplitude on the different defects concentration.

In the experiment, we use GaAs/$Al_{0.3}Ga_{0.7}As$ MQW structures consisting of a 100-period superlattice of 7 nm GaAs wells and 6 nm AlGaAs barriers. The material was proton-implanted at 160 keV and 80 keV with the same fluxes for each energy, to make it semi-insulating with the possibly uniform defect concentrations. Three series of samples were prepared with fluxes $1x10^{12}$ cm^{-2}, $1,5x10^{12}$ cm^{-2} and $2x10^{12}$ cm^{-2} and one series of samples was not implanted.

[1] P. Yeh, *Introduction to photorefractive nonlinear optics*, Jon Wiley & Sons, inc., New York 1993.
[2] D.D. *Nolte, Photorefractive effects and Materials*, Kluwer, Dordrecht 1995.
[3] Q. Wang, R. M. Brubaker, D.D. Nolte and M.R. Melloch, *Photorefractive quantum wells: transverse Franz-Keldysh geometry*, J. Opt. Doc. Am. B **9** (1992) 1626
[4] Q. Wang, D.D. Nolte and M.R. Melloch, *Two-wave mixing in photorefractive AlGaAs/GaAs quantum wells*, Appl. Phys. Lett. **59** (1991) 256

Impact of proton implantation parameters on photoconductivity of photorefractive multiple quantum wells

Błażej Jabłoński, Agnieszka Branecka, Ewa Weinert-Rączka

Telecommunications & Photonics Department,
Faculty of Electrical Engineering, West Pomeranian University of Technology in Szczecin

Semi-insulating GaAs-AlGaAs multiple quantum wells (MQW) are photorefractive materials with high sensitivity and a short response time. Semi-insulating properties of these structures are usually obtained by proton implantation.

We present results of photoconductivity measurements in three types of the samples with the same semiconductor structure and different parameters of proton implantation (Table 1.). The MQW structure, produced in the Institute of Electronic Materials Technology in Warsaw (ITME) by MOCVD method, consisted of 100-period superlattice of 7 nm GaAs wells and 6 nm $Al_{0.3}Ga_{0.7}As$ barriers.

Structure	Energy 1	Dose 1	Energy 2	Dose 2
6B	160 keV	$1x10^{12}$ cm^{-2}	80 keV	$1x10^{12}$ cm^{-2}
6C	160 keV	$1,5x10^{12}$ cm^{-2}	80 keV	$1,5x10^{12}$ cm^{-2}
6D	160 keV	$2x10^{12}$ cm^{-2}	80 keV	$2x10^{12}$ cm^{-2}

Table. 1. Energies and doses of proton implantation carried out in Institute of Physics, Maria Curie-Skłodowska University (UMCS) in Lublin

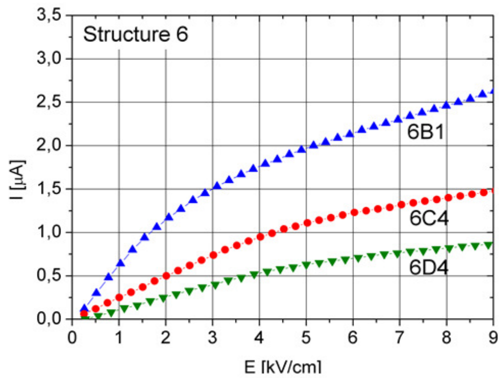


Fig. 1. An example of photocurrent as a function of the applied field for three chosen samples with different proton doses (see Table 1). Light intensity I = 6 mW/cm^2

The comparison of the results with the theoretically predicted relationship between photoconductivity and the donor to acceptor concentration ratio, $r = N_A / N_D$, allows to estimate the impact of proton dose on deep donors concentration and on the electrons to holes concentration ratio, which is essential for Photorefractive Two Waves Mixing experiments in MQW.

1. D. D. Nolte and M. R. Melloch, Photorefractive quantum wells and thin films in "Photorefractive effects and Materials" ed. By D. D. Nolte (Kluwer Academic, Boston 1995)
2. Q. Wang, R. M. Brubaker, D. D. Nolte and M. R. Melloch, Photorefractive quantum wells: Transverse Franz-Keldysh geometry, J. Opt. Soc. Am. B 9 (1992) 1626.

Supercontinuum generation in three fold symmetry microstructured fibers at visible and infrared region by sub-nanosecond pulse source

Zbyszek Holdynski[a], Marek Napierala[a] ,Lukasz Szostkiewicz[a] Pawel Mergo[b], Tomasz Nasilowski[a]

[a] InPhoTech Ltd., Slominskiego 17/31, 00-195 Warsaw, Poland, zholdynski@inphotech.pl
[b] Laboratory of Optical Fibre Technology, Maria Curie-Skłodowska University, Pl. M. Curie-Sklodowskiej 3, 20-031 Lublin, Poland

We present three fold symmetric silica microstructure fibers series for nonlinear application. We design two series of microstructured fibers. First fibers series was designed by application three air holes around core in a way to obtain normal dispersion regime pumping. Second series of tested fibers geometry was modified to bee pumped in anomalous dispersion condition. In our investigation we show that pumping condition extremely far from zero dispersion region gives possibility to introduce nonlinear interaction and special pulse broadening process can be obtain. We show possibilities to obtain visible and infrared region by application: stimulated Raman scattering (SRS) and cascaded four wave mixing (FWM) nonlinear effects. Our fibers series presents ability to keep dispersion condition (and generated spectral profile) even after large geometry difference between them.

Additionally we show strong advantages coming from both: reduced number of air holes and broadband spectrum stability effect at extremely far from zero dispersion pumping. We show for each designed fibers process of identification initial nonlinear dynamics responsible for supercontinuum generation Fig1. In Fig.1 we show nonlinear dynamics initiated by SRS process for three fibers pumped by sub-nanosecond source, cascade of SRS and soliton formation edge can be recognised.

