Abstracts: Talks

Luminescence Investigation of Hafnia and Zirconia Thin Films, Nanopowders and Ceramics

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Hafnia and zirconia are widely used materials because of their excellent mechanical, optical, thermal and electrical properties. High effective atomic number and density, transparency in UV to near IR spectral range, high melting point and chemical stability makes them promising materials for application in fields of scintillators [1, 2], solid state lasers [3], UV dosimeters [4], gas sensors [2], protective coatings [6] and modern micro- and optoelectronic industry [7].

Nanopowders frequently show more favourable properties compared to their bulk counterparts. Due to nanosize effects these nanopowders may possess unique properties, such as enhanced luminescence yield, applicable in photonics. In particular, scintillators based on nanosized materials can enhance spatial resolution due to minimal optical scattering effects.

High quality optical ceramics are considered as promising materials for applications in scintillators and as laser media. Transparent optical materials with high refractive indices play an important role in various fields (incl. optics of modern digital cameras). Among the ceramic advantages are their low cost, that they can be prepared in bigger sizes, complex shapes and with excellent homogeneity sometimes resulting in higher performance in comparison with their crystal counterparts.

In this work hafnia and zirconia thin films were prepared by Atomic Layer Deposition (ALD) method, nanopowders were prepared by solution combustion synthesis and ceramics by high-pressure sintering technique, respectively. Luminescence properties of materials were investigated under photoexcitation in UV-VUV range and e-beam excitation at temperatures 10-400 K incl. studies of temperature dependencies, decay kinetics for various emissions. The properties of electronic excitations, their dynamics and energy transfer processes for ceramic and nanopowder hafnia and zirconia will be discussed on the basis of the experimental data obtained.

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Nonequilibrium particle production in strong laser fields

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The formulation of a kinetic theory approach to the problem of nonequilibrium particle production in strong fields has been advanced recently in studies of the dynamical Schwinger effect for e^+e^- plasma creation in high-intensity lasers [1, 2, 3]. We consider the problem of vacuum e^+e^- pair creation at the focus of two counter-propagating high-intensity laser beams with wavelength ranging from the optical to the X-ray domain and field strength covering present-day optical laser capabilities up to possibilies offered by the European Extreme Light Infrastructure (ELI) infrastructure. Our approach is based on the collisionless kinetic equation for the evolution of the e^+ and e^- distribution functions governed by a non-Markovian source term for pair production. As a possible experimental setup for amplifying the e^+e^- pair production from the vacuum we consider the superposition of two laser colliders with different pulse profile and subcycle frequency, the so-called assisted pair production in a bifrequent external field [4, 5].

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Nonlinear optical properties of gated graphene systems

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Graphene is a unique bridge between condensed matter physics and relativistic quantum field theory [1] and due to its extraordinary properties is of great interest for nonlinear optical applications.

Theoretical and experimental investigations on the nonlinear electromagnetic effects in graphene so far have been mainly focused on monolayer graphene. Meanwhile, there is growing interest in bilayer and trilayer graphene systems, where the electronic band structures are richer than in monolayer and can be easily manipulated by external fields. Theoretical and experimental studies [2, 3] have shown that a perpendicular electric field applied to bilayer of graphene modifies its band structure and may open an energy gap between the conduction and valence bands, which can be tuned between zero and midinfrared energies. The magnitude of the gap strongly depends on the number of graphene layers and its stacking order [3].

In the present work we develop a microscopic theory of a strong electromagnetic field interaction with multilayer graphene systems with an energy gap opened by external gates. We study the nonlinear response of bilayer and trilayer graphene, e.g Rabi oscillations corresponding to periodic creation and annihilation of particle-hole pairs, as a function of the gate voltage when one-photon interband excitation regime is induced by intense coherent radiation. We show that at resonant photon energy close to the energy gap and by adiabatically changing the gate potentials on time one can produce full inversion of the electron population between valence and conduction bands. The proposed method resembles well known Rapid Adiabatic Passage technique for the population inversion in a two level system. Due to relative flatness of the bottom (top) of conduction (valence) band in multilayer graphene systems in the presence of perpendicular electric field, the density of coherently created particle-hole pairs becomes quite large, which can make possible Bose-Einstein condensation of electron-hole pairs. We consider also excitonic states in graphene multilayers with opened energy gap. To take into account the Coulomb interaction, we use Hartree- Fock approximation that leads to closed set of equations for the single-particle density matrix.

