Contributed papers

Poster session - Tuesday

Transient aspects of two-level atom in laser light

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In quantum optics, some models are considered to describe many aspects of the dynamics of atoms coupled to an electromagnetic field (laser). The simplest atomic model is of course the two-level-atom which is governed by the Bloch optical equations. In general this system is solved in the steady state or by using some approximations. An extended analytic approach is considered for this coupled equations. The separation approach of coupled differential equations is always possible with a sequence of special transformation into nonlinear differential equations [1]. The conditions that permit an exact solution of three coupled systems are extracted in a natural manner. The case of Eu^{3+} ion moving in plane-light wave and standing-wave is treated with some details [2, 3]. The implications of the results for operating atoms and ions using laser light are discussed.

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Possibility of enhancement of amplitude-squared squeezing in mixing with coherent light beam using a Mach-Zehnder interferometer

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Recently, Prakash and Mishra [1] showed that amplitude-squared squeezing [2] of a light beam having Gaussian statistics can be enhanced in a linear mixing with a coherent light beam using a beam splitter. We investigate, here, the possibility of enhancement of amplitude-squared squeezing, which can be detected by higher-order sub-Poissonian photon statistics [3], for Mach-Zehnder interferometer as a next order generalization. It is found that under some conditions amplitude-squared squeezing at output of second beam splitter is enhanced as compared to that at one output of the first beam splitter. But the maximum amount of amplitude-squared squeezing obtained by the present mixing is not greater than that obtained by Prakash and Mishra [1]

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Narrowing of Zeeman coherences due to diffusion induced Ramsey effects

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We investigated experimentally spectral narrowing of electromagnetically induced transparency (EIT) of the probe laser beam arising from the diffusion of atomic coherence, induced by spatially separated pump laser beam. This work extends previous studies of diffusion-induced Ramsey narrowing [1,2]. In our experiment, pump laser beam covers the entire gas cell volume, except for a small central circular region (diameter of 2 mm) reserved for interaction with the probe laser beam. Therefore, effects of Ramsey narrowing were expected to be more pronounced in comparison with spatially separated beams [1].

In the experiment we employed a diode laser locked to the $Fg = 2 \rightarrow Fe = 3$ transition of ^{87}Rb D1 line. The laser beam is divided in to two parts, and spatially separated, cylindrically symmetric probe and pump laser beams were send through Rb cell by means of the mirror with the 2 mm diameter hole in the middle. Probe laser transmission through Rb gas cell, without buffer gas, was measured in a Hanle configuration. Such set up allows coherently prepared and aligned atoms to enter central, probe laser region, from any direction. By this, we simulate effects of buffer gas cells or cells with wall coating [2]. Therefore, effects of Ramsey narrowing are expected to be more pronounced in comparison with spatially separated two linear laser beams [1].

We use different pump and probe laser beam polarization in order to better understand and describe diffusion of two photon induced coherences. Strong probe EIT resonance narrowing is measured for laser beams linearly polarized and parallel, sign inversion of the EIT is detected in the case of opposite orthogonal polarization of the probe and the pump, while dispersion like resonance is obtained when planes of laser polarizations are at 45 degrees.

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Sources of spontaneous narrow-band uv and vuv radiation

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Excilamps are a kind of gas-discharge lamps radiating in UV- or VUV-spectral region due to the decomposition of excimer molecules (excited dimer - excimer, in the case of a molecule consisting of equal atoms, Ar2* for example) or exciplex molecules (excited complex - exciplex, in the case of a hetero-nuclear molecule, XeCl* for example) [1]. According to the gas composition and conditions under which the electrical discharge is effected, exciplex/excimer is formed in accordance with different mechanisms (the Harpooning reaction, the ion-ion recombination). The spontaneous decomposition of excimer or exciplex molecules into separated atoms is accompanied with radiation of light quantum typical for this molecule. Such type of radiation sources provide photon energy from 3 to 10.5 eV, that is sufficient to apply excilamps practically to all known photoprocesses in which UV and/or VUV radiation is required. Due to extraordinary properties of excilamps, their appearance on the world market of science technologies has been met with considerable interest [2]. Originality of excilamps consists in the next:

1. simple device construction (in comparison with excimer lasers);
2. unlike mercury, hydrogen and thermal sources of spontaneous UV or VUV radiation, the main part of the radiation power of excilamps driven by the capacitive or the barrier discharges (up to 80%) is concentrated in a band of $B \rightarrow X$ transitions with 10 nm FWHM [3], because of this, excilamps can be used in applications where selective influence of radiation on investigated object is required [4, 5];
3. it is possible using excilamps to irradiate at once large area of an object;
4. working gas of excilamps does not contain metal vapors such as mercury and cadmium, that is why it is easy to recycle excilamps after ending of their lifetime. Pre-production models of excilamps developed in the laboratory of optical radiation are described; main characteristics of radiators and their power supplies, portable UV-excilamps of the barrier or capacitive discharges, and also powerful VUV-excilamps of the barrier discharge which can be used for cleaning or modifying material surfaces are presented.

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Interference phenomena in the Na^+ - He, Ar and He^+ - O_2 collisions

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In this work, we experimentally study excitation processes by optical spectroscopy method at laboratory collision energies of 2-11 keV. The spectral analysis of the radiation was performed in the vacuum ultraviolet (50.0-130.0 nm) and visible (400-800 nm) spectral region. The inaccuracy of measuring the absolute and relative values of the cross sections considered in this work does not exceed 25% and 5%, respectively.

For Na^+-Ar pair in the energy dependence of the excitation cross section of argon atomic lines (λ=104.8 nm; 106.7 nm; transition 4s, 4s'-$3p^6$) the oscillation structure have been observed.

In the case of Na^+- He pair the same type of structure for helium atomic line (λ=58.4 nm, transition 2p-1s) and sodium resonance atomic lines (λ=589.0; 589.6 nm, transition 3p-3s) have been observed in anti phase.

In the He^+-O_2 collisions the oscillation structure, especially for dissociative excitation processes, was revealed. Particularly, this phenomena was observed for the oxygen atomic (97.4 nm; 99.0 nm; 102.6 nm; 115.2 nm and 130.5 nm) and ionic (53.4 nm; 83.4 nm) lines.

An observed structural peculiarity is explained in the framework of Rozental-Bobashev model [1]. The oscillatory structure is investigated on a base of phase interference phenomena, that is realizes between quasi-molecular, closely spaced in energy states of the collision system.

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Narrowband Rb Resonant Downconversion Source for Quantum Memories

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Delay and storage of quantum information encoded in light beams is an important part of many quantum information protocols. The delay of classical information via EIT has been demonstrated and characterized recently [1]. The efficiency of the transfer of information encoded in the light depends on the noise introduced during the delay and/or storage, which makes the characterization of the noise properties of these processes essential. It is already proven [2] that it is possible to build the rubidium resonant source of squeezed light necessary for testing suitability of this delay technique on quantum information.

We present here a technically improved source of such rubidium resonant squeezed light. It uses a new pumping laser system and technologically advanced locking scheme. To produce squeezed light, we use the proven technique of downconversion in subthreshold OPO but with a distinct difference: our OPO is not pumped by a Ti:Sapphire laser, but by a diode laser system. This system consists of an external-cavity diode laser which is further amplified by an optical tapered amplifier and then frequency doubled in an LBO doubling cavity. The complete system of diode laser, amplifier and doubling stage is commercially available. Its output is modematched to the doubly resonant OPO cavity in bow-tie configuration and PPKTP as nonlinear material. Compared to Ti:Sapphire laser systems, diode lasers are easy to operate, versatile and much lower priced in acquisition and maintenance. However, the excess phase noise of the pump diode laser limits its coherence length, and by that its suitability as local oscillator. The level of noise in the homodyne signal is determined by the noise spectrum of the diode itself and by the delay introduced in the squeezed beam by different cavities. Simultaneously they increase the phase variance, creating an obstacle for successful homodyne measurement. We will compensate the delay introduced by the cavities by implementing a controllable length delay of the local oscillator. In addition we can lower the phase variance by changing the noise properties of the diode itself through building of a tight lock to the atomic resonance which would lower the linewidth of the laser. As a second improvement, the locking electronics for the OPO is not anymore based on analog electronics but on a fast digital controller circuit programmed in an FPGA. It can drive up to 8 control loops in parallel at a maximum bandwidth of 200 kHz limited by the sampling rate of the analog inputs. The use of digital electronics for the stabilization allows a more flexible and complex controller. Even more, the system can be automatically (re)locked by the controller. This makes it very stable and easy to operate.

Once proven and characterized, the source will be used for delaying the quantum information and testing the influence of the different delay techniques [1, 3] on nonclassical noise properties. The improvements we made compared with [2] are simplifying the handling of the system, and shortening the time necessary to bring the light source in operation, what is necessary when it is used in more complicated experiments.

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On Applying the Integral of Motion Method and Quasi-energy Method to the Problem Radiation of Charges in Time-periodic Fields

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In this talk some aspects of application of the integral of motion method are developed conformably to systems with time-periodic Hamiltonian. For such systems the representation by quasi-energy and quasi-energetic states proves to be the most convenient. The integral of motion method and coherent states method prove to be effective for calculating the motion and the radiation of systems of wave-guide type. The radiation of a non-relativistic charged particle which paraxially moves in a waveguide or a resonator is calculated by such method. There are examined in detail some interesting cases.

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Proposed experiment with Rydberg atoms to study the influence of particle size on quantum interference

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Atomic interferometry demonstrates quantum properties of atomic center of mass motion. In a class of atomic interference experiments internal states do not change, so that it is sufficient to consider only external states in explaining these experiments. But, in a wider class of atomic interference experiments internal states change and play an important role.

Our aim in this paper is to look for the answers to some questions, which naturally arise when one starts to think about possible influence of the size of a particle on the transmission, diffraction and interference pattern behind a grating with slits. A quite old experiment of Haroche's team [1] with Rydberg atoms shows that Rydberg atoms do not pass through $1\mu m$ wide slits if their principal quantum number is rather large ($n > 60$). Thus, the particle density measured after the slits is null. What about a wave function behind the array of narrow slits?

The wave function of an incident atom is the product of a wave function of the center of mass motion and of an internal wave function. What is the influence of slits upon each one of them? Whether both functions are equal to zero behind the slits?

In the traditional explanation of this experiment the latter two questions have not been posed. The standard interpretation considers only a wave function of the center of mass motion and supposes that if the particles do not pass, a wave function of a particle, implicitly identified with a wave function of the center of mass, is null behind the slits (*standard assumption*).

But, an internal wave function describes the size of a particle. So, logically one should expect that the slits influence an internal wave function. For particle size larger than a slit, one may assume that this function reduces to zero. Consequently, one cannot thus eliminate logically alternative interpretation of this experiment, which supposes that the wave function of external motion passes through the slits, but not the particle (*alternative assumption*) [2,3].

In this paper we propose an experiment testing this *alternative assumption* compared to the *standard assumption.* It is an experiment with large particles (Rydberg atoms or large molecules) sent trough a grating consisting of : one wide slit which let the particles pass, and many small slits which do not let them pass. Theoretical predictions under the two different assumptions, mentioned above, are derived using numerical simulation of particles' arrivals to a screen after passing through this complex grating. This numerical simulation is based on the time dependent solution of Schrodinger's equation for a quantum particle behind a grating [3,4].

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Limitations of the generalized coupled two-level model during the multiphoton absorption in different gas mixtures

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Generalized coupled two – level model is applied in different gas mixtures and investigated for high fluence regime. Functional dependence of mean number of absorbed photons per molecule ($<n>_{total}$) on buffer – gas pressure (p_{buff}) for various laser beam fluences is presented, used to confirm or predict certain possible physical and chemical processes, such as enhanced absorption and/or dissociation. Limitations of proposed models are analyzed depending on both gas pressure and laser fluence. Results are compared with other previously obtained by the same experimental technique, but for different absorbing molecule.

Calculation of the highly excited SF_6 vibrational state distributions and the dissociation yields in different gas mixtures

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Influence of the buffer - gas on the multiphoton absorption and dissociation in different mixtures was investigated. Simple method based on the empirical and theoretical vibrational energy distribution is applied for high fluence regime. Collisional effects of buffer – gas (Ar) are introduced to enhance the absorption and relaxation of irradiated molecules (SF_6 and C_2H_4). Functional dependences of mean number of absorbed photons per molecule ($<n>_{total}$) on the excitation level are presented, enabling us to confirm or predict the level of excitation, number of molecules directly involved in the absorption process and dissociated during the laser pulse.

AC magnetic field influence on the Electromagnetically Induced Transparency resonance

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Electromagnetically Induced Transparency (EIT) phenomenon has found many applications ranging from lasing without inversion through atomic cooling and slow light to atomic frequency standards and precise magnetometers. By means of optical magnetometers mainly the DC component of magnetic field (MF) is measured, and the bandwidth is limited to several hundred Hertz. In Ref. [1], the EIT phenomenon under AC MF influence has been investigated. Here Zeeman sub-levels of the two hyperfine (hf) levels of the ground states of Cs are coupled forming a superposition states that do not interact with the optical excitation. Different approach is used in [2] where ground state coherence is prepared involving Zeeman sublevels with $\Delta M = 2$. In this case the used sublevels belong to a single ground state hf level in Rb. The NMOR technique is employed and as a result AC MF amplitude could be measured with the limitation related to the relaxation rate of the alignment state.

In this communication we present the results of our study concerning the AC MF influence on the EIT resonance based on sublevels belonging to a single hf level. There are two main differences between Ref. [2] and the approach proposed here. First, we excite Zeeman coherence with $\Delta M = 1$ and second, the applied AC and DC MF are collinear in contrast to the case [2] where they are applied perpendicular to each other. The ^{87}Rb D_1 line is used to prepare the atomic medium in non-absorbing state via modulated optical pumping. In unshielded laboratory conditions, EIT resonance is observed with the width as low as 100Hz. The EIT resonance modification under the AC MF influence and the generation of new EIT components are investigated both theoretically and experimentally.

Two cases are studied: (i) when the frequency of the applied AC MF field is lower and (ii) when it is higher than the unperturbed EIT resonance width. In the first case the EIT resonance broadening is observed depending on the AC MF amplitude, while in the second one a comb of EIT resonances is generated with controlled number of resonances and controlled amplitude of every resonance. The proposed excitation of the $\Delta M = 1$ coherence allows us to follow a simple theoretical two-level model [3] that describes very well the observed experimental results and opens a way for measurement of the field amplitude. The proposed scheme allows also controlling of the frequency position of different components and makes possible engineering of a tailored comb of EIT resonances.

Based on the obtained results, a methodology can be developed for detection of weak low frequency AC MF and for measurement of the amplitude and frequency of AC MF with frequency up to several MHz. This is of great importance for application in the field of the electromagnetic pollution monitoring and control, and represents a milestone for precise magnetometry and metrology.

The work is supported by the INTAS South-Caucasus Program (grant: 06-1000017-9001) and by the National Science Fund of Bulgaria (grant: F-1404/04).

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Power dependence of the single frequency coherent-population-trapping resonances

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The investigation of the coherent population trapping (CPT) resonance on the degenerate two-level system of the ($F_g=2 \rightarrow F_e=1$) transition of the ^{87}Rb D_1 line by means of a Hanle effect configuration (the single frequency CPT resonance) in an uncoated vacuum cell has shown that the resonance has a complex shape - a very narrow (about 1 mG) structure superimposed on a broader one (about few tens of mG) [1]. In this work, the power dependence of the amplitude, width and shape of the single frequency CPT resonance structures is investigated.

The amplitudes of the narrow and broad CPT resonance structures increase with power. In the range of the power densities of our experiment (up to 1 W/cm^2), the amplitude of the narrow structure does not saturate, while the amplitude of the broad structure saturates [1,2].

While the width of the narrow structure does not change within the limits of the accuracy of our measurements, the width of the wide resonance dependence is complex [2]. The origins of the observed resonance width narrowing of the CPT resonance structures are discussed.

The influence of the high rank polarization moments (HRPM) on the CPT resonance shapes increases with power. Experimentally this influence has been evaluated separating the different resonances by magnetic field modulation [3]. As the amplitude of the narrow structure is bigger than this of the parametric resonance, we measured the influence of the HRPM on the wide component shape, eliminating the narrow structure by applying an additional transverse magnetic field.

Numerical simulations based on density matrix formalism, which take into account the high rank polarization moments (HRPM) influence and the velocity distribution of the atoms are used to obtain the shape of the resonances [4]. The comparison of the experimental shapes of the CPT resonances with the theoretical shapes has shown that the HRPM influence the shape at all powers and this influence can be used for explanation of the observed CPT resonance shape peculiarities at the center of the resonance.

The obtained results will be useful for applications in high resolution spectroscopy, metrology and magnetometry.

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Electromagnetically Induced Absorption resonance sign reversal

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Electromagnetically Induced Transparency (EIT) has attracted expanding attention due to its numerous applications in ultra-high-resolution spectroscopy and high-precision measurements. Electromagnetically Induced Absorption (EIA) phenomenon has been much less studied.