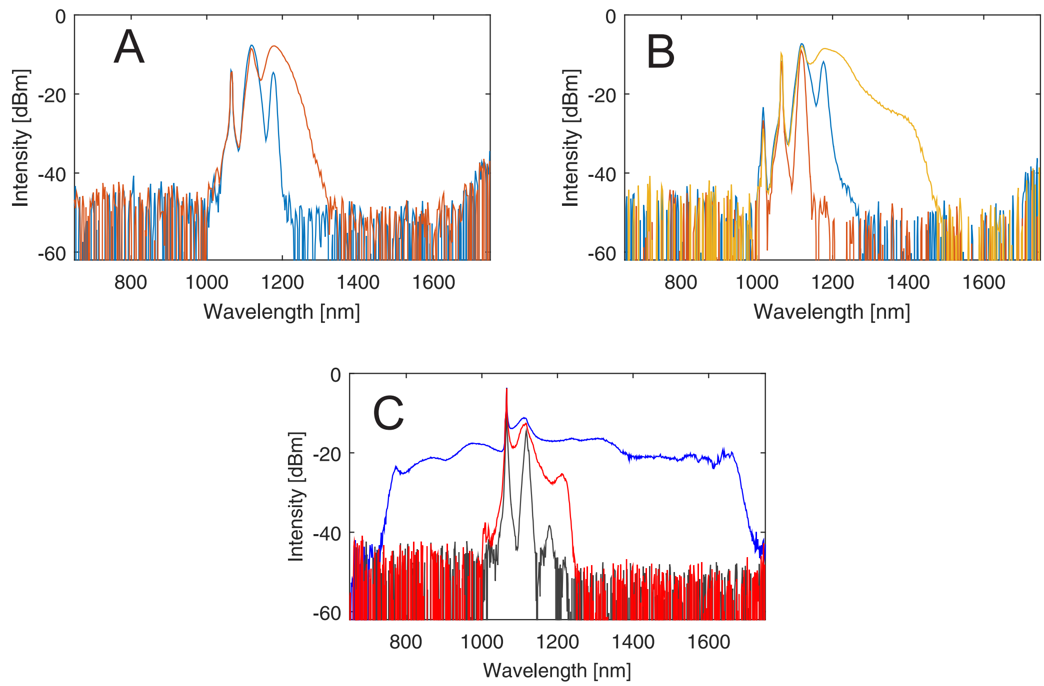


Fig. 1. Supercontinuum by three fold symmetric microstructured fibers witch: ZDW_A=1311nm; ZDW_B=1265nm; ZDW_C=1112nm.

Supercontinuum generation in highly birefringent fiber pumped at the wavelength of 1064 nm in normal dispersion regime

Michalina Jozwik[a], Zbyszek Holdynski[a], Marek Napierala[a], Dawid Budnicki[a], Michał Murawski[a], Łukasz Ostrowski, Łukasz Szostkiewicz[c] Pawel Mergo[b],Tomasz Nasilowski[a]

[a]InPhoTech Ltd., Slominskiego 17/31, 00-195 Warsaw, Poland
[b] Laboratory of Optical Fibre Technology, Maria Curie-Skłodowska University, Pl. M. Curie-Sklodowskiej 3, 20-031 Lublin, Poland
[c] Polish Centre for Photonics and Fibre Optics, Rogoźnica 312, 36-060 Głogów Małopolski, Poland

Supercontinuum (SC) generation is mostly achieved in the nonlinear photonic crystal fibers with proper fiber geometry design. When the dispersion characteristics of the fiber are well optimized, the pump source providing light with a high power density causes nonlinear effects responsible for broadening the spectrum of light. There are different nonlinear effects responsible for supercontinuum generation when different pumping regimes are applied. The efficiency of SC generation in a fiber is dependent on the difference between pump source wavelength and zero dispersion wavelength (ZDW) of the fiber as well as on pump source parameters (e.g. power, pulse duration) and nonlinearity of the fiber.
We present experimental analysis of SC generation obtained for highly birefringent and highly nonlinear fiber. The fiber comprises of air-holes of different sizes forming a geometrical layout of the three parallel layers in the center of the optical fiber. Zero dispersion wavelength (ZDW) has been determined experimentally and by simulation. SC generation was obtained for pump source wavelength of 1064 nm. We analyzed also the nonlinear effects responsible for broadening the spectrum of light.

References:

1. HLUBINA, Petr; KADULOVÁ, Miroslava; MERGO, Paweł. Chromatic dispersion measurement of holey fibres using a supercontinuum source and a dispersion balanced interferometer. *Optics and Lasers in Engineering*, 2013, 51.4: 421-425.

2. HOLDYNSKI, Zbyszek, et al. Experimental study of dispersion characteristics for a series of microstructured fibers for customized supercontinuum generation. *Optics express*, 2013, 21.6: 7107-7117.

3. NAPIERALA, Marek, et al. Influence of photonic crystal fiber manufacturing inaccuracies on supercontinuum generation. In: *SPIE Photonics Europe*. International Society for Optics and Photonics, 2014. p. 91361M-91361M-6.

Higher order modes management in multi-core hole-assisted fibres

A. Ziolowicz[1,2], L. Szostkiewicz[3], L. Ostrowski[1], M. Murawski[3], Z. Holdynski[1], T. Tenderenda[1], M. Napierala[1], A. Pytel[1], A. Kolakowska[1], P. Mergo[4], K. Poturaj[4], M. Makara[1], T. Nasiłowski[1]

[1]InPhoTech Sp. z o.o. 17 Slominskiego St 31, 00-195 Warsaw, POLAND
[2]Faculty of Physics, Warsaw University of Technology, 75 Koszykowa St, 00-662 Warsaw, POLAND
[3]Polish Centre For Photonics and Fibre Optics, Rogoznica 312, 36-060 Glogow Malopolski, Poland
[4]Laboratory of Optical Fibre Technology, Faculty of Chemistry, Maria Curie-Sklodowska University, 3 Maria Curie-Sklodowska Sq, 20-031 Lublin, POLAND

Corresponding author: aziolowicz@inphotech.pl

Already existing transmission systems based on single-core fibre are reaching their limits of capacity. The boundary of capacity, which is considered as 100Tb/s[1,2] for standard telecom fibres, results from nonlinearity of the fibres. There are several strategies to overcome capacity crunch and the one considered as the most promising are multicore fibres (MCFs)[2]. Getting advantage of space division multiplexing can be realized with various approaches, e.g. by MCFs with single-mode cores or with few-mode cores, which introduce the additional aspect of modes' multiplexing. The second approach allows beating capacity record[3], however it requires huge costs for changing already existing telecommunication infrastructure.