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Controlled spatial soliton formation and guiding in nonlinear photonic lattices: Application to all-optical devices

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The optical induction technique using nondiffracting Bessel beams is a novel, promising approach for the realization of complex wave-guiding photonic lattice structures in photorefractive materials [1–3] and provides nonspreading, high-contrast volumetric lattices.

We present controlled light propagation in an optically induced 2d azimuthally modulated Bessel-like photonic structure with a 4-fold symmetry, realized in strontium barium niobate (SBN). Probe beam localization and soliton formation in the self-focusing and defocusing regimes are presented for the first time.

Our experimental setup consists of a two-arm experimental scheme that uses light from a cw laser at a wavelength of 532 nm. In the one arm, the azimuthally-dependent Bessel-like intensity pattern with 25 μm spacing between concentric rings was formed by coherent overlapping of two in-phase co-propagating zero-order Bessel beams using a spatial light modulator (SLM) technique. These two beams are shifted towards each other by a few Bessel periods which results in the azimuthally modulated 4-fold structure Fig. 1(a).

This complex non-diffracting intensity pattern is subsequently used for optical induction of the 2d structure in the 20 mm long SBN crystal with an externally applied electric field of 1.5 kV/cm along its c-axis. In the second arm, Gaussian probe beams with diameters of 25-50 μm and power of few μW were formed. The nondiffracting lattice wave and probe beam were combined and imaged by a high numerical aperture telescope onto the input face of SBN crystal. A CCD camera was used to analyze the time evolution of intensity distribution at the output face of the crystal. Both self-focusing and defocusing regimes were studied by reversing the direction of external electric field.

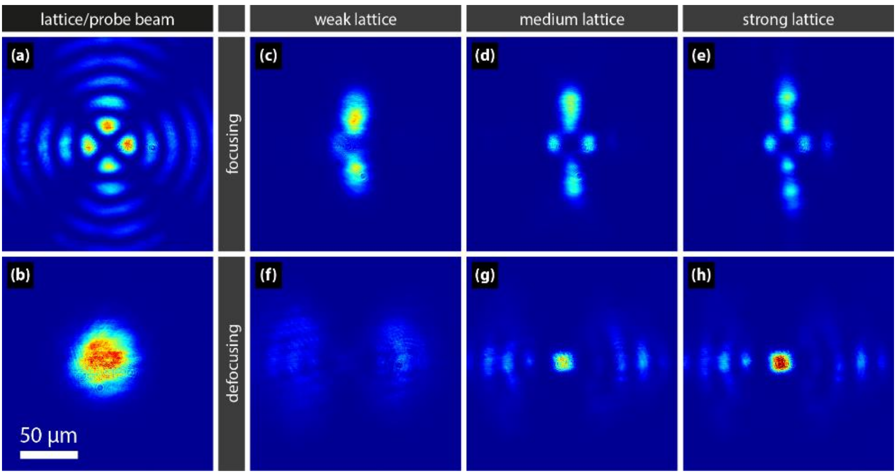

Fig.1.

Fig. 1(a) depicts the profile of an azimuthally modulated Bessel-like lattice beam, and Fig. 1(b) shows the input probe beam with a diameter of 50 μm. Figs. 1 (c)–(e) show the time evolution of the output profile of probe beam propagated through the structured medium in self-focusing regime, where probe beam localizes at the wave-guiding lattice structures. Similar measurements were performed in self-defocusing regime and results are shown in Figs. 1 (f)–(h). Here, the probe beam localizes and forms a soliton in the center of photonic lattice where the lattice beam has zero intensity and the refractive index of the crystal is larger compared with the illuminated areas of the crystal by lattice beam.

The results obtained from light localization and soliton-like behavior in nonlinear 2d structured media pave the way to novel guiding and trapping systems, and all-optical devices for information processing.