In this communication we analyze the EIA resonance observed in Cs vapour confined in cm-/nm-thick cells. Cs atoms, situated in magnetic field B orthogonal to the atomic orientation/alignment and scanned around B = 0, are irradiated by monochromatic laser field in such a configuration that different polarization components of the light couple Zeeman sublevels of one of the ground hf levels and introduce coherence between ground magnetic sublevels at B = 0. In the absence of depolarizing collisions of the excited state, EIT or EIA resonance can be observed, depending on the ratio of the degeneracies of the two states involved in the optical transition [1]. The EIT resonance is realized when the condition $F_g \longrightarrow F_e = F_g - 1, F_g$ is met, while the EIA resonance is observed for $F_g \longrightarrow F_e = F_g + 1$ transitions. Here, F_g and F_e are the hf quantum numbers of the ground and excited hf levels, respectively. When performing the experiment on the D_2 line of dilute Cs vapor, the three hf transitions starting from single ground hf level will be excited independently, each one at different velocity class of atoms. Under these conditions the open transitions are depleted because of the hf optical pumping and do not play a significant role in the formation of the resonance. At the same time, the closed transition mainly determines the sign of the resonance. Thus, in the cm-size cells EIT resonances are observed for the $F_g = 3$ and EIA resonances for the $F_g = 4$ sets of transitions. However, it turns out that the bright resonance is very sensitive to the buffering of the cm-size cell. If the cell containing Cs is buffered by some noble gas, the resonance at the $F_g = 4 \longrightarrow F_e = 5$ transition is changed from EIA to EIT one [2]. This transformation of the resonance sign has been attributed to the depolarization of the F_e level by collisions of alkali atoms with the buffer gas atoms. Recently similar transformation of the EIA resonance to EIT one has been observed [3] in Cs vapour confined in Extremely Thin Cell (ETC, thickness $\leq \mu m$) [4] where the hf transitions are well resolved, and the coherent effects are investigated under better-defined conditions than in the case of cm-size cells. It has been assumed that in the ETC a similar depolarization of the F_e level can occur due to the long-range interaction between Cs atoms and the two window surfaces of the ETC. Hence, the found sensitivity of the EIA resonance to the polarization of the excited state is promising for EIA applications in interaction study between atoms and atom:surface.

Authors are grateful for the supports from INTAS (grant: 06-1000017-9001), B.F.S.R. (grant: F-1404/04), R.F.B.R. (grant: 07-02-00954) and Rila collaboration (grant: 3/10).

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Construction of Optical Tweezer Raman System

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Optical Tweezers have become a powerful tool to study optically manipulated single particles[1]. The combination of optical tweezers with Raman spectroscopy allows to obtain the Raman spectra of a single isolated micron sized particles in a diameter range from 20 nm to 20 μm[2]. In this work we present a Raman tweezer set up to investigate a single trapped biological particle in their natural environment. In our setup a high N.A. microscope objective is being used to focus a diode laser beam at 780 nm for the optical trap. The same laser was also used as the excitation beam for Raman scattering of the single trapped particle in an aqueous solution. The Raman scattering from the trapped particle was collected by the same microscope objective and directed to the spectograph by using suitable optical arrangement. We have analyzed the raman spectra of polystyrene bead to optimize the system.

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Energy levels scheme for Eu^{3+}:$ZnGa_2O_4$

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Zing gallate ($ZnGa_2O_4$) is a normal spinal crystal structure (space group Fd3m), with Zn^{2+} ions in the tetrahedral sites and Ga^{3+} ions in the octahedral sites. $ZnGa_2O_4$ doped with some traditional metal or rare earth ions, such Cr^{3+}, Mn^{2+}, Eu^{3+} [1-3] is used for low-voltage cat hodoluminiscent and vacuum fluorescent display, promising candidate for emitting lager for field emission displays and luminescent devices and possible candidate for tunable solid state laser materials in the visible and NIR. The optical and structural properties of nanocrystalline material differ dramatically from those of the bulk [4]. Experimental data shows that Eu^{3+} ions of bulk sample $ZnGa_2O_4$ prefer to occupy Td sites or distasted Oh sites with no inversion symmetry, whilst in the nanocrystalline $ZnGa_2O_4$:Eu^{3+}, the Eu^{3+} ions preferably occupy normal Oh sites with inversion symmetry. The main goals of this work is theoretical calculation of the energy level scheme of transitions $^5D_0 - {}^7F_j$ (j=0 – 6) in the exchange charge model [5] and explain, the experimental results of [4] regarding structures spectra of $ZnGa_2O_4$:Eu^{3+} in both bulk and nanocrystalline systems. The obtained results suggest that Eu^{3+} ions can be doped into Oh Ga^{3+} sites for nanoparticles and prefers to occupy Td sites of Zn^{2+} in bulk host materials.

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Modulation of optical properties PbS quantum dots by 4,6-diamino-2-mercaptopyrimidine capping agent.

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Semiconducting nanocrystals (NC) PbS are very interesting due to their peculiar optical properties, e.g. ultrafast dynamics of the excited states or strong nonlinear features in near infrared. Thanks to these properties quantum dots can be used for construction of photonic devices. The PbS nanocrystals have already been applied for construction of the laser mirrors used for light modulation [1,2]. Herewith we present optical properties of quantum dots PbS synthesized by use of different compounds passivating the surface, what should influence the relaxation time of excited molecules. In order to get nanoparticles of different sizes (what determines the appropriate widths of the restricted bands) the investigations have been performed at different temperatures. The size and the shape of the obtained nanocrystals are found by methods of small angle X ray Scattering and Atomic Force Microscopy. Absorption and stationary fluorescence measurements are applied for investigation of optical properties of the synthesized materials. The dynamics of the relaxation process is monitored by transient absorption measurements.

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Geometry of the $^4T_{2g}$ excited state in $Cs_2SiF_6:Mn^{4+}$

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The vibronic spectra and lattice dynamics of $A_2^1 M^{IV}F_6$:MnF_6^{2-}compounds (A^1 = Cs; Ge) have been investigated from both experimental and theoretical point of view [1-3]. The spectra of Mn^{+4} ions in various crystals are strongly influenced by the coupling between the phonons of the host matrix and the electronic state of the impurity ions. The adiabatic potentials corresponding to the ground and excited states of Mn^{4+} ions in the $[MnF_6]^{2-}$ cluster have different geometries. This leads to a relative displacement of their potential energy surface along the a_{1g} and e_g normal vibration modes of the cluster.

In order to calculate the equilibrium displacement of the $^4T_{2g}$ potential surface minimum from the ground state along the a_{1g} and e_g Jahn-Teller active modes we used the following equation, $\left|\Delta Q_i\right| = \left[\frac{2S_i\hbar\omega_i}{k_i}\right]^{1/2}$, where i = a_{1g}, e_g the normal vibration modes. The k_i force constants are calculated with FG matrix method for the octahedral $[MnF_6]^{2-}$ cluster and $\hbar\omega_i$ frequencies for a_{1g} and e_g modes (590 cm^{-1} , 510 cm^{-1}, respectively) are taken from Ref.[4]. The Huang-Rhys factors S_{a1g} = 2.75 taken from paper [5] and S_{eg} = 0.823 was calculated by us from the value of the Jahn – Teller stabilization energy obtained earlier by us [6]. Using these data we estimated $\left|\Delta Q_{a_{1g}}\right|_{eg}$ = 0.1846 Å and $\left|\Delta Q_{eg}\right|_{eg}$ = 0.0879 Å. For convenience and easier visualization these numbers can be converted into the changes in the metal – ligand bound lengths, $\Delta x_{eg} = \Delta y_{eg}$ = 0.05 Å and Δz_{eg} = 0.02 Å, i.e. in $^4T_{2g}$ the bonds Mn-F are simultaneous elongated along all the axis.

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Fluorescence spectra study in extremely thin Cs-vapor layers

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High resolution laser spectroscopy of atoms confined in a thin cell (10 - 1000μm) is promising for the investigation of complex spectra of atoms and molecules [1,2]. Further study of alkali-vapor layers has been made possible through the development of Extremely Thin Cells (of thickness ≤ 1 μm) [3]. The vapor-layer thickness can be precisely controlled in an interval around the wavelength of the irradiating laser light. Interesting coherent effects are observed in absorption profiles changing their width periodically, with minima at $L= (2n+1)\lambda/2$ (n - integer) [4]. At the same time similar periodicity has not been reported in relation to the fluorescence profile behavior.
Here we present experimental and theoretical study of absorption and fluorescence spectra on the D_2 line of Cs-atomic-layers with thickness $L = m\lambda$ (where m = 0.5, 0.75, 1, 1.25), when irradiated by frequency tunable single-frequency diode laser light. The absorption spectra observed experimentally for low light intensity, are in agreement with the theory related to the Dicke-type coherent narrowing of hyperfine optical transition profiles. When the irradiating laser light intensity increases and $L>\lambda/2$, in the absorption spectra the coherent Dicke narrowing is accompanied by some drop in absorption [5]. Our theoretical model based on the Optical Bloch Equations results in qualitative agreement between the theory and the experiment in relation with absorption spectra. The calculations are made for two level system, closed or open transitions as well. The absorption spectra shows the collapse when $L = (2n)\ \lambda/2$) and revival of Dicke-type coherent narrowing of hyperfine optical transition profiles in case of $L = (2n+1)\ \lambda/2$. In the calculated fluorescence spectra and $L> \lambda/2$ for the closed transitions starts a significant power broadening, accompanied by some pick for the case of $L = 1.25\lambda$. Well pronounced narrow dip in the fluorescence (superimposed on the top of the sub-Doppler-width fluorescence profile) is observed experimentally only for the open transitions suffering hyperfine/Zeeman optical pumping and $L>\lambda/2$. In the case of closed transition, non-suffering population loss small peculiarity in the fluorescence profile is observed depending on the cell thickness. The simulations are in very good agreement with the experimental observations.
The presented results contribute to the further advancement in fundamental studies of saturation and optical pumping in extremely thin vapor layers. They show that interesting peculiarities occur when the vapor layer thickness is approaching the wavelength of the irradiating laser light.
Authors are grateful for the partial supports from INTAS (grant: 06-1000017-9001), B.F.S.R. (grant F-1404/04) and the French-Bulgarian Rila collaboration (French grant: 98013UK, Bulgarian grant: 3/10).

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Quantum time of flight distribution for cold trapped atoms

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The time of flight distribution for a cloud of cold atoms falling freely under gravity is considered. We generalise the probability current density approach to calculate the quantum arrival time distribution for the mixed state describing the Maxwell-Boltzmann distribution of velocities for the falling atoms. We find an empirically testable difference between the time of flight distribution calculated using the quantum probability current and that obtained from a purely classical treatment which is usually employed in analysing time of flight measurements. The classical time of flight distribution matches with the quantum distribution in the large mass and high temperature limits.

Angular distortion around Cr^{3+} ions doped diammonium hexaaqua magnesium sulphate single crystal

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It is well known that when a paramagnetic ion Cr^{3+} substitutes a host ion in a crystal like diammonium hexaaqua magnesium sulphate $(NH_4)_2Mg(SO_4)_26H_2O$ (DAHAMS), it can obtain useful information on the local structure around impurity center by analyzing its EPR data.

DAHAMS crystallizes with space group $P2_1|a$ and its monoclinic unit cell has lattice constants a=9.316, b=12.580 and c=6.202 Å, Z=2 and the angle β=107.09° [1].

When Cr^{3+} is introduced in DAHAMS crystal it substitutes for Mg^{2+} in a distorted octahedral coordination and are bound electrically to the neighbouring NH_4^+ vacancies necessary for charge compensation [1].

The aim of the present study is to explain the local distortion around Cr^{3+} ions in the title crystal using the latest experimental data regarding optical and EPR spectra [1]. We calculated g and D spin-Hamiltonian parameter as function of θ angle between the C_3 axis and metal-ligand chemical bond in local distorted octahedral cluster $[CrO_6]^{-9}$ formed after doped crystal. Following the line of paper [2] we estimated the value of θ from Macfarlane [3] equation for the zero field splitting. With the experimental data from [1] (optical spectra and EPR data) the obtained value is θ = 54.5512°.

Once this angle is determined, EPR g factors, and trigonal field parameters ν and ν' were evaluated. The obtained values for g factors $g_{\|}$=1.9733, $g_{\perp}$=1.9728 differ from the isotropic g =1.9763 value from [1], according the real distortion of $[CrO_6]^{-9}$ octhaedra reflected in different of zero experimental value of zero-field splitting D parameter.

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Effect of laser light ellipticity on Hanle EIA amplitude and linewidth

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Using the $^2S_{1/2}F_g = 2 \longrightarrow {}^2P_{3/2}F_e = 3$ transition in ^{87}Rb, we analyzed the interaction between the arbitrarily polarized laser light and Zeeman sublevels in the Hanle configuration. We studied theoretically and confirmed experimentally that the effect of the laser light polarization on the electromagnetically induced absorption (EIA) strongly depends on the laser light power. It was shown [1], for $F_g = 2 \longrightarrow F_e = 3$ transition in ^{87}Rb, and for single laser light power (3 mW), that EIA linewidths increase with polarization ellipticity and that EIA amplitude has maximum for certain laser light polarization different than linear.

In this study we extended the work of [1]. We present the results for resonance line shapes and for the behavior of amplitudes and widths of EIA for different laser light polarizations and for the laser light power $\leq 200\mu$W. Calculations were done by solving optical Bloch equations and by averaging over Maxwell-Boltzmann velocity distribution. We present how the behavior of amplitudes and widths of EIA with laser light polarization ellipticity changes with the laser light power. It is verified that for small laser light power maximal EIA amplitude is for the linear polarization, whereas for larger power [1] maximum of the EIA is at higher polarization ellipticity.

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Experimental suppression of the coupling laser absorption below the one-photon-transition absorption level in electromagnetically induced transparency spectra

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Electromagnetically induced transparency (EIT) spectra are often measured within a Λ-system as a function of the probe detuning from the two-photon resonance. In such a system—when the resonance conditions are fulfilled—the probe absorption spectra show a dark resonance which is superimposed to the Lorentzian profile typical for the probe absorption in the absence of the coupling laser.

Similar absorption spectra can be measured for the coupling laser. However, the corresponding measurements are seldom performed. Moreover, such measurements display a different physical phenomenon, i.e. the variation of the coupling laser absorption as a function of the probe detuning. In a way, they are measurements of the coherent interaction between the coupling and the probe laser, i.e. of the coherent population trapping.

In this contribution we present absorption spectra of a linearly polarised coupling laser interacting with a perpendicularly polarised probe laser taken in a Λ-system within the D_2 line of caesium. In particular, we experimentally show for the first time that in a lambda system it is possible to obtain absorption levels for the coupling laser which lie below the coupling absorption level measured when the probe laser is off-resonant, i.e. below the one-photon coupling absorption level. These can be considered the first measurements of real enhanced transparency for the coupling laser, in the presence of EIT for the probe. The signals were measured for various intensities of both lasers. It was possible to show that the coupling transparency was mostly enhanced when the intensity of the coupling laser did not exceed that of the probe laser. At higher coupling intensities the spectra were characterised by a broad Lorentzian profile with a central dark resonance which reached but did not cross the one-photon absorption level.

To minimise the Doppler broadening of the signals the authors utilised an atomic beam of caesium atoms propagating perpendicularly to the direction of propagation of the lasers. The lasers were phase-locked to one another with a chain of subsequent phase-locked loops and were organised in a heterodyne interferometer. In this way signals with a half-width below 20 kHz could be measured. Further details on the setup can be found in [1,2].

The work was made possible through the financial support of the grant No. SFB407 of the German Research Foundation (Deutsche Forschungsgemeinschaft).

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Investigations on Coherent Population Trapping Resonances with coherently coupled Lasers

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Coherent population trapping (CPT) is a resonance phenomenon due to a quantum mechanical interference effect in an atomic system[1]. The resonantly driven atomic level population is being trapped into a superpositional dark state, yielding the atomic medium transparent for the exciting electromagnetic fields. The observation of this effect requires a special electronic structure ($\Lambda-$System) and suitable lifetimes which can be found e.g. in alkali atoms. The vanishing absorption leads to a reduction of fluorescence light intensity and the atomic vapor appears darker, therefore the designation as a 'dark resonance'. The width of these CPT-resonances can be extremely small, so that they are of particular interest in precision measurements as well as in applications in magnetometry or as a CPT-atomic clock[2].

A condition for observation of narrow CPT-resonances is a coherent bichromatic light field. Therefore an optical phase lock loop (OPLL) laser system[3] is used. This system consists of a pair of phase stable coupled lasers. With a special design of the OPLL servo electronics a good phase noise performance and thus a good signal to noise ratio of the CPT dark resonances is achieved.

In our experiments investigations on CPT-resonances in buffered ^{87}Rb thermal vapor cells were made. We studied the behavior of CPT-resonances using magnetic hyperfine sublevels of the ^{87}Rb D_1 line in dependence of the transmitted laser power for different beam diameters, cell temperatures and buffer gases. In these experiments CPT-resonance line widths down to 30 Hz were achieved. In the latter case the width of the CPT-resonance is mostly limited by time of flight broadening effects of the diffusive motion of the Rubidium atoms in the buffergas. The dependence of the CPT-resonance width on the temperature can be qualitatively explained by spin exchange collisions and a line narrowing due to optical thickness [4].

The presented data material is interesting in fields like magnetometry or CPT atomic clocks where optimized parameters of the CPT-resonances - on the ^{87}Rb D_1 line - are needed in order to reach maximum performance.

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Intrinsic optical bistability in a two-level system as switching in fluorescence and probe absorption spectra

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Intrinsic optical bistability is considered in a two-level medium as the external field controlled switching between different spectral pictures of the probe beam absorption and fluorescent response. The steady-state spectra are calculated both analytically and numerically for the entire hysteresis loop of atomic excitation. The conditions for enhancement of the effective field contribution are demonstrated. The equations to describe the non-linear interaction of an atomic ensemble with light are derived from the Bogolubov-Born-Green-Kirkwood-Yvon hierarchy for reduced density matrices of atoms and quantized field modes and their correlation operators. The equations for spectral intensities are obtained straightforwardly within the hierarchy.