The presented fibres were designed in order to achieve compatibility with the existing single-core networks in terms of the fibre geometry, chromatic dispersion characteristic and transmission loss. Slight changes in fibre dimensions allow achieving few-mode propagation which is also advantageous, but requires different signal processing. Thus, one of the structures is optimized for suppressing higher order modes, meanwhile the other one can be used in mode-division multiplexing. The fibres are characterized by very small crosstalk between the cores, which is reached by hole-assisted structure. What is more, the fibers have considerably reduced bending loss in comparison with the standard single-core fibre.

Keywords: multi-core fibres, space division multiplexing, microstructured fibres

References:

1. Morioka, T. Ultrahigh Capacity Optical Communications Beyond Pb/s. in *Nonlinear Optics* NM2B.1 (OSA, 2013). doi:10.1364/NLO.2013.NM2B.1

2. D. J. Richardson, J. M. Fini & L. E. Nelson. Space-division multiplexing in optical fibres. *Nat. Photonics* **7,** 354–362 (2013).

3. Van Uden, R. G. H. *et al.* Ultra-high-density spatial division multiplexing with a few-mode multicore fibre. *Nat. Photonics* **8,** 865–870 (2014).

Conjugated Photoactive Ligands and their Nonlinear Optical Response

Ariadni P. Kerasidou[1], Konstantinos Iliopoulos[1, 2], Awatef Ayadi[1,3], Abdelkrim El-Ghayoury[1] and Bouchta Sahraoui[1,*]

[1]LUNAM Université, Université d'Angers, CNRS UMR 6200, Laboratoire MOLTECH-Anjou, 2 bd Lavoisier, 49045 Angers Cedex, France
[2]Institute of Chemical Engineering Sciences, Foundation for Research and Technology Hellas (FORTH/ICE-HT), 26504 Patras, Greece
[3]Laboratoire de Physico-chimie de l'etat solide, Université de Sfax, Route de Soukra; Km 4; BP:802, 3038, Sfax, Tunisie
*bouchta.sahraoui@univ-angers.fr

Extensive effort has been directed toward the synthesis and the design of new organic and organometallic noncentrosymmetric dipolar molecules, containing donor and acceptor end groups connected through a π backbone, which can be incorporated into macroscopic assemblies due to their large nonlinear optical (NLO) responses.[1]–[4] In this work, we report on the nonlinear optical response of π-conjugated azo-iminopyridine photoactive ligands containing electron donating or electron accepting fragments in their structure (Figure 1). Generally, push-pull compounds present interesting photophysical properties and undergo (partial) intramolecular charge transfer upon excitation.[5] The investigated photoactive ligands have also the advantage to covalently coordinate or to bind a metal cation in order to provide photoactive metal complexes that can exhibit coexistence or synergy between two different physical properties.[6], [7] The nonlinear optical investigation is performed by means of the Z-scan, the Third Harmonic Generation (THG) and the Second Harmonic Generation (SHG) techniques employing a 30 ps mode-locked Nd-YVO_4 laser with a repetition rate of 10 Hz.

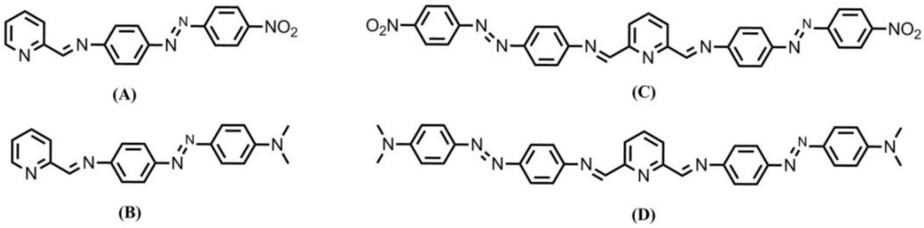


Figure 1. *Molecular structures of the investigated photoactive ligands*

ACKNOWLEDGEMENTS
K. I. acknowledges the support from the European Commission and the General Secretariat for Research and Technology (Greece) for a National Strategic Reference Framework (NSRF) Project (PE3-(1612)).

REFERENCES

[1] H. Nishihara, "Combination of redox- and photochemistry of azo-conjugated metal complexes," *Coord. Chem. Rev.*, vol. 249, no. 13–14, pp. 1468–1475, 2005.
[2] X. Xia, L. H. Gan, and X. Hu, "The synthesis and properties of novel, functional azobenzene based metal complexes," *Dyes Pigments*, vol. 83, no. 3, pp. 291–296, Dec. 2009.
[3] R. Liu, Y. Li, J. Chang, Q. Xiao, H. Zhu, and W. Sun, "Photophysics and nonlinear absorption of 4,4′-diethynylazobenzene derivatives terminally capped with substituted aromatic rings," *J. Photochem. Photobiol. Chem.*, vol. 239, pp. 47–54, Jul. 2012.
[4] C. Pei, P. Cui, C. McCleese, S. Kilina, C. Burda, and W. Sun, "Heteroleptic cationic iridium(III) complexes bearing naphthalimidyl substituents: synthesis, photophysics and reverse saturable absorption," *Dalton Trans. Camb. Engl. 2003*, vol. 44, no. 5, pp. 2176–2190, Feb. 2015.
[5] A. Slama-Schwok, M. Blanchard-Desce, and J. M. Lehn, "Intramolecular charge transfer in donor-acceptor molecules," *J. Phys. Chem.*, vol. 94, no. 10, pp. 3894–3902, May 1990.
[6] A. P. Kerasidou, F. Khammar, K. Iliopoulos, A. Ayadi, A. El-Ghayoury, N. Zouari, T. Mhiri, and B. Sahraoui, "Conjugated iminopyridine based Azo dye derivatives with efficient charge transfer for third order nonlinearities," *Chem. Phys. Lett.*, vol. 597, pp. 106–109, 2014.
[7] I. Guezguez, A. Ayadi, K. Ordon, K. Iliopoulos, D. G. Branzea, A. Migalska-Zalas, M. Makowska-Janusik, A. El-Ghayoury, and B. Sahraoui, "Zinc Induced a Dramatic Enhancement of the Nonlinear Optical Properties of an Azo-Based Iminopyridine Ligand," *J. Phys. Chem. C*, vol. 118, no. 14, pp. 7545–7553, Apr. 2014.