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Quantum Entanglement of Field States in Third-Harmonic Generation Process

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For the process of intracavity third-harmonic generation, the dynamics of the correlation function of the quantum fluctuations of the quadrature amplitudes, as well as the dynamics of the correlation function of the quantum fluctuations of the number of photons of the fundamental mode and the mode of the third harmonic is studied [1]. It is shown that in the case of evolution of the system from initial vacuum states of both modes, both of the the correlation functions converges to stationary values. It is shown that these correlations highly depend on the coefficient of the nonlinear coupling between the modes. In the case of small coupling coefficients the correlation of the fluctuations of the quadrature amplitudes as well as the correlation of fluctuations of the number of photons are weak. With the growth of the coupling coefficient both the correlations increase (states of the subsystems become more entangled by the corresponding variables). With the further increase of the coupling coefficient correlation of fluctuations of the quadrature amplitude tends to disappear (the entanglement of the subsystem states related to the quadrature amplitude disappears), and the correlation of fluctuations of the number of photons does not disappear (subsystems remain entangled by the photon-number variable).

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Transparency induced by transverse magnetic field as a tool for vector magnetic field measurement

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Weak magnetic field measurement precisely is of great importance in lots of applications, including medicine, spectroscopy, geology, etc. There are several all-optical methods for weak magnetic field measurement, but only few of them suggest measurement of the vector magnetic field. Currently we present a theoretically elaborated method to measure weak magnetic vector fields of several mkG. We consider cyclic transitions of alkali atoms, let say Rb atoms, that interact with a laser field of σ^+ polarization, as well as transverse and longitudinal magnetic fields. Transverse magnetic field couples ground and excited Zeeman sublevels, which leads to population transfer between the ground states. The latter causes transparency in the medium. Measuring the laser field transmission dependence on transverse and longitudinal magnetic fields, one can define the vector magnetic field.

Waveguide Integrated Plasmonic Slot Nano-Antenna

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Optical antennas, analogues of microwave antennas, are a new concept in physical optics which enable technology for manipulating optical radiation at subwavelength scales [1,2].

Plasmonic slot nano-antenna coupled with plasmonic waveguide is considered (see Fig.1). Various types of slot antenna shapes (rectangular slot antenna- magnetic dipole, triangle slot antenna- bowtie slot antenna) are investigated and the theory of plasmonic slot nano-antenna is developed. The analytical model takes into account also the electrical field inside the metal due to imperfectness of metal in optical range, as well as numerical investigation of 3D structures based on finite element method (FEM) is realized.

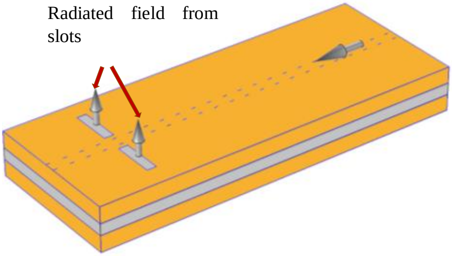

Fig.1. Schematic view of slot nano-antenna radiation coupled with plasmonic waveguide.

The slots near-field interaction is basically realized via magnetic field, unlike dipoles. This fact opens up new possibilities of slot antennas application in optical range, such as improvement and investigation of fine and quadrupole interactions and transitions, quadrupole excitation of nucleus. As the slot-type antenna can be combined with any plasmonic components made on a metallic plane easily, we expect that the slot nano-antenna will be integrated further with other plasmonic devices and play an important role in plasmonic integrated nano-circuits in the future.

According to the theory developed in [3] an additional electrical field is appears in the wire due to imperfect conductivity of metal. Based on Babinet's principle by applying $E \leftrightarrow H$, $Z \rightarrow -1/Z$ interchanges radiated field distributions can be found for slot antenna [4].

One of the key parameters of antenna theory is the antenna efficiency, which characterize the antenna and waveguide impedances matching. The impedance matching between antenna and waveguide is calculated by using standing wave ratio (SWR) parameter. SWR defined as the ratio of maximal and minimal values of electric field. Based on SWR calculations coupling efficiency of slot antenna and waveguide is estimated depends on slots and waveguide sizes distance between slot antenna and waveguide as well as dielectric constants filled waveguide and slot.

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Extractable work from correlations

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Work and quantum correlations are two fundamental resources in thermodynamics and quantum information theory. In this work, we study how to use correlations among quantum systems to optimally store work. We analyse this question for isolated quantum ensembles, where the work can be naturally divided into two contributions: a local contribution from each system, and a global contribution originating from correlations among systems. We focus on the latter and consider quantum systems which are locally thermal, thus from which any extractable work can only come from correlations. We compute the maximum extractable work for general entangled states, separable states, and states with fixed entropy. Our results show that while entanglement gives an advantage for small quantum ensembles, this gain vanishes for a large number of systems.