Finding solitons by linear stability analysis in bifurcations of stationary solutions of complex Ginzburg-Landau equation

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Nonlinear dissipative systems, particularly optical dissipative solitons are well described by complex Ginzburg-Landau equation [1]. We investigated multi dimensional complex cubic-quintic Ginzburg-Landau equation (CQGLE) [2, 3]. Dispersion and diffraction in optical pulse are compensated by interplay of opposite sign cubic and quintic nonlinearities of CQGLE. In order to take into account linear and nonlinear losses always present in actual systems and to maintain solitonic structure, gain must be included.

We study solutions of two and three dimensional CQGLE assuming exponential dependence on propagation parameter. Approximate analytical stationary solutions of CQGLE are found by solving systems of ordinary differential equations. We are solving two-point boundary problems using adapted shooting method. Stable and unstable branches of the bifurcation diagram are identified using linear stability analysis. In this way we established conditions for generation and propagation of stable dissipative solitons in two and three dimensions. These results are in agreement with numerical simulation of CQGLE and the recently established approach [2, 3] based on variational method generalized to dissipative systems and therein established stability criterion.

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Holographic interferometer as a correlator of phase distortions with response in the form of interference pattern

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Considered in the work is known properties of holographic interferometer as according to the correlator with output signal in the form of interference fringes.

It is known a space correlation have various ratios of intensity between central correlation peak and background part for objects with different phase microrelief of a surface [1]. Correspondingly an interference pattern must have different space distribution of contrast. A magnitude of contrast depends on changes in distribution of microrelief of investigated object. Whereas the interference pattern depends on macroscopic modification of a form of the object.

Used here is a scheme of Fourier-holography with a random phase modulator in signal beam, reference beam is a point source, and restoring beam is the random phase modulator with random phase shift against initial random phase modulator. Also investigated is a recording of holographic interferogram with these random phase modulators.

As the results of original theoretical consideration was obtained an expression for fringe contrast and intensity of correlation peak. This model was tested by simulating of forming of holographic interferogram and reconstruction of the cross-correlation peak with phase distortions of various statistical distributions.

Compared here are theoretical results, simulation results, and results obtained in real experiment.

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A comparative analysis of associative properties of Fourier vs. Walsh digital holograms

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A digital implementation of Fourier holography scheme with identical reference and signal beams is considered. Investigations of the properties of this scheme were reported on in a number of papers. At the same time a concept of virtual optics is widely used in data encryption and data processing. Whereas digital implementation of Fourier holography scheme may be provided using not only discrete Fourier transform. Another discrete digital transform may be used as soon as it has several properties similar to Fourier transform. Walsh transform is the subject to consider in this work.

A comparison of digital Fourier and Walsh versions of the named holographic scheme is conducted by means of their associative properties. Considered is the retrieving of information stored in the hologram using a parts of different amounts of the original data. Comparison is provided with the two types of data stored: a raster image representing visual information and an image representing a set of data bits. Comparable parameters are the mean image contrast for visual data image and the bit detection accuracy for a set of data bits.

SLM as a medium for digital holography

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Digitally controlled Spatial Light Modulator (SLM) based on Liquid Crystal Device (LCD) or Digital Mirror Device (DMD) is a promising tool for creation of optically reconstructed digital holograms. SLM can work in two ways: as an amplitude modulator or as a phase one. Discrete structure of SLM with limited number of pixels and levels of signal value can generate effects unobserved in reconstruction process of traditional optical holograms. Additionally, SLM pixels are separated by light-stopping frames.

The influence of the specific properties of SLM on the quality of optically reconstructed holographic images has been numerically investigated. The obtained results have been presented in the form of the standard deviation and the signal-to-noise ratio in reconstructed images vs. quantities describing the specific properties of SLM.

Wavefront fast recovering with an Achromatic Three Wave Lateral Shearing Interferometer (ATWLSI)

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Achromatic Multiple-Wave Lateral Shearing interferometers (AMWLSI) [1] are used to measure, with high accuracy and high transverse resolution, wave fronts of polychromatic light sources. The wave fronts to be measured are replicated by a diffraction grating into several copies interfering together, leading to an interference pattern. A CCD detector located in the vicinity of the grating records this interference pattern. Some of these wave-front sensors are able to resolve spatial frequencies 3 to 4 timeshigher than a conventional Shack-Hartmann technique [2] using an equivalent CCD detector. Its dynamic is also much higher, 2 to 3 orders of magnitude. Theoretical description of AMWLSI is detailed in reference 1 where, as can be seen on figure 8, the recovery of the wave front derivatives required a minimum of 4 Fourier Transforms (FT). The 3 derivatives are projected following a least mean square technique to get 2 orthogonal derivatives. Several other time-consuming image-processing operations (such as thresholding, masking, least-square projection, or Fourier integration) are also required. For instance, an efficient and accurate way for recovering the phase from the 2 derivatives is to rely on the following 2D Fourier processing integration: $\tilde{\varphi}(\nu,\mu) = (\nu\tilde{\varphi}'_x + \mu\tilde{\varphi}'_y)/\left[2i\pi(\nu^2+\mu^2)\right]$, i.e. 3 more FT ($\tilde{}$ means FT). This all procedure allows a very accurate recovery but is processing-time consuming. We will show it is possible to skip most of it and get a measurement as accurate if we are interested only in defocus and astigmatism. Such fast phase recovery is of interest for applications where real time phase (low orders) monitoring is required (beamalignment for instance). Let us consider a phase carrying only curvature (x^2+y^2) and astigmatism (xy and x^2+y^2): $\varphi(x,y) = (2\pi/\lambda)\cdot(ax^2+bx^2+dxy)$, where a, b and d are constants. Curvature is then quantified by $(a+b)$ whereas astigmatism is by $(a-b)$ and d. We consider here the use of the more accurate interferometer of the AMWLSI family, the ATWLSI which relies on the use of a transmission grating creating three replicas (diffraction angle β) of the input wave front that are interfering together, resulting in a honeycomb-like interference pattern recorded at a distance z from the grating. The interferogram FT leads to a central harmonic $H_{0,0}$ surrounded by 6 primary harmonics $H_{m,n}$ following the hexagonal symmetry properties. $H_{m,n}$ coordinates are $(\nu_{m,n},\mu_{m,n})$ with the origin associated with $H_{0,0}$. Due to *FT* symmetry properties only 3 harmonics $(H_{-1,+1},H_{1,0},H_{-1,0})$ are carrying independent information. We show that their coordinates are related to the *a*, *b*, *d*, β and *z* constants according to the following matrix:

$$\begin{pmatrix} \nu_{-1,+1} \\ \mu_{-1,+1} \\ -\nu_{-1,0} \\ -\mu_{-1,0} \\ \nu_{1,0} \\ \mu_{1,0} \end{pmatrix} = \frac{1}{\lambda} \begin{pmatrix} d\sqrt{3} & 0 \\ 2b\sqrt{3} & -\sqrt{3} \\ -3a-d\sqrt{3}/2 & 3/2 \\ -b\sqrt{3}-d3/2 & \sqrt{3}/2 \\ -d\sqrt{3}/2+3a & -3/2 \\ d3/2-b\sqrt{3} & \sqrt{3}/2 \end{pmatrix} \begin{pmatrix} z\sin\beta \\ \tan\beta \end{pmatrix}$$

We can observe that $\sum \vec{\nu}_{mn} = \vec{0}$ whatever the phase shape (*a*, *b*, *d*) or the ATWLSI characteristics (*z*, β) are. This Property offers an unique advantage for ATWLSI since it allows to simultaneously get the measurement together with an evaluation of its accuracy when $\sum \vec{\nu}_{mn} \neq \vec{0}$.

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Realization of a phase noise measurement bench using cross correlation and double optical delay line

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The aim of this work consists in an exploratory approach of potential performances of a phase noise measurements bench using cross correlation and double optical delay line [1] in order to measure the phase noise of microwaves sources.

We first developed and tested a first version of this bench without any cross correlation with a microwave synthesizer. Measurements bench's noise floor was characterized by suppressing the delay line. Several low noise photodiodes with or without integrated amplifiers were tested. Synthesizer was replaced by a sapphire oscillator to reduce the amplitude noise of the source. One of the advantage of this kind of source, is the low amplitude noise it delivers. Sapphire oscillator is constituted by a sapphire resonator, a 30 dB amplifier with its isolators, a 10 db coupler, a phase shifter and a band pass filter. The power delivered is about 10 dBm. We have chosen a laser diode with a low Relative Intensity Noise (RIN) about -155 dB/Hz as the optical carrier used to uncorrelate the RF signal from the DUT. Noise floor was considerably reduced down to -145 dB.rad²/Hz at 10 kHz from the 10 GHz RF carrier. It shows that the AM noise of the 1.3 µm laser is one of the main limiting parameter in our bench. Optical fiber are then inserted in our system as delay lines to make uncorrelated the two arms at the input of the mixer, and measure the noise floor of the source to be characterized. A 2 km delay line corresponds to a delay of τ=10 µs. This delay allows the measurement of the phase noise of the oscillator placed at the input of our bench. It is obtained by using the relation between the measured spectral density of phase noise $S_{\varphi FFT}$ with the Fast Fourier Transform (FFT) analyzer and the phase noise of the oscillator $S_{\varphi osc}$ that are related by the following expression: $S_{\varphi osc}= S_{\varphi FFT} - 20.\log(2\sin(\pi f\tau))$. Sensitivity of the bench increases with the length of the delay line, but the cutoff frequency decreases as the band pass drops from a 100 kHz Fourier frequency for the 2 km delay line, to a 50 kHz for a 4 km. We first measured the phase noise of an Anritsu synthesizer, type 69000. Then we characterized another source: a sapphire oscillator developed in the laboratory. The principal advantage of this system is that it operates in the 8 to 12 GHz frequency band and so we can caracterize any oscillator in this band.

The noise floor was reduced by making inter correlation bench. The signal delivered by the source to be characterized is divided in two arms and then, two similar parallel benches as developed in the first part of our work. It allows the different noises from the devices in each bench, to become uncorrelated. Then the noise floor can considerably be reduced by performing averaging of incoherent sources. Noise floor is then reduced of β (expressed in dB) proportional to the *m*, number of averaging made as follows: $\beta = 10 \log (1/\sqrt{2m})$. Thus, obtained results using 2 km optical fibers delay lines and performing inter-correlation on 200 averaged, give a noise floor is -160 dB.rad²/Hz at 10 kHz from the 10 GHz. Next to this 10 GHz carrier, we measured -110 dB.rad²/Hz at 100 Hz.

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Birefringence dispersion measurement in nematic liquid crystals by using a Stockwell transform

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An analysis of the transmittance signal of the nematic liquid crystals (LC) by using a Stockwell transform is presented. Dispersion curve of birefringence is obtained by this analysis and data are fitted to the Cauchy formula whereby the dispersion parameters are extracted. The continuous dispersion curve of birefringence is experimentally verified on 5CB coded LC and it is compared with fringe counting technique. Result is found to be in favorable accordance with the published value.

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Laser sheet scattering and the cameras' positions in particle image velocimetry

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Digital particle image velocimetry (PIV), as a technique of determining the instantaneous flow velocity field, utilizes the double exposure records made on a CCD (or CMOS) camera chips do yield the displacement of particles immersed in a fluid flow. Laser beam, performing in pulse mode synchronized with cameras, undergoes scattering on the scattering centers i.e. seeding particles in general, and makes practically "frozen" images by this recording process. The scattering centers can be injected in a fluid flow in appropriate way or they can be present in fluid itself (bubbles, dust ...). The seeding particles behavior, with its own dynamics determined by particle generator, couple with fluid dynamics.

Most of the efforts put in improving the digital PIV have considered processing techniques for extracting the particle displacements and its validation. The acceptable results with contemporary devices can be obtained at almost any position of COD cameras. Of course, in the stereoscopic digital PIV, the Scheimpflüg arrangement should be applied in order to achieve higher quality of records (camera focusing and the perspective calibration). Yet, because of the specific angular distribution of intensity of scattering on seeding particles, the more detailed analyses of laser beam scattering could help in finding the optimum positions of the cameras. Furthermore, the angular distribution of the scattering intensity depends on particle shape, size (versus laser wavelength) and indices of refraction of the particles and the flowing fluid.

The seeding particles (solid, liquid or gaseous) may be considered as spheres, especially in the case of droplets and bubbles. More complex cases include particle anisotropy as well as multiple shell cases and will not be considered in this paper. Therefore, if the seeding particle densities are not very high, single-scattering analysis can be performed keeping in mind the Lorenz-Mie scattering theory. It is possible also to consider the necessity of applying the generalized Lorenz-Mie theory according to the properties of the laser beam cross-section electric field distribution. Note that in the PIV applications laser beam has to be shaped in the special way (in general - sheet). The concentration of the seeding particles has to be carefully controlled i.e. preferably without mutual scattering interactions between them. Having all these facts in mind the aim of this paper is to consider the best position of recording cameras. For higher seeding densities the multiple-scattering should be and will be considered in this paper. Appropriate numerical analyses will be performed for various types of seeding particles that are usually applied in PIV measurements.

The results of the flow velocity field measurements obtained by the chosen PIV system configurations and in different cameras' positions will be analyzed. The conclusions of performed analyses will be compared to the predictions made according to the scattering theories. The modeling will include analytical and numerical approaches.

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Moiré metrology technique to characterize the topography of a MW satellite antenna

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In this experimental work we apply a non-invasive technique that presents a variation of classical moiré metrology methods. The method is designed to characterize the topography of two models of the off-set MW satellite antennas, at the scales 1:4 (reduced dimension 130 mm x 180 x 6 mm) and at 1:1 (original dimension 520 mm x 720 mm x 60 mm). The surface of the antenna has the form of a paraboloidal torus. This type of antenna is planned to be installed in the SAC-D/ AQUARIUS Satellite Mission, that presents a collaboration between the NASA, USA and the "Comisión de Actividades Espaciales" (CONAE), Argentina. It is expected that two antennas will work at 23.8 GHz and 36.5 GHz radiometers to study the global water cycle by analyzing various geophysical parameters.

A variation of the moiré metrology methods described in this paper makes use of an object with known geometry as a measurement standard, to obtain most of the information necessary to analyze the moiré fringes over the antenna, without knowing each parameter of the experimental arrangement. We project a Ronchi grid over the antenna and the measurement standard and then we observe the image through another Ronchi grid and capture the image of the formed moiré fringes with a CCD camera. To compute the topography of the antenna, the only information that we need about it is the Ronchi period projected over the antenna and its center, and the relative position of the moiré fringes of the antenna with respect to ones of the measurement standard.

A study of adsorption kinetics of ferritin and albumin on gold surface with ellipsometry

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The interaction of proteins with solid surface is a fundamental phenomenon with implication for biomaterials, biotechnological processes and nanotechnology. Quantification of adsorption and microstructural parameters of thin organic layers on planar surfaces is high interest, especially in areas like biomaterials and surface-based biointeractions.

The thickness resolution and *in situ* advantage of ellipsometry make this optical technique particularly suitable for studies of thin layers of biological interest. The kinetics of adsorption of horse spleen ferritin and human serum albumin on gold (Au) surface was study with null ellipsometry. The thickness and the refraction index of the adsorbed layer were determined using a four-layer theoretical model of the system: glass prism-solution-adsorbed layer-gold surface. Received was also the relation between parameters of adsorbed layer and pH, and protein concentration. The results suggest that the ferritin adsorption can be described as a multistage process than adsorption of albumin pass quickly during the first minutes, and measure up saturation.

The data enable modelling of the protein adsorption on blood vessels and tissues in pathological processes.

Mapping and diagnostic of no melanoma skin cancer with laser induced fluorescence based in a fluorosensor BCDF

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It is defined and found the fluorescence iso-probability curves within and surrounding the tumoural tissue by means of the technique Laser Induced Fluorescence (LIF)[1],[2],[3]. They are compared to the hystopathological results acquired from anatomics pieces of patient´s tissues with skin cancer no-melanoma at the Carlos Andrade Marin Hospital and at the Gonzalo Gonzalez Hospital of Dermatology, placed in Quito. the photo-sensibilizer (delta-amino-levulinic acid ALA.[4],[5].[6]) has been used, which produces protorporfirin IX (Pp IX) when it is applied topically over the tissue tumors. The ALA is absorbed in major quantity by tumoural cells due to their rapid metabolism. Fluorescence spectra were collected from several locations inside the tumour and healthy surrounding tissues allow us to define the *probability for the existence of cancerigenous cells* as the reason between the intensity from the peak of fluoresce of the protoporfirin IX and the intensity of the auto-fluorescence peak (major fluorescence peak in the spectra at healthy tissue). The results show that all tumors non-melanoma analyzed are limited inside of 35% and 15% the iso-probability curves.