NLO Properties of Thin Films Containing Metal and 8-Hydroxyquinoline Complexes

A. Zawadzka

Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University, Grudziadzka 5, PL 87-100 Torun, Poland, Tel. +48566113244, e-mail: azawa@fizyka.umk.pl

This work contains results of the structural and optical properties of the thin films containing complexes of metal (M = Zn, Cu and Al) and bis- or tris(8-hydroxyquinoline). The films were successfully grown by physical vapor deposition (PVD) technique in high vacuum on transparent (quartz, glass) and semiconductor (n-type silicon) substrates kept at room temperature during the deposition process. Selected films were annealed after fabrication in ambient atmosphere for 24 hours at the temperature equal to 50°C, 100°C and 150°C. Linear optical properties of these films were examined using transmission and photoluminescence measurement. Nonlinear optical properties were studied by Second and Third Harmonic Generation technique. The experimental spectra were allowed to determine optical constant of the films. Structural properties were investigated by AFM measurements. The Mq_n (n =2 or 3) films exhibit high structural quality regardless of the annealing process, but the stability of the film can be improved by using an appropriate temperature during the annealing process. We find that the linear as well as nonlinear optical properties were strictly connected with the morphology and the annealing process can significantly change the structural properties of the films. The following figure shows example of THG experimental curves.

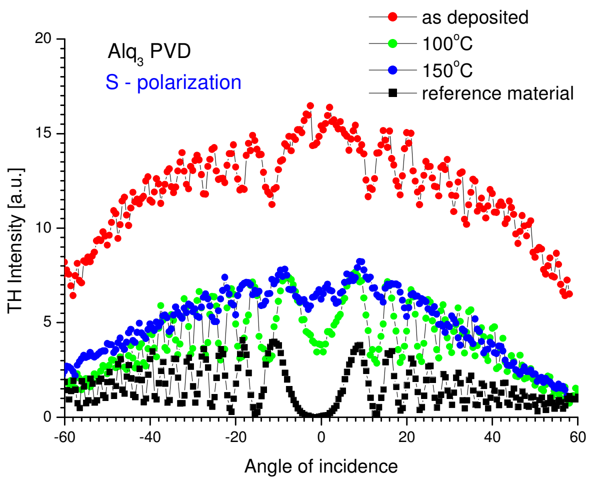


Fig. Experimental curves of THG generation process for Alq_3.

Bistability and spontaneous symmetry breaking with nematicons

G. Assanto[1,2], A. Piccardi[1], A. Alberucci[2], N. Kravets[1] and O. Buchnev[3]

[1] NooEL – Nonlinear Optics and OptoElectronics Lab, University "Roma Tre", 00146 Rome, Italy
[2] Optics Laboratory, Tampere University of Technology, FI-33101 Tampere, Finland
[3] Zepler Institute, University of Southampton, United Kingdom

Nematicons stem from the reorientational response of nematic liquid crystals and are stable and robust. In configurations exhibiting the optical Freedericks transition, beyond a power threshold a nonlinear bifurcation can take place via spontaneous symmetry breaking, with the appearance of novel kinds of hysteresis and optical bistability involving propagating beams. We report on optical bistability between soliton and diffracting states versus input power excitation and soliton bistability versus incident angle, with hysteresis and memory of the system evolution.

Spatial routing of soliton-guided signals in inhomogeneous nematic liquid crystal structures

Filip A. Sala[1], Mirosław A. Karpierz[1] and Gaetano Assanto[2,3]

[1] Laboratory of Nonlinear Optics and Photonics, Faculty of Physics, Warsaw University of Technology, 00-662 Warsaw, Poland
[2] NooEL – Nonlinear Optics and OptoElectronics Lab, University "Roma Tre", 00146 Rome, Italy
[3] Optics Lab – Dept. of Physics, Tampere University of Technology, Tampere, Finland

The reorientational nonlinearity of nematic liquid crystals supports self-localized beams, *nematicons* [1-3]. In homogeneous structures such beams undergo walk-off, depending on the angle between the wavevector and the director [4]. Collating regions with different director orientations allows engineering the walk-off and thus guided-wave demultiplexing with improved channel separation and cross talk. We will describe the spatial routing of signals guided by nematicons excited in regions with distinct walk-offs. In order to describe light propagation and the formation of solitons with transverse velocity in this anisotropic nonlinear medium, we will present numerical results based on a Full-Vector Beam Propagation Method and a model based on the Frank-Oseen elastic equations for the director deformation [5-7].

[1] G. Assanto and M. Karpierz, Nematicons: Self-localized beams in nematic liquid crystals, *Liq. Cryst.* 36 (2009) 1161–1172.
[2] G. Assanto, A. Minzoni and N. F. Smyth, Light self-localization in nematic liquid crystals: Modelling solitons in reorientational media, *J. Nonl. Opt. Phys. Mat.* 18 (2009) 657–691.
[3] M. Peccianti and G. Assanto, Nematicons, *Phys. Rep.* 516 (2012) 147–208
[4] A. Piccardi, A. Alberucci, U. Bortolozzo, S. Residori and G. Assanto, Soliton gating and switching in liquid crystal light valve, *Appl. Phys. Lett.* 96 (2010) 1071104.
[5] F. A. Sala, M. A. Karpierz and G. Assanto, Spatial routing with light-induced waveguides in uniaxial nematic liquid crystals *J. Nonl. Opt. Phys. Mat.* 23 (2014) 1450047.
[6] F. A. Sala and M. A. Karpierz, Modeling of molecular reorientation and beam propagation in chiral and non-chiral nematic liquid crystals, *Opt. Express* 20 (2012) 13923–13938.
[7] F. A. Sala and M. A. Karpierz, Chiral and non-chiral nematic liquid crystal reorientation induced by inhomogeneous electric fields, *J. Opt. Soc. Am. B* 29 (2012) 1465–1472.

Nonlinear light beam propagation in chiral nematic liquid crystals

Urszula A. Laudyn

Laboratory of Nonlinear Optics and Photonics, Faculty of Physics,
Warsaw University of Technology, Koszykowa 75, 00-662 Warsaw, Poland

Nematic liquid crystals (NLC) have been widely exploited in experiments because of their highly nonlinear and nonlocal response, uniaxial nature, extended spectral transparency [1-2]. In particular, due to the reorientational nonlinearity, NLCs have been successfully used to observed spatial solitons, self-traped non-diffractive light beams, called nematicons [3-5]. A lot of effort in recent years have been concentrated on the manipulation of light in nematic liquid crystals (NLCs), in particular nematicons have attracted much interest because they constitute an ideal tesbed for the study of nonlinear optical phenomena and they have a strong application potential in smart optical interconnections.