Memristive Properties of Transparent Li-doped ZnO films on metal and transparent oxide substrates

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The resistive switching (RS) phenomena in series of multilayer metal/oxide/metal (MOM) structures differing from each other by an oxide layer [ZnO, ZnO:Li (1 and10 at.%Lithium), SnO2)], electrode material [Al, Ag, Au, Pt, SnO2:F (20% fluorine), LaB6] and interface at oxide/electrode contacts prepared by an e-beam evaporation technique are studied. On the basis of the structural (composition, crystalline structure, surface morphology), electrical [current-voltage, capacitance-voltage, breakdown, resistance ratio (Rset/Rreset)], and optical (reflectivity, transmittance, refractive index, band gap, concentration of free charge carriers) characteristics as a function of electrode and oxide material, impurity (lithium) content, polarity of applied voltage, Schottky barrier height, number of switching

cycles, forming and annealing processes are studied memristive (resistance memory) properties [unipolar (URS), bipolar (BRS) and monostable threshold (MTS) resistance switching, memory endurance, data retention, number of data erasing and writing cycles, characteristic variation from cell to cell] of abovementioned MOM structures.

In summary, coexistence and reversible conversion of URS and MTS polarity-dependent modes of Al/ZnO:Li10%/LaB6 structure is observed. The La2O3 interlayer inserted between ZnO:Li10% and LaB6 electrode activates only BRS mode that is related to the interfacial RS effect. Resistive switching memory mode depends on Li content impurity in ZnO films, height of the Schottky barrier at oxide/electrode interface, and reactivity between electrode and oxide film. Ohmic and space-charge-limited current laws are responsible for conductivity mechanism of resistive states. In first, it is shown that ZnO:10%Li/SnO2:20%F transparent structure exhibits nonvolatile bipolar resistance memory properties with high memory endurance that can find an application in transparent electronics.

A note on the Natanzon potentials for the Schrödinger equation

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We show that if the potential term in the stationary Schrödinger equation is proportional to a parameter which is independent of energy and if the potential shape itself is independent of this parameter and energy, the Natanzon family of potentials [1] solvable in terms of standard special functions is dropped into a restricted set of distinct potentials involving a fewer number of independent continuous parameters. Only a few of these potentials are independent in the sense that each cannot be derived from others by specification of the parameters. There are only two independent hypergeometric (Eckart [2] and Pöschl-Teller [3]) and three confluent hypergeometric (oscillator plus inverse square, Coulomb plus inverse square, and Morse [4]) potentials. Discussing the confluent Heun potentials [5], we show that there exist only six independent potentials which all are seven-parametric. Two of these potentials present generalizations of the hypergeometric ones, three others generalize the confluent hypergeometric cases, and a last potential does not possess hypergeometric sub-potentials. In the last case the potential is explicitly given by a coordinate transformation written in terms of the Lambert W -function, also known as the product logarithm.

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Electrical tuning of silicon metasurfaces

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Metasurfaces are two-dimensional structures consisting of planar arrays of nanostructured building blocks ("meta-atoms") which possess strong electric and magnetic resonances at the optical wavelengths. Tailoring properties of metasurfaces gives potential to provide flat, ultrathin components for multitude of optical functionalities.

Previous works have demonstrated that using array of silicon nanodisks gives possibility to create all-dielectric metasurface with efficiency close to 100% [1]. The ability to dynamically and reversibly shift the spectral position of the metasurface resonances in liquid crystal is shown in the recent work [2]. An active tuning of both electric and magnetic resonances was realized using the temperature dependence of the liquid crystal refractive index. However, the realization of complex, spatially dependent tuning patters cannot be achieved by temperature tuning and voltage control over the liquid crystal orientation is highly required. Moreover, temperature tuning switches resonance in step-like behavior at transition between the nematic and isotropic phases of the liquid crystal, whereas electrical tuning allows continuous moving of the resonances with a relatively high speed. Here we demonstrate, for the first time to our knowledge, the voltage control of the spectral positions of the electric and magnetic resonances of an all-dielectric metasurface. Figure 1 shows two transmission line for polarization parallel to alignment of liquid crystal at an applied voltage 0 and 10 V. These results open the possibility to the realization of tunable dielectric metasurfaces with electronically dialed up properties.