Key words: Laser Induced Fluorescence, Photo-dynamics Therapy, delta amino-levulinic acid, no-melanoma skin cancer

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Optical and Magnetooptical Properties of Clinical Dextrans

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Dextran is a bacterial polysaccharides polymer composed of α–D-glucopyranosyl residues, all having the $\alpha(1 \rightarrow 6)$ linkage with some $(1 \rightarrow 3)$ or $(1 \rightarrow 4)$ branching possible. Clinical dextrans saline solution (M_w=40,000 and M_w=70,000) for injection and other purposes are commonly used in clinical practice [1]. Iron dextran is applied for treatment of anemic iron deficiency [1]. Sulfate dextran have been tested as substitute for heparin in anticoagulant therapy [2]. Recently dextran based hydrogels have received increased attention due to their potential application as control delivery and release of bioactive agents [3]. Dextran and its derivatives are use as polymer coating of magnetic nanoparticels, which application in biomedicine become to be very attractive [4]. Chiraloptical properties of dextran polymer were studied by VUV CD [5] although prior to those work optical rotation mainly for yellow D line was used to characterize this polysaccharide [6]. Preliminary results of ORD and the light refractive index dispersion have been published recently by authors [7]. MORD may be especially useful in description of metal center with polymer as ligands but this study are scarcely in the literature. Systematic concentration, temperature and pH dependence of ORD, MORD and absorption of dextrans and their metal complexes are not discussed.

Increasing interest of dextrans stimulate us to above-mentioned optical research. The presented measurements are the first step to better understanding the physicochemical properties of iron-saccharides complexes which closely mimic those of ferritin.

The measurements are performed for two the most frequently used clinical dextrans. The paper presents results of measurements of ORD and Faraday effect (MORD) in the spectral range 350-650 nm and the UV/VIS absorption as a function concentration (c=0.001-10%), temperature (T=278-353 K), pH (range 2-12). The influence of urea and oxidation on optical properties of dextran polymer will be also discussed.

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Development of low-cost photo dynamic therapy device

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Due to the fast development of the microelectronics it is now available very economy and powerful light sources with small dimensions such as light emitting diodes (LED), which are also available in the whole visible spectrum range.

New device for Photodynamic therapy (PDT) is built based on the light-emitting diodes light sources. This system can be used for both diagnosis and therapy. There are two types of LEDs built in the system, these sources emit on 630 nm (for therapeutic applications) and 405 nm (for diagnostic applications). The red emitting LEDs, applied for PDT, are described with high emitting power, which allows achieving power density up to 40 mW/cm². The system is optimized for PDT applications using aminolevulinic acid/protoporphyrin IX as photosensitizer drug.

ALA is a naturally occurring precursor in the biosynthetic pathway for heme production. The last step in the biosynthetic route involves conversion of protoporphyrin IX (PpIX), a photosensitizing species, to heme. When exogenous ALA is added, the low physiologic rate of iron insertion by ferrochelatase, enzyme responsible for heme synthesis, is unable to compensate for the excess PpIX that is formed. PpIX, therefore, accumulates in cells and renders them photosensitive. ALA-based PDT could be used in the treatment of non-melanoma skin cancers because of the skin's accessibility to light treatment and the availability of a preparation of ALA for topical use.

Photo Dynamic Therapy mode of the system developed is described with power density of 1000 mW at 630 nm wavelength, where PpIX has maximum of absorption. Ninety-four LEDs type L2-0-R5TH20-1 (LedSupply Inc., USA) were chosen, which after geometry positioning and focusing can achieve power density enough for therapeutic applications.

Photo Diagnostic mode of the system developed is described with power density of 40 mW on 405 nm emission wavelength.. For building of the diagnostic channel 6 LEDs type L3-0-U5TH15-1 (LedSupply Inc., USA) were chosen.

For realization of this prototype, a universal board with parallel connected pins is used. This approach makes easer mounting and connecting the LEDs, which are arranged in rectangular matrix 12x9 cm^2.

The main advantage of the system developed is its low price, because of the LEDs usage instead of expensive laser sources or optic fiber elements. This also improves the safety usage of the system due to non-usage of high voltage, and low light power levels. The optical characteristics are suitable for PDT using aminolevuling acid/protoporphyrin IX as a photosensitizer. The therapeutic mode can be used also with some other photosensitizes from the porphyrins derivatives, which have similar absorption maximum around 635 nm.

Laser- and light-induced autofluorescence spectroscopy of human skin in dependence on excitation wavelengths

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The clinical applications of optical spectroscopy are related to extracting information on the optical absorption, fluorescence and scattering features of the tissues under investigation. The fluorescence spectroscopy of the human skin is one of the most appropriate techniques for early diagnosis and determination of different cutaneous diseases and normal skin properties in real time.

In current work are presented some initial results of using of N_2-laser (λ=337.1 nm) and LEDs (with emission in 365, 375, 385 and 400nm) as excitation sources for cutaneous fluorescence investigations. The main studies are made by developed in IE-BAS experimental fibro-optic system for fluorescence spectroscopy. Methodical base of the work are previous results from our investigations which give us some diagnostic criteria for diagnosis and differentiation of skin lesions. Multispectral and discriminant analyses of normal skin spectral data are made. Detection and differentiation algorithms are developed on the base of the diagnostically-important changes in narrow spectral regions. These algorithms will be used for building of simplified automatized set-ups for optical biopsy.

Several volunteers, representative of each skin phototype typical for Bulgarian region, namely – phototypes I, II and III were investigated by the methods of fluorescence spectroscopy of the human skin on several anatomic sites, typical for this type of measurements – palm, medial part of the forearm and lateral part of the forearm. Five to seven spectra were obtained from each anatomic section and were averaged. The resultant spectra are smoothed using Savitzky-Golay algorithm to reduce the instrumental noise of the spectrometric system. All spectra from the volunteers were obtained in the 90^o – angle between incident beam and skin surface - approximation, that skin surface could be treats as flat surface for the existing conditions of the experiment was made.

In the fluorescence spectra obtained several typical spectral features were observed, related to fluorescence of some endogenous chromophores from one side and to re-absorbance of the fluorescence by typical skin pigments from the other side. These features are the maximum at the region 480-500 nm – collagen, elastin; max at the region 450-470 nm – NADH, flavins; max at the region 550-600 nm – keratin; and minima in the region at 420, 540-570 nm, related to hemoglobin absorption. Intensity variations in whole visible spectral region are related to melanin content differences from skin to skin samples, which is clearly observed in comparison of different skin phototypes, or in comparison of different anatomic sites of one patient, which have different melanin content.

Optimization of fluorescence detection could give ones broad opportunities to increase the sensitivity and specificity for early diagnosis and differentiation of cutaneous lesions. Application of cheaper light sources as LEDs could also help to spread the optical diagnostic methods in clinical practice.

Optodynamic characterization of laser-induced bubbles

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Laser-induced bubbles can be caused by an optical breakdown in water. They are a result of the optodynamical process where the energy of a high intensity laser pulse is converted into the mechanical energy through an optodynamic conversion. At this process the absorbed optical energy causes plasma expansion that in turn initiates dynamic phenomena: spreading of a shock wave and the development of a cavitation bubble. When the cavitation bubble reaches its maximum radius it starts to collapse due to the pressure of the surrounding liquid. This collapse in turn initiates a new bubble growth and bubble collapse. The process therefore repeats itself, resulting in so-called cavitation-bubble oscillations, with a new shock wave being emitted after every collapse. Cavitation bubbles as well as shock waves are interesting due to ocular microsurgery, where Q-switched lasers with ns pulse durations are commonly used to vaporize the tissue in procedure such as a cataract removal [1]. Understanding the development of the cavitation bubble and the pressure front, their dynamics and propagation is important to avoid adverse effects on the eye during ophthalmology procedure based on laser surgery [2].

We present an optodynamic characterization of cavitation bubble's oscillations and accompanying shock waves based on a laser beam-deflection probe (BDP) [3]. Employed setup enabled us one- or two-dimensional scanning with deflections of a laser probe beam. Deflections were detected with a fast quadrant photodiode. From BDP signals times of flights for cavitation bubble during its expansion as well as its collapse were determined. From maximum bubble's radius the energy converted form the laser pulse energy into the mechanical energy of the cavitation bubble were estimated for the first three oscillations. Measured bubble dynamics was compared with Rayleigh-Plesset theory [4].

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Holographic measurement of dental tissue contraction and stress, due to post-polymerization reaction

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Contraction of dental polymers during polymerization is a long standing problem in dentistry [1]. When placed inside tooth cavity, polymer contraction is transferred to surrounding hard tissues (dentine, enamel). This, in turn, induces internal stress, possibly resulting in pain, dental filling debonding or microcracking. It is therefore important to observe tooth deformation during various techniques of dental filling placement. This makes possible to choose the most appropriate placement and polymerization techniques. The aim of this research was to investigate the duration of postpolymerization and resulting build-up of stress inside the tooth.

A real-time holography was used to measure deformation of dental tissue due to dental filling contraction [2]. Human third molar with mesio-ocluso-distal (MOD) cavity were used in this study. Cavity was filled with dental composite photopolymer and polymerized using blue-light LED lamp. Split-beam setup with liquid gate was used to in-situ record and chemically process holographic plate. Deformation could be observed and recorded by a CCD camera from the very beginning of polymerization. Three phases were distinctly observed: initial stage, when the polymer is still viscous and contraction is compensated through polymer flow; contraction stage, where contraction forces gradually build up inside a tooth, and finally, post-polymerization occurs after the termination of polymer illumination and continues contraction for some time.

Finite element method was used to calculate stress inside a tooth, based on deformation measurement. A simplified model of a human third molar was constructed and used to calculate von Mises and principal stresses.

We have found that pospolymerization reaction continues for several minutes, following illumination. During that period, contraction is further increased for approximately 10%, and maximal principal stress reaches up to 70 MPa. It should be noted that tooth may crack under pressures ranging from 50 to 150 MPa, depending whether forces are tensile, contraction or shear.

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Optical and electron spectrometry of molecules of biological interest

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Optical absorption and emission spectroscopy together with low energy electron interaction (elastic scattering, excitation, ionization, resonances) with biologically relevant molecules (nitrogen, oxygen, water, alcohols, tetrahydrofuran, tetrahydrofurfuril alcohol, glycine, alanine) are studied in order to understand radiation damage. Versatile high resolution electron spectrometers are used in the present study of electron-molecule interactions [1]. Energy loss spectra were recorded for these molecules in order to identify electronic transitions from ground state to both allowed and optically forbidden states. Optical emission spectra have been recorded from gas discharge processes by low resolution optical spectrometer (Ocean 2000). Also, electronic spectra were compared with high resolution synchrotron photoabsorption spectra where these spectra had been available.

Another aim of the present studies of organic molecules is to investigate the presence of pollutants. Different laser spectroscopy methods are available for these purposes. Absorption–based laser spectroscopy is one of the most widely used analytical tools for detection of a specific molecule and one of the most important techniques for gas sensors in environmental [2]. Direct laser absorption spectroscopy based on the Beer –Lambert absorption law is often used for quantitative measurements.

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Influence of laser pulse spatial profile on optodynamic source shape in liquid media

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The detailed knowledge of the special characteristics of the laser beams propagating through optical systems has an important impact on the success of the applications of laser sources. The spatially nonhomogeous laser beam profile can significantly influence the mechanism of laser induced breakdown (LIB) processes. The need to study the parameters which influence the creation of the LIB site has largely grown out of the increasing clinical use of Nd:YAG laser systems for various kinds of ophthalmic microsurgery. For this, and other applications it is important to monitor LIB processes in real time. It was already established that optodynamic (OD) methods of ultrasound detection are suitable for the task [1].

The aim of the present study is to demonstrate the influence of the spatial nonhomogeneity of the laser beam intensity profile on LIB in aqueous medium by use of OD methods [2]. In the experiment the OD waves were induced with a multimode pulsed Nd:YAG laser beam. Laser beam spot with elliptical profile area of 9x16 mm^2 had several "hot spots". The LIB was induced at different positions above and inside the liquid. The following OD transient waves were detected with two detectors: piezoelectric (PE) transducer at the bottom of the container, and a laser beam deflection probe inside the liquid, parallel to the liquid surface.

The results of the experiment indicate the existence of numerous smaller waves that are observed before the main signal in the optoacoustic waveform, which are not observed in waveforms of LIB generated by homogenous laser beams.

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Contributed papers

Poster session - Thursday

Saturable discrete vector solitons: theory and experiments

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Discrete vector solitons (DVS) are a special class of vector solitons which have been found to exist in periodic media such as, for example, one-dimensional (1D) and two-dimensional photonic lattices [1,2]. Individual components of such complex structure are unable to form stable localized structures on their own. In this contribution we explore the DVS in 1D nonlinear waveguide arrays (NWA) with saturable nonlinearity in a special case in which the components of DVS have the same frequency but differ in polarization [3].

The theoretical model is based on the slowly varying approximation and on the assumption of nearest neighbour interactions [3]. A conserved quantity of the system is the total power $P = P_u + s_1 P_v$, where P_u is the power of TE mode, P_v is the power of TM mode while s_1 is a function related to birefringence and average refractive index [3]. The final stage of mode profiles after the DVS is formed can be represented with: $u_n(\xi) = u_n \exp(i\lambda\xi)$ and $v_n(\xi) = v_n \exp(i\lambda\xi)$ where u_n and v_n are real quantities, ξ is the propagation coordinate, while λ is the propagation constant. It can be shown that the power of the TE mode is always higher in comparison to the power of the TM mode. Also, while the TE mode has permanently a single-hump form [1] and spreads in cascades in saturation [4], the TM mode exhibits splitting into a two-hump structure which also saturates in the high-power regime. If the components are initially in phase, the power transfer will be towards the TE mode provided that $\Delta k>0$, and towards the TM mode otherwise where Δk is the difference of TE and TM wave numbers.

Experimentally, this unique form of DVS is observed for both mutually coherent and incoherent input beams. The green light from a laser is split into two orthogonally polarized mutually coherent beams by a polarizing beam splitter. On the other hand, to study mutually incoherent interactions of two beams we use a TM polarized beam from a second laser of the same wavelength. A polarizer and a half wave plate have been used to adjust the input power, while a single channel excitation is achieved by a 40× microscope lens. Our 1D NWA is fabricated in an 11 mm-long lithium niobate crystal doped with copper. We use another microscope lens to collect light from the output of the sample onto a CCD camera and another polarizer to observe independently both TE and TM components of DVS. We have demonstrated that the stationary form of DVS for a fixed value of TE power slightly changes for different values of TM power. In accordance with our theoretical predictions, one can recognize a dominating single-hump TE mode and a weak two-hump TM mode [3]. We also observe the power transfer from TM to TE component of DVS by blocking the TE beam. The TM beam has transferred most of its power to the TE component, forming a single-hump structure, while the remaining power is trapped in a two-hump structure. This power transfer from TM to TE mode is due to formation of holographic gratings in photorefractive photovoltaic crystals. Light is anisotropically diffracted from shifted gratings showing polarization conversion, which results in a power exchange between the modes. This power exchange can be suppressed by using mutually incoherent input beams.

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Interactions of two co-propagating beams near the edge of one-dimensional nonlinear waveguide arrays

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Nonlinear waveguide arrays represent a periodic system of weakly coupled waveguides. Strongly localized and dynamically robust structures, better known as discrete solitons, exist in such systems when the diffraction effects are exactly balanced by the nonlinearity. It has been shown that the waveguide-based devices are good candidates for the fully controlled switching of optical discrete solitons between the input and the output ports [1-3]. Beside discrete solitons, it is possible to excite and stable nonlinear Tamm states in nonlinear waveguide arrays. Such strongly localized optical surface states exhibit a threshold behaviour and they have been observed recently at the edge of one-dimensional uniform nonlinear waveguide arrays with self-focusing cubic and self-defocusing saturable nonlinearity, respectively [4,5].

The concepts of all-optical switching and gating may be achieved by exploiting the interactions of a couple of co-propagating beams [2,6,7]. We investigate numerically in detail the problem of two beams interaction close to the interface between a uniform nonlinear waveguide array and a homogeneous media (substrate). The most interesting results are almost diffraction-less deflection of two out-of-phase beams in a low-power regime and power controlled switching of fused beam in a medium-power regime.

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Dynamics of spatial solitons of nonlinear Schrodinger equation in inhomogeneous media

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Spatial solitons are self- guided optical beams which are the solutions of the integrable spatial nonlinear Schrodinger equation(NLS). They are stable and can propagate without changing their shapes due to a balance between the nonlinearity and dispersion effect of the medium.
The dynamical evolution of the solitons in homogeneous systems has been studied elsewhere by various methods [1,2] .
In this paper, at the first we derive the spatial nonlinear Schrödinger equation in the inhomogeneous medium with arbitrary inhomogeneous refractive index . We consider the one soliton solution like for such medium. We will show that the motion of the solitons in such inhomogeneous medium governed by the Newton's second law like. We will use different inhomogeneous medium and show that The propagation of spatial solitons keeps quasi-particle properties.
We have investigated the effect of temperature in the behavior of solitons too. We Know the thermal load due to heat deposition in the medium change the refractive index. The effect of such heat induced inhomogeneous refractive index on the soliton behavior studied analytically. The analytical solutions compared with the numerical solution and good consistency bas shown between our methods.

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Using 2D Distributed Feedback in Optical Laser

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The use of two-dimensional (2D) distributed feedback has been suggested in [1] as a method of producing spatially coherent radiation from either sheet or annular high-current relativistic electron beam with the transverse size greatly exceeding the wavelength. The 2D distributed feedback can be realized in planar and coaxial 2D Bragg cavities with a double-periodical corrugation of the walls

In present paper we consider possibility of using the 2D distributed feedback for production of spatial coherent radiation from laser active medium. We assume that 2D Bragg grating are formed by background medium with the following modulation of the dielectric constant

$$\varepsilon(x,z) = 1 + \varepsilon_0 \cos\left(\bar{h}z\right)\cos\left(\bar{h}x\right),$$

which provides the mutual scattering of the partial waves

$$A = \mathrm{Re}\left(\left(A_z^+ e^{i\bar{h}z} + A_z^- e^{-i\bar{h}z} + A_x^+ e^{i\bar{h}x} + A_x^- e^{-i\bar{h}x}\right)e^{i\omega_0 t}\right)$$

under the Bragg resonance condition $\omega_0 = \bar{h}c$. In an laser active media all partial waves $A_z^{\pm}(x,z)$, $A_x^{\pm}(x,z)$ are amplified regardless of their directions of propagation.