Here we focus our discussion on light beam propagation in chiral NLCs (ChNLCs) in general and nematicons creation in particular in this complex structures. The ChNLCs consists of molecules arranged in thin anisotropic layers, with the successive layer rotated through a small angle, leading to a spiral configuration. In principle, the light beam propagation and nematicons creation in ChNLCs are similar to those in nematics in particular there are some differences with makes this novel platform more complex [6]. Furthermore, the configuration with ChNLCs offers some additional opportunities due to the fact, that the width of the guiding layer is determined not only by the thickness of the sample but mainly by the chirality pitch. In addition to this, the properties of the guidying layer are strongly dependent and can be easily modified by changing the parameters of the used NLCs as well as by applying the external fields [7].

In this overwiev, we give insight into the properties of light beam propagation in different NLCs materials i.e. with different pitch, birefringence, elastic constant and configurations. We optimize the parameters of the NLC materials to obtain stable nematicon propagation in desirable configuration. Developing/improving strategies for the control of such self-induced waveguides is crucial for potential applications.

We explore also the properties of ChNLCS confined in a wedge-shaped cell to obtain highly steerable nematicon propagation [8]. We study the simple interaction of nematicons with disclination line created in a wedge shaped cell filled with ChNLC. We show that in most cases the self-confined beam preserves this interaction. We demonstrate that this interaction can be employed for efficient bending of the soliton trajectory, as a result of reflection and refraction.

[1]. C. Khoo, *Liquid Crystals*, 2nd Edition (Wiley, New York, 2007).
[2]. C. Khoo, Nonlinear optics of liquid crystalline materials, Phys. Rep. **471,** 221–267 (2009).
[3]. Assanto, G., Peccianti, M., Conti, C., *Opt. Photon. News* **14**, 44, (2003).
[4]. Nematicons: spatial optical solitons in nematic liquid crystals, ed. By G. Assanto, Wiley, 2013
[5]. Karpierz, M. A., *Soliton Driven Photonics*, Boardman, A. D., Sukhorukov, A.P., (Eds.), p. 41, Kluwer Academic Publishers: Dordrecht (2001).
[6]. U. A. Laudyn, M. Kwasny, M. A. Karpierz, *Appl. Phys. Lett.* **94**, 091110 (2009)
[7]. U.A. Laudyn, M.A. Karpierz; Appl. Phys. Lett. 103 (2013) 221104
[8]. U. A. Laudyn, P. Jung, K. B. Zegadło, M. A. Karpierz and G. Assanto; Optics Letters Vol. 39, Issue 22, pp. 6399-6402 (2014)

Solitons in nematic liquid crystals reoriented by magnetic field

Adam Królewicz and Justyna Lutkiewicz

Laboratory of Nonlinear Optics and Photonics, Faculty of Physics,
Warsaw University of Technology, Koszykowa 75, 00-662 Warsaw, Poland

A spatial solitons in nematic liquid crystals (nematicons) are formed due to a balanced interplay between diffraction and optically-induced change in refractive index resulting in beam focusing. They have attracted a great deal of attention in the last few years for several reasons including: the high nonlinearity stemming from molecular reorientation, the highly nonlocal response, the possibility to control their trajectory. So far a number of possible beam guiding and routing by means of an external electric field, or specially prepared alignment layers in various types of liquid crystals have been investigated. In this work we investigate for the first time to our best knowledge the possibility to generate nematicons under the magnetic field. Most LC organic molecules are diamagnetic thus the induced magnetic dipoles are responsible for the reorientation of the LC molecules in a magnetic field. The NLC molecules under a magnetic field, as in the case of electric field, tend to orient themselves parallel or perpendicular (depending on the sign of the magnetic anisotropy) to the magnetic field. It is worth to mention here that the magnetic field has less damaging effects on the NLCs molecules, is “optically cleaner” and increase the potential safety of the device.

Measurements of the nematic liquid crystals alignment quality

Iga Ostromęcka

Laboratory of Nonlinear Optics and Photonics, Faculty of Physics,
Warsaw University of Technology, Koszykowa 75, 00-662 Warsaw, Poland

The huge availability of liquid crystals mixtures with a variety of parameters (including optical birefringence, sign of electrical and optical anisotropy, thermal stability, etc.) allows easy customization of the designed device for specific conditions and allows for an operation in a variable range. However, a highly important technological problem faced by many researches nowadays is the quality and strength of orientation (i.e. alignment layers) used for changing the refractive index distribution within a liquid crystal cell.
Whereas the existing knowledge about the liquid crystals, in general, and nematic liquid crystals, in particular, is quite advanced, there is still a gap in understanding of the liquid crystal/solid surface interaction and their impact on the creation of spatial solitons (i.e. nematicons) and its stability.

In this work we investigate the influence of the quality of alignment layer obtained by different methods (e.g. rubbing, photo-orientation, etc) on nonlinear light beam propagation (i.e. nematicon) in a finite size media. Much attention will be paid to the uniformity of the obtained orientation its impact on the ease of nematicons generation, optimization of power needed for their creation as well as their stability. On the one hand, the quality of orienting layer is very important factor since it determines the uniformity of obtained nematic liquid crystals layer, for the other the high strength of the anchoring forces has an impact on the beam power needed to create nematicon which in turn can lead to a stronger thermal effects that have a destructive effect on the generation of solitons and their stability. Our work is focused on determining the proper quality of alignment layer for applications in nonlinear propagation of the beam in the form of soliton and its stability.

The influence of electrical field on disclination lines

Michał Kwaśny

Laboratory of Nonlinear Optics and Photonics, Faculty of Physics,
Warsaw University of Technology, Koszykowa 75, 00-662 Warsaw, Poland

In this work we investigate spatial solitons (nematicons) in chiral nematic liquid crystals (ChNLCs) confined in a wedge shaped cell. Such geometry results in formation of discontinuities in the chiral structure (disclination lines) where additional half twist of a helix is accumulated as a cell thickness increases. Nematicons in ChNLCs propagates in thin layers where effective refractive index is the largest and their shape is rapidly changing around perturbed area of disclination. By using ChNLCs with negative dielectric anisotropy i.e. ones in which the molecules arrange perpendicular to the force lines of the electric field, we are able to modify the refractive index profile. Depending on the applied voltage disclination lines might be sharper or smoother and as a consequence interplay between nematicons and disclination lines is changing. When nematicon strikes disclination line it may change its trajectory, reflects from disclination line or collapse. We have demonstrated that reflectance and transmission coefficients depend on the intensity of the electric field and its optical power. A potential configurations of electro-optical beam switching using chiral NLCs will be discussed. Ongoing studies on interplay between nematicons and disclination lines in the presence of external electric field are aimed at determine optimal conditions for effective steering and switching at disclination lines in ChNLCs.