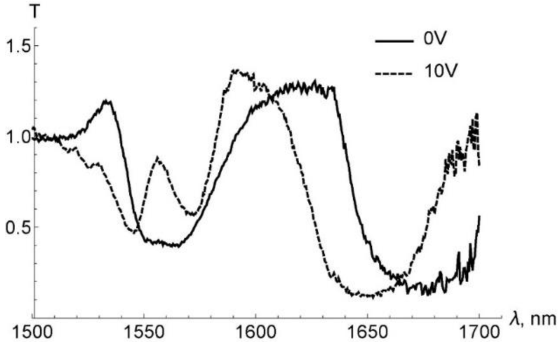

Figure 1. Experimentally measured normalized transmittance spectra of a metasurface embedded in nematic liquid crystal at the applied voltages of 0 and 10 V.

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Non-exponential Auger decay

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The exponential decay law of excited states of quantum systems is well known and has a rather universal character [1]. The decay is exponential, when the energy distribution of the excited state has a Lorentzian shape. The non-exponential decay, first considered by Khalfin [2], occurs in a variety of quantum systems. For long observation times, it is caused by deviations of the energy distribution of a non-stationary state from the Lorentzian shape. For example, the photon emitted as a result of a spontaneous de-cay of an excited state has a positive energy. Therefore, the energy spectrum of the emitted photons is cut at zero energy. Generally, at long observation times such cutoff results in a power-law decay of the state instead of exponential decay. The specific law of the non-exponential decay is mostly defined by the behavior of the width of the excited state as a function of energy near the edge of the energy spectrum. If the width has a power-law dependence on the energy, then the decay also has a power-law dependence on the time. With an exponential dependence of the width on the energy, the probability for the system to stay in the initial state decreases exponentially, however, with an index of the exponent involving the time in a fractional power. We discuss the possibility of non-exponential Auger decay of atoms irradiated by X-ray photons. This effect can occur at times, which are greater than the lifetime of a system under consideration. The mechanism for non-exponential depletion of an initial quasi-stationary state is the cutting of the electron energy spectrum of final continuous states at small energies. Then the Auger decay amplitude obeys $t^{-1/2}$ power-law dependence on long observation times [3].

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Thermoelectric Single-photon Detector on the Base of CeB_6 and $(La,Ce)B_6$ Nanowires

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Intense development of science and engineering requires new generation of devices for precise measurements. Interest in single-photon detectors (SPD) has recently increased dramatically, due to many novel applications in various research fields, such as quantum communication, quantum cryptography, space astronomy, chemical analysis, particle physics, medical applications, traditional and quantum-enabled metrology and others [1]. The most developed SPD are currently based on superconductors. Over the last ten years superconducting nanowire single-photon detectors (SNSPD) are actively investigated because of their high system detection efficiency, low dark count, high counting rate and timing resolution [2]. Following the theory, thermoelectric detectors can compete with superconducting detectors [3] and Thermoelectric Nanowire Single-Photon Detector (TNSPD) with superconducting nanowire single-photon detectors [4].

We have collected and analyzed the values of thermoelectric parameters of cerium and lanthanum-cerium hexaborides and on this basis calculated the energy resolution and photon count rate of the TNSPD with different geometries. It is concluded that the TNSPD can achieve higher specifications, as compared to the best single-photon detectors. The lanthanum-cerium hexaboride sensors of TNSPD are expected to reach more than gigahertz count rates and will have a sensitivity of 0.1 eV. It means that the device is sensitive enough to register and spectrally characterize not only X-ray and UV, but also optical and infrared photons, as its major competitors, the superconducting and semiconducting single-photon detectors.

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Resonant Kapitza-Dirac Diffraction with Small Population Transfer: Application for Light-Pulse Atom Interferometry

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Examining the Kapitza-Dirac diffraction problem, we extend the Bloch-state approach to atomic translational states out of generally used Raman-Nath and adiabatic following approximations, by including the possible transfer of population from the initially populated internal energy level. The presented theory introduces a notion of potential energy for the initially populated internal state. We apply the theory for a two-pulse standing wave atom interferometer (studying noncoherent processes in the cold atomic gases) and discuss its ability for constructing a large-angle multipath atom interferometer.