Linear analysis of 2D Bragg resonators in the absence of the active media gives the following expression for eigenmodes

$$\omega = \omega_0\left(1+\delta_{n,m}\right), \quad \delta_{n,m} = \pm\frac{\pi^2 mn}{2\alpha l_z l_x} + i\frac{\pi^2}{2\alpha^2 l_z l_x}\left(\frac{n^2}{l_z}+\frac{m^2}{l_x}\right),$$

where m, n are longitudinal and transverse indexes, l_x and l_z are corresponding grating dimensions. If $l_z > l_x$, the mode m=1, n=0 at exact Bragg frequency $\mathrm{Re}\left(\delta_{0,1}\right) = 0$ has the maximal Q-factor and minimal diffraction losses. For the active medium with the gain b the threshold conditions can be presented in the form: $\mathrm{Im}\left(\delta_{n,m}\right) = b$.

Nonlinear stage of generation has been studied by numerical simulation in the frame of semi-classical model of two level active medium [2]. Simulation shows the possibility of the single mode steady-state oscillation regime even when the threshold conditions are fulfilled for several different modes. Spatial profiles of partial waves in steady-state regime are close to the structures of fundamental mode. The radiation frequency is also close to the Bragg frequency. The developed theory allowed to estimate the possible laser schemes with 2D distributed feedback based on different active media.

As in traditional DFL two dimensional feedback can be realized by using coupling of guided modes in thin dielectric films. Varying width of film as $\cos\left(\bar{h}z\right)\cos\left(\bar{h}x\right)$ can provide proper coupling. In the practical case a chessboard corrugation pattern is sufficient for realization 2D feedback mechanism.

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Images forming and analysis in the fractional Fourier transform domain: approach on the basis of a generalized ambiguity function

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In this work we introduce new method of optical systems description on the basis of a generalized ambiguity function (GAF) [1]. The GAF is proposed as generalization of usually ambiguity function (AF) and it is shown that Wigner distribution function and ambiguity function are only particular cases of generalized distribution. In this work we introduce canonical representation of GAF which is generalization both generalized Wigner function [2] and the GAF. The GAF is characterized by two parameters: the form representation parameter and the fractional Fourier transform (FrFT) parameter. It is also shown that the ambiguity function forms from the Wigner function as rotational displaysment on the informational diagram.

Thus we combine two concepts the fractional Fourier transform and the generalized ambiguity function. The FrFT is well known in optics [3,4] and many optical systems could be described using the FrFT methodology. The GAF opens new possibilities in this direction as in all previous works Wigner distribution or ambiguity function are used. Taking into account the fact that the GAF is generalization of these functions we introduce new methods of single and double optical stages description. We use direct reconstruction scheme that allows us obtain the intensity distribution of the signal which is registered experimentally.

In our work we also are interesting in conditions of the forming of the optical images in the fractional Fourier transform domain. The properties of the intensity distribution of two shifted and modulated by the plane wave optical signals corresponding to the generalized FFT are investigated [5]. The results of analitic and numerical calculations show the design possibilities of new systems for informational processing of information. As an example the correlator based on the generalized FFT is considered. The domains of the generalized FFT in the practicable optical systems is obtained and analysed. The principal possibility of the formation and recording of an interference pattern is demonstrated when the images of the FFT, starting from the general form of the cascade matrix, are optically superimposed.

The main purpose of this paper is to show the advantages and the of principal possibilities of systems for the optical proccesing of information due to using the generalized matrix. Based on this matrix the generalized FFT is constructed. The main advantage of this approach consists in the possibility for the coefficients of matrix to gain any values. The parameters of the optical systems are calculated using the invariant parameters. Using of the generalized FFT allows us to improve the existing information proccesing systems and to construct new such systems. In particular, the example for the correlator based on the generalized FFT shows this possibility.

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On bright and dark breathers in lattices with saturable nonlinearity

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The comparative study of the moving localized bright and dark modes in lattices with saturable nonlinearity is presented. This study is based on the analysis of the eigenvalue (EV) spectra of the localized configurations and the grand canonical free energy concept. The grand canonical energy is defined through the conserved quantities, power and Hamiltonian, or complementary power and complementary Hamiltonian, for bright or dark localized modes, respectively. The difference between the grand canonical free energy of the on-site and inter-site localized configuration with the same power is associated with the Peierls-Nabarro (PN) barrier [1].

The cascade amplitude saturation mechanism [2] as the particularity of bright localized modes in lattices with self-focusing nonlinearity reflects to their EV spectrum. Varying the power P for almost each its value the on-site configuration with two pure real EVs and the inter-site configuration with all pure imaginary EVs coexist and vice versa. The appearance of the pure real EV branches is associated with the bifurcation of the saddle center type. Only for a few P values both the on-site and inter-site configurations are simultaneously characterized by the pure imaginary EV spectrum. Both modes are neutrally stable there.

For the on-site dark configuration branches of the discrete EV spectrum with complex eigenvalues exist which indicates presence of the oscillatory instability. On the other hand, for the inter-site dark configuration branches with pure real EV indicate the presence of the exponentially growing instability. In the first case the Hopf type bifurcation appears, while in the second one occurs the saddle-center bifurcation. All configurations of the dark breathers are mainly unstable [3,4]. However, the regions with pure imaginary EVs, which indicates both neutral stability and possibility for the dark breathers existence, have been found [5].

It is shown that the transparent points identified by the zeroth value of the PN barrier [1, 6, 7] for bright localized modes in latices with self-focusing nonlinearity, coincide with the points of neutral stability of the on- or inter-site localized configuration and maximal instability growth rate of the corresponding inter- or on-site configuration, respectively. The moving bright localized modes are observed within these transparent windows. Finally, in the case of dark modes, the PN barrier also may vanish in the region of the modes neutral stability giving rise to their free steering [4].

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Third-order nonlinear optical characterization and optical limiting behavior of Pb(II), In(III) chloride, Ni(II) metallated 1,4,8,11,15,18,22,25-Octaalkylphthalocyanines

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ABSTRACT

Optical limiting based on RSA has been reported using Phthalocyanines (Pc) and metallophthalocyanines (MPc) [1, 2] and the results show that they are the best candidates for optical limiting in the visible region of the spectrum. To investigate the optical limiting (OL) behavior of a series of 3 metallated 1,4,8,11,15,18,22,25-octaalkylphthalocyanines, the third-order nonlinear optical (NLO) properties, one-photon absorption (OPA) and two-photon absorption (TPA) characterizations have been computed using AM1, ZINDO and configuration interaction (CI) methods. The highest values for the TPA cross-section $(\delta(\omega))$ have been obtained by indium and lead derivatives. We have found that the nickel-metallated compound has given the lowest $\delta(\omega)$ of the series, indicating its unsuitability as potential material for practical passive optical limiter. Our calculated results on $\delta(\omega)$ and second hyperpolarizability (γ) are consistent with the experimental results in the literature.

(Primary Topic= Nonlinear Optical Effects and Applications and Secondary Topic = Optical Properties of Materials).

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Third order nonlinear optical properties of donor substituted 4'-methoxy chalcone

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Non-linear optical (NLO) materials with large and fast NLO resoponses are needed for numerical optical device applications.like optical switching, optical rectification and optical limiting. A variety of materials have been investigated for NLO properties in which organic materials are attractive due to their large variety, high non linearity, ultra fast response and the flexibility they offer to tune the optical properties through structural modification. To increase the NLO response in this class of materials, researchers have established various design strategies such as donor-acceptor-donor (D-A-D), acceptor-donor-acceptor (A-D-A) and donor -π - donor (D-π-D) types of molecules. Chalcones are intramolecular charge transfer molecules, which allow one to design them based on above design criteria.

Single crystal of donor substituted chalcone of size 30mm x 10mm x 5mm have been grown by slow evaporation solution growth technique. The grown crystals were subjected to characterization techniques viz: elemental analysis, powder and single crystal X-ray diffraction analysis. The crystal fails to exhibit second harmonic generation due to the presence of inversion symmetry in the solid state structure. However, the crystal shows good third order nonlinear response. The peak and valley configuration of z-scan trace of the compound revealed the negative sign of the nonlinear refractive index. The nonlinear absorption coefficient and nonlinear refractive index is measured to be 6.19 cm/GW and -2.3 x 10^{-11} esu respectively. This donor substituted chalcone also exhibit good optical limiting characteristics.

Novel nonlinear optical material : 2-[(3-nitrophenyl)carbamoyl]benzoic acid

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Organic nonlinear optical (NLO) materials have attracted considerable attention as they provide the key functions of optical second harmonic generation, optical modulation, optical switching, optical logic, and optical memory for emerging technologies in areas such as optical communication, signal processing, and optical information storage devices [1]. A number of organic materials have been identified and synthesized, showing considerable optically nonlinear effects. However only a few of them could be crystallized and investigated for NLO applications. The search for new NLO materials has been on the increase as a result of growing demand for such materials. The obligatory requirement for NLO materials is that a crystal with a space group is from the noncentrosymmetric class.

A new organic single crystal, 2-[(3-nitrophenyl)carbamoyl]benzoic acid of size 5mm x 2mm x 1mm have been grown by slow evaporation of acetone solution. The grown crystals were characterized by single crystal X-ray diffraction technique. Linear optical properties of the crystal were investigated using UV-VIS spectroscopy. The title compound crystallizes in noncetrosymmetric structure and is in consistence with the non-zero second harmonic response observed in this crystal. The compound is stable up to 205^{o} C. The relative second harmonic generation (SHG) conversion efficiency of the compound was determined using Kurtz powder technique. The powder SHG conversion efficiency is found to be 5 times greater than that of urea.

Intense Femtosecond Pulsed Laser Interaction with SK3 Glass (II): Optical Properties Modification

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In the recent years, the interaction of ultra-short intense infrared laser pulses, femtosecond and in some cases even picosecond laser pulses, with transparent materials, especially optical glasses, has attracted much attentions, theoretically and experimentally [1-4]. High nonlinear responses, white-light supercontinuum generation, plasma generation and optical properties modifications are among the well known phenomenon.

In this work the laser-induced optical properties modification (refraction and absorption) of SK3 glass sample is investigated under irradiation of focused 200 femtosecond infrared laser pulses at 800 nm wavelengths at 100 Hz repetition rate. Effect of incident pulse energy and laser shout number on laser-induced optical properties modification, length and area, are investigated.

The laser pulse accumulation model [4] is applied to explain the evaluation of modification sizes with incident pulse energy and shout number. The move focal model for self-focusing is also applied to explain the experimental result of the laser-induced modifications length.

Some potential applications such as optical data storage, optical devices constraction can be considred by controling of photo-modifications inside glasses.

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Transition rate dependence on the non-zero initial momentum in the ADK-theory

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Abstract

Tunneling regime, introduced by Keldysh, in the interaction of strong lasers with atoms has been accepted as the reliable method for describing processes when low frequency lasers are involved. Yet it was always assumed that the ionized electrons are leaving the atom with zero initial momentum. Because we are interested how non-zero momentum influences the transition probability of tunnel ionization, we have obtained the exact expression for aforementioned momentum.

Here was conducted the estimation of the transition probability with non-zero momentum included. Potassium atoms in the laser field whose intensity varied from $10^{13}\ \mathrm{W/cm^2}$ to $10^{14}\ \mathrm{W/cm^2}$ were studied. It seems that all light quanta of laser field are used for tunneling ionization process at the beginning of laser pulse – ionization probability is large. After that, with further impact of laser pulse, ionization probability decreases, probably because part of laser pulse light quanta is used for increasing momentum of ejected electrons, leaving smaller amounts of light quanta available for ionization of remaining electrons. If laser pulse lasts long enough, then the amounts of light quanta available for ionization become larger, resulting in increasing of ionization probability, now with greater starting energy of ejected electrons.

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Spectroscopic studies, structure and calculated third-order nonlinear optical properties of *N*-(2-hydroxy-4-methoxybenzalidene)3-nitroaniline

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N-(2-hydroxy-4-methoxybenzalidene)3-nitroaniline has been synthesized, and characterized by X-ray diffraction analysis. The maximum one-photon absorption (OPA) wavelengths recorded by quantum mechanical computations using configuration interaction (CI) method are estimated in the UV region to be shorter than 450 nm, showing good optical transparency to the visible light. To provide an insight into the microscopic third-order nonlinear optical (NLO) behavior of the title compound, we have computed both dispersion-free (static) and also frequency-dependent (dynamic) linear polarizabilities (α) and second hyperpolarizabilities (γ) at $\lambda =$ 825-1125 nm and 1050-1600 nm wavelength areas by means of time-dependent Hartree-Fock (TDHF) method. The *ab-initio* calculation results with non-zero values on (hyper)polarizabilities indicate that the synthesized molecule might possess microscopic third-order NLO phenomena.

Three-frequency wave interactions in the field of 100-fs Ti:sapphire laser pulse in PPLN

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Periodically poled nonlinear crystals (PPNCs) are widely used for effective realization of nonlinear optical wave interactions. In a such crystals the phase mismatch of interacting waves is compensated by the reciprocal grating vector of periodically changing nonlinear coefficient of the crystal [1]. Due to realization of quasi-phase matching (QPM) the largest nonlinear coefficients can be involved, thus high efficiency of frequency conversion may be achieved. It is also possible to satisfy simultaneously two QPM conditions for two different nonlinear optical processes by selecting modulation period of nonlinear coefficient. Such processes is called consecutive or coupled wave interactions. In this case the nonlinear grating vector compensates the phase mismatches of several nonlinear optical processes [2]. The efficiency of nonlinear wave interactions is determined by the intensity of interacting waves. Therefore application of ultrashort pulses allows us to increase the energy exchange between interacting waves.

The paper contains theoretical investigations and experimental results of femtosecond three-frequency conversion processes in PPNC. We used laser pulses of about 100-fs duration produced by tunable Ti:Sapphire laser, the average power 1.5 W, and the repetition rate of 80 MHz. PPNC was the periodically poled lithium niobate $LiNbO_3$ crystal (PPLN) where the modulation period of nonlinear coefficient is equal to 16.6 μm. Domain boundaries were normal to x-axis and $z-y$ and $x-y$ surfaces of the crystal were polished. Such a crystal was produced by the repolarization method. In our PPLN the implementation of consecutive wave interactions are possible. Experimental investigations were carried out with PPLN samples of 5–6 mm length. The spectral distributon and the power of radiation at the PPLN output pumped by Ti:Sapphire laser were measured. Interpritation of experimental results is dicussed.

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Symmetry properties of Molecular and Nanomaterials

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The notion of symmetry is one of the most important conceptual tools in modern science. Originating directly from symmetry considerations, Second Harmonic Generation (SHG) is an experimental technique that is extremely sensitive to anisotropy. More specifically, it is a nonlinear optical process that, in the dipole approximation, occurs only in noncentrosymmetric materials. In combination with Faraday rotation (a linear optical technique which nevertheless is based on a phenomenon related to nonlinear optics), SHG constitutes a valuable tool for the study of symmetry properties of molecular and nanomaterials.

In order to clarify the role of symmetry in processes such as magnetism, chirality and interface formation, and to understand the interplay between them, we have undertaken several research projects on which our preliminary results will be presented.

Regarding magnetism (related to the *time reversal symmetry*), we show that a large Faraday rotation is observed in $CoFe_2O_4$ and Fe_3O_4 superparamagentic nanoparticles, embedded in a polymer matrix. Due to the ease of preparation and low cost of this material, numerous applications in magneto-optical devices are possible.

Concerning chirality (connected to a break in the *rotation symmetry*), we demonstrate the high sensitivity of SHG to this property in molecules, which our experimental equipment allows us to investigate in the ranges 750-900 nm and 1140-1560 nm. To our knowledge, this is the largest spectrum for studying off and on resonance chiral behavior so far.

On the subject of interface formation (associated with a rupture in the *translation symmetry*) we see that the presence of a submonolayer concentration of p-nitrothiophenol in ethanol can be detected with SHG as the molecules adsorb at the surface of Ag(111). Our preliminary results indicate that a monolayer of p-nitrothiophenol forms through a so called “liquid-gas” phase transition mechanism, similar to the one reported by Maclagan [1].

Finally, present a straightforward way to construct a magnetometer capable of detecting fields below 100 nT by using our materials. While our long term goal is to reach 10^{-14} T, a sensitivity of 1nT is expected to be achieved by the end of this year.

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"Necklace-ring" beams in saturable Kerr media with square-root nonlinearity

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Analytical and numerical investigation of the propagation of "necklace-ring" optical beams in Kerr-like saturable photorefractive media with square-root nonlinearity is carried out. Analytic expression for the propagation dynamics of the necklace beams as a function of the propagation distance is in good agreement with numerical findings.

A spectroscopic study on the nonlinear optical susceptibilities of a series of organic molecules.