This work was supported by the National Science Centre under the decision number DEC-2012/05/D/ST7/00147.

References:

[1] M. Kwasny, U. A. Laudyn, M. A. Karpierz, „Nematicons in chiral nematic liquid crystals", *Appl. Phys. Lett*. **94**, 091110 (2009).

[2] U. A. Laudyn, M. A. Karpierz, „Nematicons deflection through interaction with disclination lines in chiral nematic liquid crystals", *Appl. Phys. Lett*. **103**, 221104 (2013).

[3] M. Kwasny, U. A. Laudyn, K. A. Rutkowska, M. A. Karpierz, „Nematicons routing through two types of disclination linesin chiral nematic liquid crystals", *J. Nonlinear Opt. Phys. Mater* **145**, 1450042 (2014).

Thermal effects in reorientational nonlinearity in liquid crystal

Bartłomiej W. Klus

Laboratory of Nonlinear Optics and Photonics, Faculty of Physics,
Warsaw University of Technology, Koszykowa 75, 00-662 Warsaw, Poland

Liquid crystals are materials widely used in optical and optoelectronic laboratories and commonly used devices such as LC's displays. From the fundamental point of view a key role in the design of such devices play material parameters such as optical and electrical anisotropy and Frank elastic constants. The values of these parameters define the maximum change of the refractive index and the voltage necessary to obtain the reorientation of anisotropic molecules of LC. Unfortunately, parameters of these materials are very sensitive to temperature changes which can lead to change the nature of interaction between substance and external electric or optical field.

In this work we present thermal effects induced by external optical field which can be observed in the LC. To measure the change of refractive index in LCs we adopt the z-scan setup. Thermal effects observed in our experiments can be strengthen under the influence the external electric field or by dye which is sensitive to used laser beam. In the experiments we used two commonly used liquid crystal with normal and low birefringence prepared by the Military University of Technology in Warsaw. The results are compared with other experiments and confirmed the theoretical predictions.

Modelling of reorientational nonlinearity in chiral nematic liquid crystals

Paweł Jung

Laboratory of Nonlinear Optics and Photonics, Faculty of Physics
Warsaw University of Technology, Koszykowa 75, 00-662 Warsaw, Poland

In nonlinear optics of liquid crystals reorientational nonlinearity has the greatest influence for changing orientation of liquid crystals molecules induced by the electric field of electromagnetic wave. The interesting and promising application capability is phenomena utilize reorientational nonlinearity to creation optical spatial solitons in NLCs called nematicons. Furthermore in chiral nematics liquid crystals spetial solitons, their interaction and self-driving mode transformation have been reported.

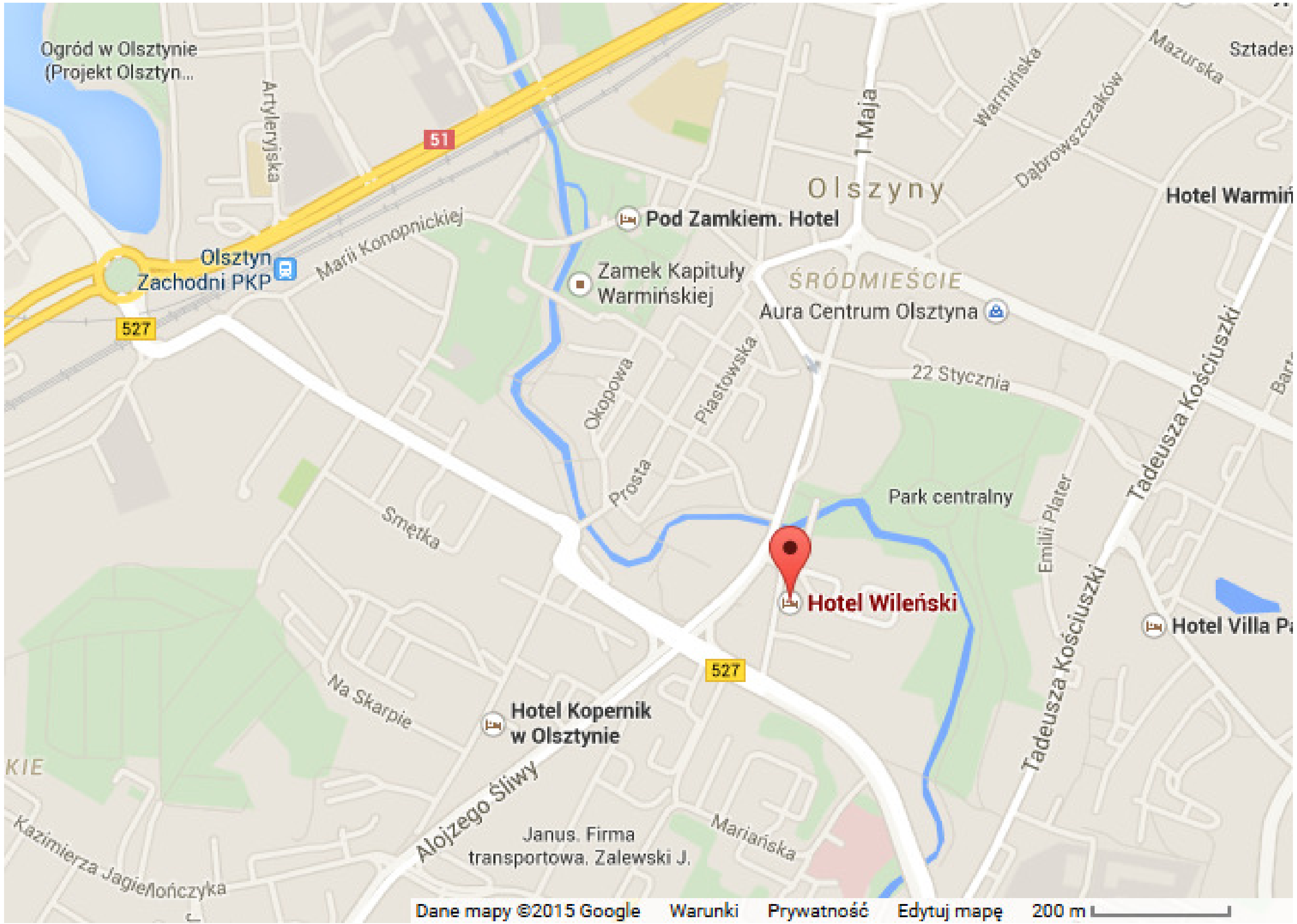
To simulate light propagation in chiral nematic liquid crystal it is needed to calculate electromagnetic beam propagation as well as reorientation of liquid crystals molecules. The accurate method for simulate field propagation is Full Vector Beam Propagation Method based on equations derived directly from Maxwell. While the exact description of reorientational nonlinearity in ChNLCs is based on distortion theory namely Frank-Ossen theory which gives complex equations.