Pumping Duration Effects on the 1.5 μm Downconversion Luminescence Kinetics of Er:YAG

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Currently, YAG:Er^{3+} crystals are widely used in laser industry due to their radiations near the 1.5μm and 3μm wavelength range which have various applications in optical communications systems, medicine, remote sensing and ranging. The dynamics of radiative and nonradiative energy transfer processes under pulsed excitations in doped single crystals are poorly investigated. Study of the spectroscopic properties of Er^{3+} ions in YAG crystals and influence of the specific excitation on their luminescence characteristics are important for 1.5μm generation optimal pumping scheme suggestion. In this work we investigated the dependence of 1.5 μm luminescence kinetic properties on pumping pulse duration for various excitation wavelengths (445nm, 808nm and 980nm) in the YAG:Er^{3+} crystals. The measurements are carried out for two different concentrations of Er^{3+} (5 at.% and 40 at.%): In order to minimize the radiation trapping effect on registered decay times a special experimental setup is realized with usage of pinhole technique. The registered luminescence kinetics shows strong dependence on pump duration with tendency to shorten the luminescence decay time from $^4I_{13/2}$ level. Luminescence decay form change from exponential law is registered for higher concentrations of Er^{3+} and longer excitation durations. To explain this tendency different nonradiative energy transfer processes between Er^{3+} ions are discussed. Taking into account these considerations a mathematical model is suggested which allows to estimate the corresponding coefficients of nonradiative energy transfer probabilities. The proposed model shows close similarity between calculated and experimental results.

Reorientation of nematic liquid crystal under the influence of laser light and electric fields

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The effective refractive index of the liquid crystal can be modified under the influence of an electric field. In case of liquid crystal with positive dielectric anisotropy a torque is generated in the volume to align the highest polarizability with the electric field. Hence the energy density is minimized and the system gets to an equilibrium.

We report on the generation of domains in nematic liquid crystal due to the joint influence of laser beam and an electric field (Fig. 1). The generated domains are an order of magnitude larger than the size of the optical field profile. To create quasi-stable domains in the nematic liquid crystal with anti-parallel rubbing it is necessary to get an opposite tilting with respect to the rest of the cell. For that reason an optical field needs to be applied first. The final reorientation strongly depends on the starting conditions and properties of this optical field. If the pre-tilt is reversed, an additional application of the voltage amplifies the reorientation dramatically.

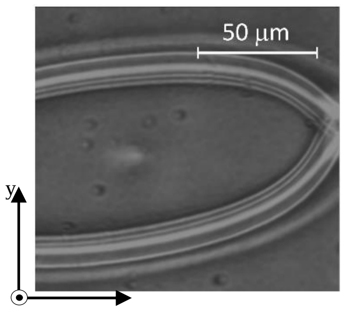

Fig. 1 Microscope transmission image of planar NLC, seconds after switching on the voltage. The preliminary present IR laser beam (inducing the spot near the middle) has inclination angle of 10°.

The resulting reorientation of the director due to the joint influence of the focused laser light and the electric field leads to an unusual refractive index profile which itself causes lensing effects. In our experiments we confirm the concept of competitive switching when simultaneously electrical and optical torques are present in a nematic liquid crystal [1].

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Hanle optical vector magnetometer based on compensation of *B*-field

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A concept of an optical magnetometer for measurement of magnitude and direction of magnetic field in two orthogonal directions is developed based on double scanning of a *B*-field to compensate the measured field to the zero value, which is monitored by a resonant magneto-optical process in an unshielded atomic vapor cell. Implementation of the technique using nonlinear Hanle effect on D_2 line of Rb has shown viability and efficiency of the proposed concept.

The non-shielded Rb vapor cell is placed in an assembly of three-axis magnetic coils. A magneto-optical process used in this approach is chosen to yield a peculiarity (maximum or minimum of the recorded signal) at $B = 0$ [1]. The measurement procedure implies computer-controlled scanning of magnetic field produced by the coils covering all the values in the set range of $-B_m$ to $+B_m$ with the set step. In the course of measurement run, the scanning will pass a unique value B_{comp}, at which the B-field in interaction region is compensated to zero, so the measured value monitored by optical signal extremum will be $B_{meas} = -B_{comp}$. The maximum field produced by the coils determines the maximum range of measured B-field (see Fig.1).