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In the past century the invention of lasers has opened up a new research area concerning all kinds of interesting optical phenomena, especially in the nonlinear regime. These include Second Harmonic Generation (SHG) and Third Harmonic Generation (THG). One of the characteristics, and at the same moment a drawback in the use of the lasers is their inherent monochromaticity, limiting their use to only a few fixed wavelengths.
The aim of our study is to investigate the spectral dependency of the nonlinear optical susceptibilities responsible for the nonlinear optical analogue of circular dichroism, known as second harmonic generation - circular dichroism (SHG-CD) [1], but other phenomena like THG and fluorescence can be investigated as well.
We report on the setup of an entire new experimental setup, used for the determination of the nonlinear optical susceptibilities of a series of organic molecules in the near-infrared range. More specific we have used a tunable, amplified lasersystem, capable of producing femtosecond pulses in the wavelength range from 1140 - 1550nm. Furthermore we recorded polarisation patterns by changing the polarisation of the incident beam by using a quarter wavelplate. In this report we discuss the technical details concerned with building such a setup. These include carefully choosing the polarizing elements and the care that should be taken when detecting the produced light of higher order.
The main elements of our setup are: an adjustable polarizer that can be set at either p- or s-polarisation, a quarter waveplate that is continously rotated during the measurement to change the input polarisation from linear over elliptically to circulary and vice versa. The sample holder is fixed on a rotation stage to change the angle of incidence. The analyzer is also fixed on a rotation stage, to control the polarisation of the transmitted light (both fundamental and higher order). In front of the photomultiplier which is used as a detector we use a monochromator to carefully choose the wavelenght of the light we want to detect.
The complete setup is computer-controlled and can run several experimental setups independantly. By doing so we get a complete set of data which enables us to determine the nonlinear optical susceptibilities of the molecules studied at different wavelenghts.

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Models of interactions of laser beams with materials of interest for optical components and provoked damages

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Models of interactions of laser beams with materials of interest for optical components are presented in this paper. Laser damages which appear within active materials and optical components inside the path of a propagating beam are treated as well. The applications of components and their possible damages induced by laser beams are theoretically treated via various models. In the literature, there are various data considering the threshold of damages, namely, laser-induced damage threshold (LIDT). In spite of the tendency for standardization of fracture-appearing phenomena, there are many possible approaches in fracture physics to explain phenomena occurring during interaction between intensive (mostly pulsed) laser beams and materials. Many kinds of damages exist via dielectric, thermal, Brillouin or other breakdown processes, among which the material purity is important. For instance, if inclusions in optical components are in the form of metal particles, specific cracks appear. Also, damages provoked in active materials (ruby, glass) need specific approaches in order to be explained. Besides the various theoretical approaches, with plasma phenomena included or not, experimental results are the most reliable confirmation of recommended model.

Various optical materials and elements have been exposed to laser pulses and their damages have been analyzed by microscopic and other methods. Among the elements, there are lenses and other components of various glasses or polymers ("plastic materials"). The tendency to replace a glass material with a plastic one, theoretically requires various models to be included for the explanation of damages. The question of damages provoked by single-pulsed or multi-pulsed beams is another point of view in the evaluation of some modeling. The state of the surface of optical components is closely connected to the evaluation of the damage threshold (LIDT), depending on the correction with the index of refraction included, i.e. the shape of "micro-scratch". The analyses include Sellmeier approximation formulas for less-known materials.

Components "history" (i.e., whatever happened to the material during the operation of the component) has to be included as well. According to the types of both optical components and lasing media, the following features are considered: a) samples which are a subject of degradation; b) operative tasks which prolong the life of a component; c) possible technological reparative processes. The irradiation with levels below damage threshold might improve mechanical performances and properties of some fibers or detectors.

High temperature gradients commonly arise in active materials during their operation. To calculate the stresses provoked in active materials during thermal processes (including cooling) is a complex task. Lasing processes in some chosen configurations are analyzed in that manner. The inclusions of various impurities in the material lead to stresses which exceed the limits of the material during the operation, and mechanical cracks frequently appear. The detection and the analysis of these states are considered through contemporary methods of mechanical stress control. They are compared to theoretical considerations and calculations of crack processes in previously mentioned cases, where the inclusions are in the form of metal particles.

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Stable one-dimensional dissipative solitons predicted using analytical stability criterion and confirmed by numerical simulations

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The possibility of generating soliton structures in nonlinear media is of considerable interest due to potential applications in all-optical information processing and transport. In telecommunication, temporal solitons are carriers in dispersion compensated optical fiber transmission systems [1]. Bright temporal soliton is generated compensating anomalous group dispersion by cubic (Kerr) nonlinearity. Such solitons are well described by (1+1)-dimensional nonlinear Schrödinger equation (one transverse dimension corresponding to the time and the propagation one described by the coordinate **z**. A prerequisite to establish a bridge between the theory and the experiment is to consider dissipative systems. In such systems, the solitonic structure can be preserved if appropriate gains match linear and nonlinear losses. In order to stabilize this dissipative soliton the saturating nonlinearity containing also a quintic term of opposite signs is required. Therefore, here we investigate one-dimensional complex cubic-quintic Ginzburg-Landau equation describing such a category of dissipative systems. Such complex systems are treated mainly numerically [2]. However, in order to have a better physical inside into the problem, an analytical approach even though approximate is needed. We extended the variation approach to complex Ginzburg-Landau equation [3]. Based on this variational approach an analytical stability criterion for steady state solutions of Ginzburg-Landau equation is obtained. If such stable solutions are taken as input for numerical simulations, they evolve into solitons. We demonstrated that numerical evolution always leads to stable dissipative one-dimensional solitons. The stability domain of dissipative parameters is established for various types of dissipative solitons.

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Counterpropagating dipole beams in nematic liquid crystals

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We investigated the behavior of counterpropagating optical beam structures in nematic liquid crystals. We restrict our attention to the dipole-dipole beam arrangements. A time-dependent model for the beam propagation and the director reorientation in a nematic liquid crystal is numerically treated in three spatial dimensions and time. A stable dipole beams are observed in very narrow threshold region of control parameters. Bellow this region the beams diffract, above spatiotemporal instabilities are observed as the input intensity are increased.

Beam propagation in nematic liquid crystals

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We investigated the behavior of beam propagation in nematic liquid crystals. A time-dependent model for the beam propagation and the director reorientation in a nematic liquid crystal is numerically treated in three spatial dimensions and time. We display the formation of stable solitons in very narrow threshold region of beam intensities for fixed birefringence and show soliton breathing. Bellow this region the beams diffract, above spatiotemporal instabilities are observed as the input intensity, the optical and static permittivity anisotropies of the liquid-crystal molecules are increased. We demonstrate the filamentation of solitons above the threshold with increasing input intensity.

The Bechgaard salts - an example of optically nonlinear materials

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The family of the organic conductors with the generic chemical formula $(TMTSF)_2X$ was synthetized in 1980 [1], and later named the Bechgaard salts after the name of the main author of [1]. In this formula, the symbol $(TMTSF)_2$ denotes a complex called di-methyl-tetra-selena-fulvalene, and X is one of various kinds of anions, which can be added to the complex. A few examples of the anions are $X = FSO_3, ClO_4, NO_3 \ldots$

Already early work has shown that the electrical conductivity of these salts can not be described within the standard theory of metals, but that a more elaborate theoretical framework has to be used. The logical choice was the Hubbard model. For a recent review of the calculation of the electrical conductivity of the Bechgaard salts using the Hubbard model and the so called memory function method see [2].

The aim of this contribution is to analyze to some extent the reflectivity of these materials. In this contribution the reflectivity will be calculated using a well known theoretical framework (for example [3]). Since this calculation demands as input data the electrical conductivity and the susceptibility, results from [2] were used. The main motivation for the calculation was to attempt to "tie up" the reflectivity with various parameters of the Bechgaard salts in the Hubbard model. As these materials are quasi one dimensional, it is hoped to extend the results of this contribution to systems of higher dimensionality.

Details of the calculation will be presented in the paper. A resulting expression for the reflectivity will be discussed. It is non linear, and shows the dependence of the reflectivity on various material paremeters (within the Hubbard model), such as the transfer integral or the band filling. The position of the region where the reflectivity tends to zero will also be estimated as a function of the model parameters. Finally, some possibilities of extension of the results obtained to 2D systems are briefly mentioned.

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Diffusion profile of multi-step core fibers for variable diffusion coefficient

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In this paper, the graded-index plastic optical fibers (POF) based on thermal diffusion of the dopants in multi-step core is treated. We report a procedure based on the diffusion equation in cylindrical coordinates, with variable diffusion coefficient D. In the real experiments the diffusion coefficient can, and will, vary. For a given composition the diffusion coefficient can vary with concentration and distance from the fiber axis. In this work we assumed D is a function of distance. Using the explicit finite-difference method we solved the corresponding inhomogeneous diffusion equation for two-step and for-step core fibers in order to determine the diffused profile. The typical concentration distributions when $D = D_0\left(1 + f(r)\right)$ are obtained.

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Surface plasmon-polariton assisted metal-dielectric multilayers as passband filters for ultraviolet range

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Metal-dielectric multilayer thin films have been traditionally used for optical filtering [1]. A renewed interest for this field has been created with the andvent of nanoplasmonics and with the introduction of left-handed metamaterials, perfect lenses and metal-dielectric superlenses [2]. Scalora et al [3] experimentally showed that under certain condition metal-dielectric multilayers (termed by them transparent metals) transmit light by resonant tunneling, enabling extraordinary transmissions. One-dimensional metal-dielectric nanofilm multilayer filters for the UV range were analyzed theoretically and experimentally in [4].

In this work we design and fabricate metal-dielectric multilayers intended for passband filters in the ultraviolet range. We utilize the transfer matrix method taking into account real dispersion and absorptive losses in the metal part to design our multilayers for the desired range. To design the dispersion characteristics of our structures we applied the Bloch approach to evanescent wave resonant coupling.

A significant place in our investigation was given to the influence of nanoscale interface roughness to the performance of the metal-dielectric filters. Instead of decreasing the performance of the filters, it was used as a means to couple evanescent electromagnetic field to the propagating far field modes in the spectral range where propagating and evanescent transmission windows overlap. In this manner, both propagating and evanescent modes contribute to the filter performance, resulting in an enhanced transmission in the desired range, while retaining a strong suppression of undesired frequencies of more than four orders of magnitude. The unit cell of the designed metal-dielectrics must be symmetric to enable large transmission in the pass band.

In our experiments we used radiofrequent sputtering to fabricate our metal-dielectric multilayers. We utilized silver-silica material pair. The reflection and transmission of the finished photonic crystals was characterized by UV-vis spectroscopy. A good agreement was obtained between the designed and the fabricated spectral characteristics.

The designed multilayers are also applicable as multilayer superlenses for sub-diffraction-limited imaging.

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Far-infrared study of DX-like centers in $Pb_{0.95}Mn_{0.05}Te(Ga)$

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Lead chalcogenides are well-known materials for the infrared optoelectronics. They are mainly used for the production of lasers and LEDs operating in the middle and far infrared [1]. The band gaps energies of IV-VI semiconductors, which have direct gaps at L point of the Brillouin zone, range from 0 to 0.4 eV. As the band gaps depend on composition of mixed crystals, lasers made from these materials exhibit large tuning ranges [2] making them uniquely suited for high resolution molecular spectroscopy applications [3].

Semimagnetic semiconductors are studied for a long time and the strong influence of magnetic impurities microscopic arrangement in the host crystal on the semimagnetic properties is known. The doping of PbTe with Mn increases the band gap with the rate $\partial E_g/\partial x \approx 40$ meV/mol% MnTe, but does not introduce local or quasi-local levels in the vicinity of the actual bands [4]. Renewed interest in this material is related to spintronics.

In this paper we present far-infrared reflection spectra of $Pb_{0.95}Mn_{0.05}Te$ single crystal doped with gallium between 10 and 300K. The analysis of the far-infrared reflection spectra was made by a fitting procedure based on the model of coupled oscillators. Together with the strong plasmon-phonon coupling we obtain three local modes of gallium at about $122cm^{-1}$, $166cm^{-1}$ and $192cm^{-1}$. The position of these modes depends of impurity center charge, and their intensity depends of temperature.

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Charge screening and exciton spectra for single-walled carbon nanotubes (SWCNTs)

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Here we propose the following 1D large radius exciton model for semiconducting SWCNTs in vacuum.

- We study the spectrum of large radius excitons in semiconducting nanotubes and corresponding wave functions within the framework of elementary potential model, in which exciton is modeled as bound state of two oppositely charged quasi-particles confined on the nanotube surface and interacting through the attractive Coulomb potential. Due to the parity of the potential, exciton states split into the odd and even series.
- It turned out that the ground state energy of even excitons, calculated for individual semiconducting carbon nanotubes in vacuum without account of the effect of the e-h interaction potential screening by nanotube electrons, well exceeds the energy gap.
- To make clear whether the screening of e-h interaction by the nanotube electrons could result in the shift of exciton levels into the gap we consider different forms of screening of the interaction potential of electron and hole.
- We obtain the nanotube dielectric function within the framework of the Lindhard method (the so-called RPA) then in the limiting case of small wavenumber values we get the Thomas-Fermi screening theory for charged particles in semiconducting SWCNTs and also the contribution to the screening of free charges at high temperatures.
- Using the values of effective masses and energy gaps obtained in [1] within the framework of the null-range potential method [2] we have calculated unscreened and screened e-h interaction potentials and corresponding exciton binding energies of the ground and excited states, which either explicitly or implicitly depend on parameters of concrete semiconducting SWCNT (chirality, radius, reduced effective mass, band gap magnitude or temperature).
- In the all cases the binding energies of SWCNTs even excitons in the ground states nevertheless appeared to be larger than corresponding band gaps. Similar results have been obtained in [3].
- We show that for SWCNTs in a medium the dielectric screening of e-h interaction in nanotube by surrounding matter is enough for returning of the lowest exciton level inside the band gap. This explains results of experiments on exciton photo-absorption and fluorescence in SWCNTs [4],[5].

We conclude that single-electron states in SWCNTs in vacuum are most likely unstable at least in the vicinity of the energy gap as regards to formation of excitons.

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Boundary influence on permittivity in molecular films

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A microscopic theory of optical properties of thin molecular films, i.e. quasi 2D systems bounded by two surfaces parallel to XY planes was formulated. Harmonic exciton states were calculated using the method of two-time, retarded, temperature dependent Green's functions. It has been shown that two types of excitations can occur: bulk and surface exciton states. Analysis of the optical properties (i.e. dielectrical permittivity) of these crystalline systems for low exciton concentration shows that the permittivity strongly depends on boundary parameters and the thickness of the film. Influences of boundary conditions on optical characteristics of these nanostructures have been especially analyzed.

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Optical and thermal investigation of sol-gel derived $Eu^{3+}:Y_2SiO_5$ nanoparticles

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Many practical applications of inorganic luminescent materials such as cathode ray tubes, lamps and X-ray detectors made them very attractive research subject for decades. More recently, the developments of high resolution electroluminescence, plasma and field emission flat displays have increased the demand for the nanosize phosphor materials. Numerous synthesis techniques have been developed aiming to produce the nanopowders with better characteristics than their bulk counterparts, in term of stability,brightness and industrial processing ability [1].

Yttrium oxyorthosilicate Y_2SiO_5 is an important material exhibiting many valuable properties. Rare earth oxyorthosilicates (R_2SiO_5) doped with Eu^{3+}, Ce^{3+}, Pr^{3+}, Tb^{3+} and Yb^{3+} are well-known luminescent materials because of their cathodoluminescence, storage phosphor, scintillator and laser properties [2, 3]. In particular, $Yb:Y_2SiO_5$ have demonstrated efficient laser action and optical conversion exceeding 50% have been obtained [4]. Indeed Y_2SiO_5 is technologically important as it is used as a host for luminescent materials and was found to be a promising candidate for coherent time-domain optical memory applications [5-10].

$Eu^{3+}:Y_2SiO_5$ nanoparticles are prepared by sol-gel technique using tetraethylorthosilicate (TEOS) as silica source, yttrium nitrate and europium nitrate. We present here research on evaluation of optical and thermal properties during conversion of gel into nanocrystalline form. Fourier transform infrared spectroscopy (FT-IR) and fluorescence spectroscopy of Eu^{3+} ions were used for the optical characterizations, while thermal analysis is done with TGA-DTA (thermo-gravimetric/differential-thermal-analysis) technique.

The emission spectra and lifetime measurements of Eu embedded in Y_2SiO_5 have been performed at room temperature. Strong red emission characteristic of Eu^{3+} ions is observed. Two site occupancy corresponding to two different coordination numbers (7 for Y_I and 6 for Y_{II} site) are observed from the $^5D_0 \rightarrow {}^7F_0$ transition. Obtained $^5D_0$ level luminescence lifetime of 1.8 ms is in good agreement with the value obtained from the bulk sample.

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Investigation on the crystallization process of Eu^{3+}:$CaSiO_3$ gel using optical and thermal methods

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One technologically important category of nanostructured materials consist of rare earth doped insulators, better known as phosphors. The most succesfull red phosphors were achieved with the Eu^{3+}-activated oxides, and thus the luminescence propertiesof Eu^{3+} in various hosts have been investigated extensively [1]. The luminescence of a Eu^{3+} ion depend predominantly on the chemical environment i.e. on the host lattice. However, several requirements for producing a successful industrial phosphor are always required: apart from having a well-defined composition with no impurity phases, the materials should also be free of crystal defects, and the distribution of the doping ions should be as uniform and random as possible in order to avoid non-radiative losses.