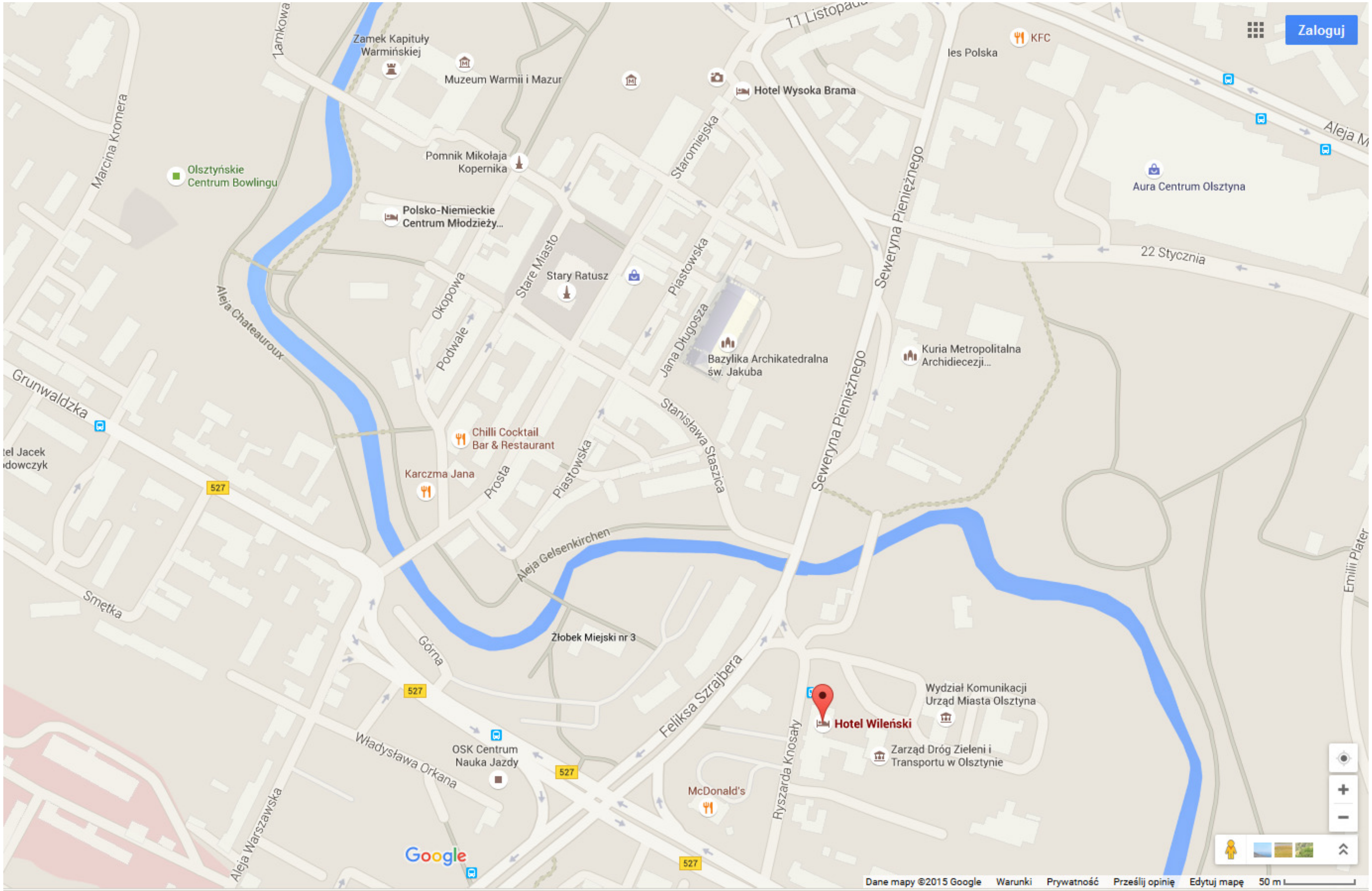
The exact approach of calculation molecules orientation of liquid crystals molecules is quite complicated and require a lot of computing time. In this work we take the deep insight into reorientational mechanism in ChNLCs combined with nonlocality and saturation and propose new model for accurate description of the nonlinear light beam propagation and nematicon creation in this complex structures.