Calcium silicate, with its high temperature strength, creep resistance, chemical inertness, thermal stability, low thermal expansion and low thermal conductivity, is material suitable for the variety of applications [2]. For example, Pb and Mn activated $CaSiO_3$ act as yellow range lamp phosphor material. The $CaSiO_3$ containing materials are used for the production of special radio ceramics, sanitary components, porcelain materials, lining bricks, glaze and flux [3]. $CaSiO_3$ ceramics also exhibits good bioactivity and biocompatibility and find use as biomaterial in medical industry, for the artificial bones and dental roots [4-7].

Crystallization of rare-earth-doped gel is a potential preparation method for rare-earth activated phosphors. The gel, in which a small number of rare earth ions can be mixed homogeneously on a molecular scale, can be obtained through hydrolysis-condensation reactions of different metal alkoxides [8, 9] (in our case tetraethylorthosilicate (TEOS) is used as silica source). In this way the rare-earth-activated phosphors can be prepared at lower working temperature than that required for the solid state reactions. Here we present the study on the process of crystallization of Eu^{3+}-activated $CaSiO_3$ gel and the influence of the crystallization on the luminescence of the Eu^{3+} ions. Fourier transform infrared spectroscopy (FT-IR) and fluorescence spectroscopy of Eu^{3+} ions were used for the optical characterizations, while thermal analysis is done with TGA-DTA (thermo-gravimetric/differential-thermal-analysis) technique. All optical measurements have been performed at room temperature.

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Electroluminescence of porous silicon built in alumina matrix

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Electroluminescent structures based on porous silicon built in anodic alumina have been fabricated and studied. The porous silicon layer was formed by magnetron co-sputterig of aluminum and silicon with subsequent electrochemical anodization. Silicon content in the anodic alumina films was about 45 at. % according to Auger analysis. The electroluminescent structures were formed like in [1]. Light emission was observed at applied voltage more than 5 V in both directions. Mechanisms of light emission are discussed.

The work is supported by the contract No B-276.2 within the ISTC program.

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Si-based led microdisplays for NTE applications

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The development of nanostructured porous silicon light emitting diodes is analysed. Electrophysical properties of the investigating devices are considered. Prospects for nanostructured porous silicon applications in optoelectronic integrated circuits are discussed.

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Group delay in semiconductor structures with energy dependent effective mass

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We consider tunneling of a particle with energy dependent effective mass (nonparabolicity) through one-dimensional potential barrier and extend previously given theory [1,2] to obtain a general expressions for relevant tunneling times (group delay time, dwell time and self-interference time), including the terms due to nonparabolicity. For the special case of a rectangular barrier, the times are calculated in explicit form. Energy dependence of group time is calculated for two semiconductor structures.

In case of GaAs/$Al_x Ga_{1-x}$As/GaAs, the influence of nonparabolicity on group time is rather modest for particle energy not exceeding the barrier height. This is due to large energy gap throughout the structure compared to both the particle energy and the maximum achievable barrier height in the structure. For the particle energies larger than the barrier height situation changes, but this is not of practical interest.

More suitable candidates for demonstrating the influence of nonparabolicity on tunneling times are material systems having substantial barrier heights, compared to the energy gaps in the materials, one of which is InGaAs/AlAsSb/InGaAs system. Unlike the AlGaAs based structures, the inclusion of nonparabolicity is now most pronounced at low particle energies.

In general, depending on the material parameters, i.e, barrier height, energy gap values etc., accounting for the nonparabolicity may increase the group time up to 30% in realistic structures. Even more prominent is the influence of nonparabolicity on the saturation of group delay with increasing the barrier length, which is due to the fact that both the dwell time and the self-interference delay time are proportional to the integrated probability density [3].

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Refractive and dispersive properties of acrylic materials

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Several acrylic materials have been measured and their refractive properties for the spectral region from 405 nm to 1100 nm are investigated [1]. Their normal dispersion behaviour is considered on the base of the Cauchy – Schott's approximation [2-4]. A polymer structural analysis with the aid of the group contribution theory [5] is accomplished involving the physicochemical parameters of the studied materials. A molecular structural parameter is suggested and a theoretical connection between this parameter and the dispersive coefficients is derived. Calibration Schott test glasses have been selected and comparative analysis of their molecular refraction and dispersive data with the acrylic materials is accomplished. A number of comparative dispersion curves generated for the examined optical polymers are illustrated applying the developed OptiColor programme. The refractive and dispersive properties (Abbe numbers, the molecular refraction for three wavelengths, mean and relative molecular dispersion) of the measured acrylic polymers are juxtaposed to the data of similar plastics included in optical catalogues of Code V and Oslo program packages.

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Loosing of lightguiding properties of an opical fiber exposed to axial extensions

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Optical fibers could be used to guide optical signals for remote control of sensors and various types of devices. Very often for such purpose they are embedded in the materials and structures. Depending of the application they could be exposed to such kind of stresses that they completely loose their lightguiding properties without beeing broken. It is noticed to happen if the optical fiber was exposed to a large axial extensions , or when the embedded optical fiber in the material is exposed to a high energy impacts. After the applied stress is decreased or stoped the optical fiber has its previous lightguiding properties. Such loosing of guiding properties could cause the malfunctioning of a system and it is important to predict such situations and calculate the allowed stresses on the optical fiber in those situations.

Pure axial extension of a fiber is the case when guiding properties of the optical fiber depend only of stresses in the optical fiber as well as of its longitudinal and transversal dimensions and not of its bending and microbendings. So, it is the best case for investigation of pure stress induced losing of guiding properties of an optical fiber.

In this work we are investigating the values of applied relative longitudinal strain that cause the loosing of guiding properties of the monomode and multimode step index optical fibers.
At first the stress distribution in the extended optical fiber is calculated, taking into account close but different values of Young modulus and Poison coefficients of core and cladding and changing of their longitudinal and transversal dimensions for increasing values of applied axial relative strain. Then using stress-optic coefficients the radial and transversal components of index of refraction along core and cladding in the middle part of the optical fiber are obtained. Differences in core and cladding refractive indices is calculated versus applied relative strain and based on them the optical power transmitted along that middle part of the optical fiber.
The values of the input applied strain are increased until the optical power became zero.
Such obtained critical values of strains are compared with measured results for optical fibers that could stand large longitudinal stresses.

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Time delay in thin slabs with Kerr-type nonlinearity

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In this paper we have analyzed the following model: a thin slab with Kerr nonlinearity placed between two semi-infinite samples of linear and nonmagnetic materials. A general relation between the bidirectional group delay and the dwell time is derived for the thin slab. It is shown that the group delay is equal to the dwell time plus a self-interference delay. Particular attention is given to solving the Helmholtz equation for this case. Detailed and rigorous treatment has revealed that the solutions of the Helmholtz equation are given via elliptic functions of the first kind, and the boundary conditions at the interfaces are determined precisely. Finally, we provide an overall procedure for numerical calculation of the dwell times.

Imaging properties of laser – produced, parabolic profile, microlenses

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Microlenses and microlens arrays have been successfully produced on a layer of tot'hema and eosin sensitized gelatine (TESG), by focused beam Nd:YAG laser operating at 532 nm. Tot'hema is a drinkable solution used in medicine for curing an iron deficit in human organism. Eosin is an organic dye, with absorption maximum in the green part of the spectrum used in medicine, too. Chemical components are well known, easily accessible, nonpoisonous and cheap. TESG layer, thickness of 100 μm, was fabricated on the microscope glass substrate, by the gravity settling method [1]. Microlenses, with different focal lengths, were formed at several distances from the laser beam focus. For all microlenses the exposure time was 10 sec and the laser power was 25 mW. Created microlenses were aspheric concave with a parabolic profile. For the purpose of ray tracing and analysis of the microlens imaging properties they are approximated by a combination of an even asphere and a flat surface [2, 3, 4].

Five different microlenses were produced by placing TESG layer at the focus of the laser beam and at distances of 1 cm, 2 cm, 3 cm and 4 cm from the focus. Microlenses had the focal lengths from 55 μm to 310 μm and the numerical apertures from 0.55 to 0.01. They had excellent, near diffraction limited, performances for the moderate total field of view ($2\omega = 16°$). Imaging properties are analyzed by the Strehl ratio, the root mean squares (RMS) wavefront error, and the spot diagram [5, 6].

It is accepted that the Strehl ratio for a diffraction limited system is 0.8. The Strehl ratio varied in our case from 0.45 to 0.98 for the maximum field angle.

The calculated RMS wavefront errors, for the maximum field angle, were from 0.14 waves to 0.02 waves. The wavefront error that corresponds to the diffraction limit for these microlenses was 0.07 waves.

The Airy disk radius is a function, among other parameters, of the numerical aperture of the microlens and for considered microleneses it was from 0.69 μm to 3.4 μm. The RMS spot diagram for the maximum field angle was from 1.2 μm to 0.5 μm.

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Surface solitons in two-dimensional anisotropic lattices

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The study of discrete surface solitons in nonlinear photonic lattices has attracted a lot of attention inside the optics community in recent years. The interplay of periodicity and nonlinearity facilitates the formation of discrete optical solitons. In infinite 1D discrete systems, they can exist for arbitrarily low beam powers, while near the surface of a semi-infinite array, a minimum beam power is needed to create them [1]. The situation is different in 2D, where a minimum level of power is needed to create a discrete optical soliton for an infinite waveguide array. What happens if the soliton is near a boundary? Would this minimum power increase or decrease? These are the questions we address in this work.

We consider a 2D semi-infinite nonlinear square lattice with cubic (Kerr) nonlinearity which can be described by a DNLS-type model with fixed boundary conditions. We study the effect of surfaces and anisotropy in the excitation of localized states. By tuning the anisotropy parameter and using a *power threshold landscape*, we are able to study the crossover between 1D and 2D arrays and also to observe the differences in the level of power required to excite a localized state in different regions of the lattice. We demonstrate that, in sharp contrast to 1D discrete surface solitons, the threshold power is reduced at the surface, and 2D surface solitons can be generated more easily near the lattice corners and edges than at the center. It seems that the surface of a 2D lattice generates an effectively attractive potential for localized modes, reducing the required excitation power. We also found that there exists a critical value of the lattice anisotropy where we observe a crossover between 1D and 2D behaviors.

In addition, we study the dynamical generation of surface modes in the square lattice. By numerical integration of the dynamical equations, for the same input conditions, we confirmed that the excitation of a localized state located on the corner is easier (less amount of power) than the excitation at the middle of the lattice.

A really nice feature of our theoretical work [2] is its confirmation by two very recent experimental observations of discrete optical surface solitons in a square waveguide array [3]. There, the authors have successfully generated and observed such entities providing a good support for our theoretical study.

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Thermoluminescent mechanism in lilac spodumene

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The silicates are materials of special interest for science and technology due to their wide application in optical and semiconductor devices. α-spodumene is a natural lithium aluminosilicate mineral with chemical formula $LiAlSi_2O_6$. Its transparent varieties are considered as semi-precious gemstones, and besides, the natural crystals are strongly luminescent under UV or electron beam excitation [1,2]. These facts make the spodumene an interesting optical material for various applications in jewel industry or detector design.

The principal optical characteristics of α-spodumene are caused by lattice defects which exist in natural samples. The most frequent are exchange of Si^{4+} and Al^{3+} ions and a presence of different impurities on substitutional and interstitial sites. On exciting the samples by ionizing radiation, electrons and holes can be trapped by these sites. They can be thermally released from traps causing a radioactive recombination and thermoluminescent peaks. Thermoluminescence (TL) is a process in which heated insulator or semiconductor emits the light in correlation with the previous absorption of energy from radiation. TL competes with the process of luminescence, but reveals the information about radiation dose received by the material in the past. Previous TL measurements performed on synthetic β-spodumene and its EPR spectra lead to the conclusion that the Fe impurity "kills" the TL centers, while the Mn impurity improves its TL response [3].

In present work the thermoluminescence of a natural lilac α-spodumene (kunzite) from Minas Gerais State, Brazil, was investigated. Toward this aim the gamma and ultraviolet (UV) irradiation, as well as several heating processes have been carried out. The sample presented a glow curve with various TL peaks. Another sample of pure spodumene policrystal doped with controlled amount of Fe and Mn was used for comparison sake. Emission spectrum from both samples showed only one prominent band at 610 nm, which indicates the existence of only one recombination center despite the several TL centers exhibited, due to intrinsic defects. Using correlation between TL and Optical Absorption (OA) techniques we discuss the effects of ionizing radiation and thermal heating in kunzite, and propose the mechanism by which this sample emits light at wavelengths of some of the TL peaks. In discussion we refer to recently available theoretical data concerning the optical absorption of a pure α-spodumene [4].

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The systematic variation of optical properties of alkali halides: an ab-initio study

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The alkali halides form a family of compounds which is considered to be the prototype of ionic compounds. They are insulators and crystallize in face centered cubic structure [1]. Some of them exhibit strong scintillation effects, being used as detectors (famous examples are LiF and NaI). The other may be colored by exposure to radiation or impurity doping. In any case, alkali halides are interesting optical materials and often serve to test new theories and calculation approaches [2].

Objective of the present work is to study a correlation between the optical properties, electronic structure and the anion-cation electronegativity difference in several groups of alkali halides (defined by fixing a cation and varying the anion). Towards this aim we have calculated the electronic structure of three groups of alkali halides MX (M=Li,Na,K; X=F,Cl,Br,I) using the first-principle, density-functional theory based full-potential linear augmented plane wave (FP-LAPW) method [3], as implemented into Wien2k computer code [4]. Knowledge of the MX band structures permitted us to calculate imaginary part of the complex dielectric function, and to determine all optical constants of the compounds: refraction and reflection indices, extinction coefficients end energy losses, as functions of incident radiation energy up to 50 eV. The results were interpreted in terms of calculated band structures and correlated with the cation-anion electronegativity difference in each compound. The latter is estimated on the basis of topological theory of Bader [5].

The Bader analysis showed that ionic character of the M-X bond decreases as anion varies from F to I in all three groups. At the same time the band gap decreases, while the band structures around the gap stay very similar. In groups with M=Li,Na the top of the valence region consists of two distinct bands: halide s-states and the mixture of the alkaline s- and the halide p-states. The ultraviolet (UV) optical absorption occurs in very compact energy regions, 7-8 eV wide. Positions of optical peaks decrease in energy scale as anion changes from F to I. The group with M=K exhibits different band structure in the vicinity of the gap: the K p-states position themselves between the halide s- and p-states. This fact makes the UV absorption region less compact, causing appearance of various additional optical peaks at higher energies for each compound in the group.

Present work systematizes a great number of theoretical data concerning the optical properties of alkali halides in UV region.

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Influence of various impurities on the optical properties of YbF_3-doped CaF_2 crystals

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Due to the good optical and mechanical properties of the fluoride, the (RE)-doped crystals are used as laser active media. Several of RE ions (such as Eu, Sm and Yb) can be stabilized in the divalent state in the CaF_2. The Yb^{3+} ion properties in CaF_2 host have been intensively studied due to its strong IR luminescence that can be easily pumped with laser diodes. The properties of Yb^{2+} ion have been less investigated, mainly only for its intense and broad yellow-green luminescence [1-4]. The change of valence has been attained by exposing the crystals to ionizing radiation, baking them in a suitable atmosphere or electrolytic annealing [1, 2, 4]. The influence other impurities, such as Pb, Na or Li, on the absorption and emission spectrum of YbF_3-doped CaF_2 have been also less studied.

The goal of this work is to study the influence of the PbF_2, LiF, NaF- co-doping on absorption and emission spectra of the YbF_3-doped CaF_2 crystals.

Calcium fluoride crystals doped with YbF_3 and co-doped with PbF_2, LiF and NaF have been grown using the vertical Bridgman method [5].

The optical absorption spectra (190–1090 nm) reveal the characteristic absorption bands of the Yb^{3+} and Yb^{2+} ions. It has been observed that the Pb^{2+} ions have beneficial effects on the absorption and emission spectra. The presence of the Li^+ and Na^+ ions drastically decrease the absorption coefficient of the Yb^{2+} ions in the UV band and the emission intensity by excitation in 230nm.

ACKNOWLEDGMENT. This work was supported by the Science Research Council, Romania, Grant CEEX, nr. 72/3758/2006.

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The effects of nonstoichiometry on optical properties of oxide nanopowders

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The high surface-to-volume ratio of nanocrystals suggests that the surface properties should have significant effects on their structural and optical properties. The emission efficiency, spectrum, and time evolution are very strongly affected by the surface [1]. This is generally understood as a consequence of the presence of gap surface states arising from surface nonstoichiometry, unsaturated bonds, etc. So, investigation and control of the processes at the surface is in particular the key to understanding the optical properties of oxide nanocrystals.

In this paper we illustrate the change of optical properties of laser synthesized anatase TiO_2 nanopowder and mechanically activated wurtzite ZnO powder due to nonstoichiometry caused by laser irradiation in vacuum. Both of these materials are widely used in optoelectronics and the examination of their optical properties under different environmental conditions has great practical interest.

Optical properties of as prepared and laser irradiated samples were investigated by photoluminescence (PL) and Raman spectroscopy. The spectra excited by different lines of Ar^+ and He-Cd lasers were recorded at room temperature using Jobin Yvon U1000 monochromator and photomultiplier as detector.

Nonstochiometry induced by laser irradiation in vacuum of anatase TiO_2 nanopowders generally causes broadening and blueshift of the highest intensity E_g Raman mode [2, 3]. The dependence of these changes on laser irradiation as well as on powder preparation conditions points out to the presence of different type of defects. The main feature of the TiO_2 luminescence spectra is a complex band in the visible range, with peak position depending on the laser irradiation conditions. This PL band is attributed to the oxygen vacancy defects [4].

Laser irradiation in the vacuum doesn't have great influence on the Raman spectra of mechanically activated ZnO powders. However, its influence on PL spectra can be great and dependent on activation time. The intensity of luminescence excited by UV (325 nm) line of He-Cd laser changes without substantial PL shift, while there is a prominent changes both in the PL intensity and position in the spectra excited by visible line (442 nm) of the same laser. The later changes are related to the enormous increase of green luminescence, which is strongly correlated to the density of singly ionized oxygen vacancies [5] located at the surface [6]. Note that observed changes are mostly reversible, i.e. after laser irradiation in air spectra become very similar to that obtained from as prepared samples.

This study confirms a great influence of surface defects, especially oxygen vacancies, on the optical properties of oxide nanopowders and shows how this properties could be altered by laser irradiation under different conditions.

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Silicon Photonic Waveguides for Near- and Mid-Infrared Regions

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The basic building block of every photonic circuit is a waveguide. In this paper we investigate several silicon waveguide structures including rib, strip, free-standing and omnidirectional waveguides.

There is a trend towards miniaturisation of silicon photonic circuits due to performance and cost reasons. Conventional circuits are based on rib and strip waveguides on Silicon on Insulator (SOI) platform. Soref's equation [1] has been extensively used for the design of single mode rib waveguides. This equation is, however, valid for relatively large rib waveguides and it has been shown that modifications need to be introduced for smaller rib waveguides [2]. Here, we analyse single mode and birefringence-free condition for small rib waveguides and the influence of the top oxide cladding. Polarisation conversion in optical filters based on these waveguides is also given. Further miniaturisation can be achieved by using strip waveguides, although at the cost of higher propagation loss and polarisation dependence. Design rules for this type of SOI waveguides are presented.

Mid-infrared wavelength region is interesting for several application areas including sensing, communications, signal processing, missile detection and imaging [3]. SOI material structure, however, is not suitable for longer wavelengths due to the absorption spectra of silicon dioxide [3]. In this paper, we discuss the design, fabrication and propagation loss measurements of two different waveguide structures, the free standing and omnidirectional waveguides, including the hollow core waveguides.

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Scanning near-field optical microscope detection of surface phonons and their role in nano-optics

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Abstract

Polar materials with phonon resonances in the infrared are known to support surface phonon polaritons which can be employed to achieve subwavelength field confinement and even near-field superlensing thereby showing great potential in infrared nano-optics. We discuss various geometries where these effects occur, including a simple planar interface and both planar and curved layered structures. We investigate different experimental configurations based on scanning near-field optical microscope (SNOM) and present the results of our simulations. The results indicate a nano-scale resolution if the surface phonon resonance conditions are met.

Laser – PMMA interaction and mechanical stresses

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Polymethylmetacrylate (PMMA) is a known material. Its optical properties make it promising for many applications in various fields. Some of them are the automotive industry, building and lighting industry and other, including POF for home and car networks and illumination, glass replacement, CD production, toys, pens, furniture, electronics, medicine; modeling of stress/strain characteristics of other materials could be done via PMMA, which is also interesting from the side of laser-material interaction [1-4]. The investigation of the microscopic details of laser-material (PMMA) interaction (engraving, drilling, surface modification, etc...) could be useful from commercial point of view, especially for new types of lasers.

The PMMA samples were exposed to laser beams of various types of lasers. The modification of the surfaces of the samples was observed by light microscopy and scanning electron microscopy (SEM). Numerical approach to thermal distribution analysis for specified power ranges of selected lasers has been obtained. The results of PMMA drilling, performed by laser and non-laser means, were compared by photoelastic methods.

The observations of samples showed that it has been possible to obtain the information on the processes occurring during laser-PMMA interaction. The occurrence of excessive material ejected from the drilled hole to the vicinity of the hole, the shape of debris, the occurrence of graphite, and others – all this can lead to the conclusions about the melting/evaporation/disintegration processes, the amount of evaporated material, possible impurities in the material, etc. Methods like photoelastic provide the information on the mechanical stresses appearing before or after the interaction.

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Wave propagation in finite one-dimensional Thue-Morse superlattices containing negative refractive index metamaterials

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We investigate wave propagation in non-periodic one-dimensional stacks composed from alternating layers of media with positive and negative refractive index. The stacks follow a design rule based on an aperiodic Thue-Morse substitution sequence [1]. The spectral characteristics of the NIM-containing multilayers are a consequence of the phase compensation effects associated with the presence of negative refractive index metamaterial (NIM) layers. We employ the standard transfer matrix method for our numerical computations and analysis [2].

The interplay between the order and the phase compensation greatly affects the spectral resonances in the stacks based on the Thue-Morse substitution sequence. These resonances are connected to the pole structure of the transfer matrix that indicates the existence of the complex eigenvalue spectra for the finite superlattice [3]. The periodic superlattices with NIM layers media exhibit wider bandgaps and flatter transmission, and the Thue-Morse superlattices also exhibit a similar behavior with a distinctive feature of the existence of resonances in the middle of the Bragg bandgap [4]. We consider the evolution of the transmission spectra and the field distribution associated with the spectral resonances, for the finite structures with both the on-axis and the off-axis wave incidence and for both TE and TM polarizations.

The spectral self-similarity occurring in the Thue-Morse superlattices composed solely from ordinary positive index media is lost in the case of the structures incorporating NIM, for both the dispersive and the dispersionless case [3]. In contrast with the quasi-periodic and pre-fractal Cantor NIM-containing superlattices, where self-similar and scalable spectra occur for higher generations [5], with Thue-Morse multilayers these spectral properties are completely removed, even in the dispersionless and lossless case.

A non-Bragg, zero-n bandgap (for which the averaged value of the refractive index in the structure is close to zero) in the Thue-Morse superlattice has been predicted in [4]. We further investigate the zero-n bandgap existence for both polarizations in the finite structures with losses and dispersion. We investigate the field localization and resonant tunneling associated with the spectral resonances in higher generations of the superlattices. In addition, we found that alternating symmetric and asymmetric arrangements of layers in successive generations of the Thue-Morse superlattices influence both the spectral resonances and the zero-n bandgap, leading to spectral shifting and a pronounced angular dependence of the zero-n bandgap.

The influence of internal losses, which always occur within dispersive materials, to the phase compensation, is of great importance for the existence of the zero-n band gap. We apply this argument, introduced in [5] for the pre-fractal NIM-containing Cantor superlattices, to the Thue-Morse superlattices.

The designed finite Thue-Morse superlattices can be utilized as spectral filters with enhanced resonant tunneling and as directional polarization splitters.

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Probing of surface properties of droplets of suspension with optical methods

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The evaporation of single levitated water droplets containing 200 nm's diameter polystyrene spheres was studied. Each single droplet was kept in an electrodynamic quadrupole trap (see e.g. [1]), mounted in a small climatic chamber. Two laser beams of different color and perpendicular polarization were used for droplet illumination. Optical signals of both conserved polarization and depolarization were recorded simultaneously. The evolution of the droplet radius was inferred from the signal of *s* polarization conserved (see e.g. [2, 3]). The signal of *p* polarization conserved provided information on the average inclusions concentration evolution. Depolarization signal provided information on inclusions density fluctuations as well as of inclusions aggregation. Transformation from a droplet of suspension into a solid object via kinetically driven nano-structures self assembly was inferred (compare [4]). The application of surface pressure concept (see e.g [5]) to the inclusions on the droplet surface was proposed feasible. The surface pressure isotherm was obtained from the droplet radius evolution. Several surface layer phase transitions were detected by this means. A few phase transitions within inclusions structures in the droplet volume were found by comparing polarized and depolarized scattered light irradiance.

Acknowledgment
This work was supported by Polish Ministry of Education and Science grant No. 1 P03B 117 29.

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Giant Goss-Hanchen effect at the reflection from a one-dimensional photonic crystal containing left-handed metamaterials

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We study the beam reflection from a semi-infinite one-dimensional photonic crystal made of alternate left-handed metamaterial and right-handed material. We show that such layered structures can demonstrate a giant lateral Goos-Hänchen shift of the scattered beam accompanied by a splitting of the reflected and transmitted beams due to the resonant excitation of surface waves at the interfaces between the left-handed metamaterial and photonic crystal. The beam shift can be either positive or negative, depending on the type of the surface waves (backward or forward type of surface waves) excited by the incoming beam. In other words it depends on the incident angle of the beam.

Keywords: Goos-Hänchen Shift, Tamm States, Left-handed Metamaterial, Photonic Crystal

Surface optical waves in semi-infinite one-dimensional photonic crystals containing alternating layers of positive and negative media with a cap layer

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An analytical direct matching procedure within the Kronig-Penney model was applied to analyze the dispersion behavior of the localized surface states supported in the surface of a semi-infinite one-dimensional photonic crystals truncated with air or cap layer [1]. The photonic crystals contain alternating layers of positive and negative media. The present study demonstrates that by choosing some proper value for the PC parameters, zero and negative dispersion of surface modes emerge in a large range of $k_{||}$. New forward and backward surface waves are introduced. Due to the different nature of the band structure the surface modes are more localized compared to those appeared in the conventional photonic crystals.

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Crystal field analysis of Cr^{3+} in the $LiGa_5O_8$ spinel

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Cr^{3+} - doped inverse spinel $LiGa_5O_8$ crystal has interesting magnetic properties and is used in various microwave techniques, holography and cathode batteries [1]. $LiGa_5O_8$ belongs to the O_h^7 (Fd3m) space group, with 8 formula unit in a unit cell. After doping, Cr^{3+} ions substitute for Ga^{3+} ions at the octahedral sites, with the C_2 orthorombic symmetry.

The aim of this paper is to perform detailed and consistent crystal field analysis of Cr^{3+} spectra in the framework of the exchange charge model [2] of crystal field.

Using crystal structure data, we calculate the crystal field parameters (CFPs) for Cr^{3+} ions; subsequent diagonalization of the crystal field Hamiltonian enables us to obtain the energy level structure of Cr^{3+} ions in $LiGa_5O_8$.

To ensure a good convergence of the lattice sums needed for the CFPs calculations, large clusters consisting of 56631 ions were considered. With the CFPs calculated, the crystal field Hamiltonian of the Cr^{3+} was diagonalized in the space spanned by wave functions of all 8 LS terms of the $3d^3$ – electron configuration (spin – orbit and vibronic interactions were left out of consideration). Calculated in this way energy levels and estimated Racah parameters *B* and *C* were compared with experimental spectroscopic data [3,4]; good agreement between the calculated and observed energy levels was demonstrated (Table 1).

Table 1. Observed and calculated (this work) energy levels (in cm^{-1}) of Cr^{3+} ion in $LiGa_5O_8$

Energy levels (O_h group notations)	This work			
	Calculated	Averaged	Observed [3]	Calculated [5]
$^4A_{2g}$	0	0	0	
$^2E_{2g}$	14017 14251	14134	14071	14339
$^2T_{1g}$	14733 14808 15071	14871	15046	14976
$^4T_{2g}$	16346 17211 17247	16935	16936	17088

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Dispersion of Bloch modes in a multilayer structure with alternating left-handed and right-handed materials

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The Bloch modes of all-evanescent fields that propagate perpendicularly to the surface or guided modes are shown to allow for the efficient radiation energy transport across a multilayer metal-dielectric nanofilm structure [1-3]. However, such Bloch modes are strictly TM-polarized. Here, we demonstrate that transparent bands of both TE- and TM-polarizations can exist in a one-dimensional periodic structure with alternating left-handed and right-handed materials. Moreover, those transparent bands, in some cases, may overlap. The transparent photonic bands can be excited in the structure provided it is composed with unit cells that possess mirror symmetry. In fact, a unit cell represents a slab with the core with simultaneously negative dielectric permeability and permittivity (left-handed) and normal dielectric cladding (right-handed). The surface or slow guided modes appear to be eigenmodes that can propagate along the surface of such a slab [4]. Namely, the coupling of the eigenmode evanescent fields in neighboring unit cells makes possible the existence of the Bloch modes, even in an infinite multilayer structure. We investigate frequency bands as a function of the two orthogonal wavevectors: the Bloch wavevector $\vec{k}_B$ and the surface wavevector $\vec{k}_S$.

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Gaussian-induced rotation in trigonal photonic lattices

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Time-dependent rotation of counterpropagating mutually incoherent self-trapped Gaussian beams in periodic optically induced fixed photonic lattices is numerically investigated. Rotation occurs for some values of control parameters. For parameters of such rotation, the solitonic solutions are found using modified Petviashvili's method. It is shown that they correspond to the lowest values of propagation constant in the power diagrams and relation between observed rotation and less confined discrete solitonic solutions are demonstrated.

Aperiodically poled nonlinear crystals as sources of multi-frequency laser radiation

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The simultaneous realization of several nonlinear processes can be achieved in crystals with aperiodically changing nonlinear coefficient (aperiodically poled nonlinear crystals) [1, 2]. However, well-known aperiodic structures have sufficiently complex algorithms of fabrication and allow to realize only one or two nonlinear optical processes in such a crystal.

Several nonlinear processes can be realized rather simply by using a new type of aperiodically poled nonlinear crystals, in which the aperiodic changing of nonlinear coefficient is defined by superposition of several harmonic functions, each of them corresponds to their own nonlinear process [3, 4]. Thus the quasi-phase matching condition is fulfilled for each of the nonlinear processes and multi-frequency coupled wave processes can be implemented.

For these aperiodically poled nonlinear crystals we have study the new multi-frequency process, which consists of three coupled nonlinear optical interactions: two parametric down-conversions and one up-conversion. In such process five waves with different frequencies take part. In our paper the spatial dynamics of wave intensities is studied in detail. We have found the optimal conditions between nonlinear coupling coefficients and wave amplitudes, for which the initial stage of wave interactions is parametrically unstable. We have demonstrated, that the secondary simplification of coupled differential equations with spatial modulated nonlinear coefficients, which result in differential equations with constant effective nonlinear coefficients, allow us correctly to describe the dynamics of wave interactions.

The possibilities of obtaining multipartite entangled photon states and ultrashort light pulses generation in the studied type of aperiodically poled crystals are discussed.

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Holographic fabrication of periodic microstructures in dichromated pullulan

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One way to create photonic crystal structures is realized by holography [1 - 4]. In this study dual-beam multiple exposure technique is used to generate various lattice structures. In the dual-exposure process, the photonic crystal structure is obtained by rotating the holographic recording material between exposures. A range of lattice structures can be obtained by varying the angle between two beams, ant the rotation angle of holographic material.

Previously, photonic structures have been recorded also in low - refractive index materials such as photoresists [4]. The holographic material used in this study is pullulan (which is biopolymer), doped with dichromate [5 - 6].

A single-frequency, diode pumped Nd-YAG laser, at 532 nm, is used for exposure (200 mW laser power). Linearly polarized, laser beam is split into two equal power beams. The beam interference pattern is recorded and surface relief is obtained after chemical processing. By proper choice of rotation angles and exposure method, different structures can be generated [7].

Double and triple exposures of pullulan were used. Relief structure of photonic lattice with rectangular array of peaks and holes was obtained by rotating the material for 90˚, between exposures. A rhombic photonic crystal lattice was similarly produced by rotating the material for 45˚. A hexagonal array was produced using three exposures with holographic material rotated by 0˚, 60˚ and 120˚.

The structures were characterized by atomic force microscope (AFM) needle sensor on the TwinSnom system. The structures have periodicities of the order 1.1 μm and depth greater than 50 nm. Our samples, although with low refractive index, could be used as templates for fabricating photonic crystal structures with higher refractive index for complete band gaps.

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Calculation of diffusion current in tunnel diode by a quantum mechanical approach

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***Abstract**:* - In this paper, we use a quantum mechanical approach to make a good approximation of the magnitude of the diffusion current in a tunnel diode. At first we look at tunnel diode as a p-n junction with a potential barrier between the two ends of depletion region. We also suppose that an external voltage is applied on the device as biasing which can be forward or inverse. The exact form of the potential barrier will be given for a typical tunnel diode which is of a linear form. Then we will solve Schrödinger equation for this system and extract the solutions as well as the coefficient of transmittance and reflection for electrons. These processes are repeated for holes, too. The Airy functions appear in as the solutions. Finally, we will give a good and near exact estimation of the diffusion current for tunnel diode. A comparison is also made between our results and those are presented in electronic texts. It will be seen that there is a good accordance between our obtained I-V diagram with that of found in electronic texts.

***Key Words**:* - Diffusion current, Tunnel diode, Potential barrier, Schrödinger equation, Coefficient of transmittance, Airy functions

Electroluminescence and the Photo-Trigger Effect in mono-Crystals of GaSSe1 Solid Solutions

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Effects of switching and electroluminescence and also interrelation between them in mono-crystals of solid solutions GaSSe1 are found out and investigated. It is established, that the threshold voltage of switching depends on temperature, from specific resistance and composition of solid solutions, and also from intensity and spectral composition of photoactive light. Therefore the photo-trigger effect under action of light from area of fundamental absorption is observed. In pre-breakdown areas of current-voltage characteristics is observed the electroluminescence, which intensity by jump decreases up to zero at switching a sample from a high-resistance condition into low-resistance. Experimental results which testify to the injection mechanism of an electroluminescence and effect of switching as it takes place in other layered crystals such as A3B' are resulted.