Wednesday Sept. 9th, 2015		
18.00 - 22.00	Registration	
19.00 - 21.00	Dinner	
Thursday Sept. 10th, 2015		
8.00 - 9.30	**breakfast**	
9.30	**Opening**	
10.00 - 11.00	Falk Lederer	Parametric Cavity Polariton Solitons
11.00 - 11.30	**coffee break**	
11.30 - 12.30	Fedor Mitschke	The dilemma of optical telecommunications: Nonlinearity to the rescue
12.30 - 13.00	Paweł Berczyński	Complex geometrical optics and collapse effect
13.00 - 14.00	**lunch**	
15.00 - 16.00	Roberto Morandotti	Guiding Discharges Around Obstacles and Arbitrary Trajectories
16.00 - 16.20	Eliza Miśkiewicz (PhD. St.)	Influence of the ion implantation on absorption spectrum in semiconductor quantum wells (MQW)
16.20 - 16.40	Błażej Jabłoński (PhD. St.)	Impact of implantation parameters on photoconductivity characteristics in photorefractive multiple quantum wells
16.40 - 17.00	**coffee break**	
17.00 - 17.30	Zbyszek Hołdyński	Supercontinuum generation in three fold symmetry microstructured fibers at visible and infrared region by sub-nanosecond pulse source
17.30 - 18.00	Michalina Jóźwik (MSc. St.)	Supercontinuum generation in highly birefringent fiber pumped at the wavelength of 1064 nm in normal dispersion regime
18.00 - 18.30	Anna Ziołowicz (MSc. St.)	Higher order modes management in multi-core hole-assisted fibres
20.00	**big dinner**	
Friday Sept. 11th, 2015		
8.00 - 9.30	**breakfast**	
9.30 - 10.15	Ariadni Kerasidou (Phd. St.)	Conjugated Photoactive Ligands and their Nonlinear Optical Response
10.15 - 11.00	Anna Zawadzka	NLO properties of thin films containing metal and 8-Hydroxyquinoline complexes
11.00 - 11.30	**coffee break**	
11.30 - 12.30	Gaetano Assanto	Bistability and spontaneous symmetry breaking with nematicons
12.30 - 13.00	Filip Sala	Spatial routing of soliton-guided signals in inhomogeneous nematic liquid crystal structures
13.00 - 14.00	**lunch**	
15.00 - 15.50	Urszula Laudyn	Nonlinear light beam propagation in chiral nematic liquid crystals
15.50 - 16.10	Justyna Lutkiewicz (St.), Adam Królewicz (St.)	Solitons in nematic liquid crystals reoriented by magnetic field
16.10 - 16.30	Iga Ostromęcka (St.)	Measurements of the nematic liquid crystal alignment quality
16.30 - 17.00	**coffee break**	
17.00 - 17.30	Michał Kwaśny	The influence of electrical field on disclination lines
17.30 - 18.00	Bartłomiej Klus (PhD. St.)	Thermal effects in reorientational nonlinearity in liquid crystal
18.00 - 18.30	Paweł Jung (PhD. St.)	Modelling of reorientational nonlinearity in chiral nematic liquid crystals
19.00	**dinner**	
Saturday Sept. 12th, 2015		
8.00 - 9.30	**breakfast**	
10.00	Ewa Weinert-Rączka and Mirosław Karpierz	Trends in nonlinear optics: panel discussion
12.00	**closing**	

NONLINEAR OPTICS APPLICATIONS, OLSZTYN 2015
LIST OF PARTICIPANTS

1	Assanto	Gaetano	University Roma Tre
2	Berczyński	Paweł	West Pomeranian University of Technology in Szczecin
3	Hołdyński	Zbyszek	InPhoTech
4	Jabłoński	Błażej	Westpomeranian University of Technology in Szczecin
5	Jóźwik	Michalina	InPhoTech
6	Jung	Paweł	Warsaw University of Technology
7	Karpierz	Mirosław	Warsaw University of Technology
8	Kerasidou	Ariadni	University of Angers
9	Klus	Bartłomiej	Warsaw University of Technology
10	Królewicz	Adam	Warsaw University of Technology
11	Kwaśny	Michał	Warsaw University of Technology
12	Laudyn	Urszula	Warsaw University of Technology
13	Lederer	Falk	Friedrich-Schiller-Universität Jena
14	Lutkiewicz	Justyna	Warsaw University of Technology
15	Miśkiewicz	Eliza	Westpomeranian University of Technology in Szczecin
16	Mitschke	Fedor	Universität Rostock
17	Morandotti	Roberto	INRS-EMT
18	Nasiłowski	Tomasz	InPhoTech
19	Ostromęcka	Iga	Warsaw University of Technology
20	Sala	Filip	Warsaw University of Technology
21	Weinert-Rączka	Ewa	Westpomeranian University of Technology in Szczecin
22	Zawadzka	Anna	Nicolaus Copernicus University
23	Ziołowicz	Anna	Warsaw University of Technology / InPhoTech
24	Żegliński	Grzegorz	Westpomeranian University of Technology in Szczecin


Ogród w Olsztynie
(Projekt Olsztyn...
Artyleryjska
51
Olsztyn
Zachodni PKP
527
Marii Konopnickiej
Pod Zamkiem. Hotel
Zamek Kapituły
Warmińskiej
Olszyny
1 Maja
Warmińska
Dąbrowszczaków
Mazurska
Sztadex
Hotel Warmiń
ŚRÓDMIEŚCIE
Aura Centrum Olsztyna
22 Stycznia
Okopowa
Piastowska
Prosta
Smętka
Park centralny
Emilii Plater
Tadeusza Kościuszki
Tadeusza Kościuszki
Hotel Wileński
Hotel Villa Pa
527
Na Skarpie
Hotel Kopernik
w Olsztynie
KIE
Alojzego Śliwy
Janus. Firma
transportowa. Zalewski J.
Mariańska
Kazimierza Jagiellończyka
Dane mapy ©2015 Google
Warunki
Prywatność
Edytuj mapę
200 m



Zaloguj
Zamek Kapituły Warmińskiej
Muzeum Warmii i Mazur
Hotel Wysoka Brama
les Polska
KFC
Aleja M
Aura Centrum Olsztyna
22 Stycznia
Marcina Kromera
Olsztyńskie Centrum Bowlingu
Pomnik Mikołaja Kopernika
Polsko-Niemieckie Centrum Młodzieży...
Staromiejska
Seweryna Pieniężnego
Stare Miasto
Stary Ratusz
Piastowska
Okopowa
Podwale
Jana Długosza
Bazylika Archikatedralna św. Jakuba
Kuria Metropolitalna Archidiecezji...
Aleja Chateauroux
Grunwaldzka
Chilli Cocktail Bar & Restaurant
Karczma Jana
Prosta
Stanisława Staszica
527
Aleja Gelsenkirchen
Smętka
Żłobek Miejski nr 3
Górna
Feliksa Szrajbera
Wydział Komunikacji Urząd Miasta Olsztyna
Hotel Wileński
Zarząd Dróg Zieleni i Transportu w Olsztynie
Władysława Orkana
OSK Centrum Nauka Jazdy
McDonald's
Ryszarda Knosały
Aleja Warszawska
Emilii Plater
Google
Dane mapy ©2015 Google
Warunki
Prywatność
Prześlij opinię
Edytuj mapę
50 m