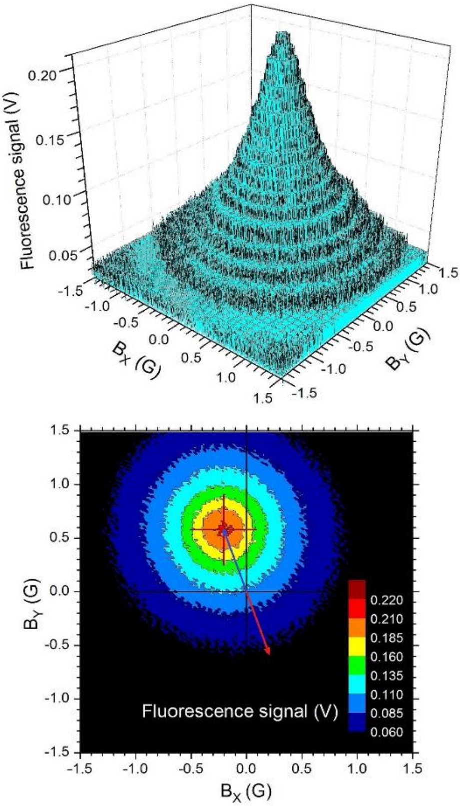

Fig.1. Hanle fluorescence signal recorded on ^{85}Rb $F_g=3 – F_e=4$ hyperfine transition of D_2 line while 2-axis scanning magnetic field in transverse plane from –1.5 to +1.5 G. *Upper graph*: 3D presentation; *Lower graph*: contour plot, center of circular structure (red cross) corresponds to $B = 0$. The measured B-field vector in X-Y plane (B_X = +204 mG; B_Y = –581 mG) shown by a red arrow is opposite to compensation field (blue arrow).

Compared with other optical vector magnetometers, the proposed technique has lower sensitivity and long measurement time. Nevertheless, among its merits are simplicity and wide measurement range. It can find applications for compensation of an ambient magnetic field, for geophysical and material science studies.

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Faraday Effect in an optical nano-cell

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The peculiarities of Faraday Effect (rotation of the plane of polarization of laser radiation in a magnetic field) are studied in atomic vapors of Cs D1 line with the usage of nano- cell with the varying thickness L=80-900nm. The comparison of Faraday Rotation (FR) signal parameters for two selected thicknesses $L=\lambda$ and $L=\lambda/2$ shows the unusual behavior of FR signal. CW narrow-band (~1 MHz) diode-laser radiation as well as a technique based on the crossed Glan polarizers have been used. For $L= \lambda/2$ = 447.5nm and the laser power of 0.1 mW the FR signal spectrum (~ 35 MHz) is narrower than that for $L= \lambda$= 895nm (~ 140 MHz) and has 3.5 times larger amplitude than that for $L= \lambda$= 895nm.The nano-cell temperature is 150 ^{0}C. These peculiarities become more significant with increasing of laser power. Despite the small thickness of atomic vapors (447.5nm) the FR signal is detectable with the magnetic fields ≥ 0.4G, which can be used in practical applications. When the atomic vapor thickness is < 100nm the spectrum of FR signal demonstrates the "red shift", which is a manifestation of Van der Waals effect. The developed theoretical model very well describes the experimental results.

The research was conducted in the scope of the International Associated Laboratory IRMAS (CNRS-France & SCS-Armenia).

Nonlinear Upconversion Based on Enhancement of Third Harmonic Generation in Gold Nanomatryoshka: A Nonlinear FDTD Analysis

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Up-conversion mechanism is well known in medical applications, principally in mainly with diagnostics and therapy. Among different mechanisms for lowering the excitation, the approaches based on nonlinear optics are well known because it is needless to any specific chemical compound. Nonlinear plasmonic based on enhancement of nonlinearities is in center of attraction for biomedical applications [1]. Gold Nanomatryoshka has been introduced as structures containing core of gold, covered with SiO_2 layer and gold shell with remarkable local field enhancement in fluorescence imaging [2]. We have studied the third order nonlinear response of gold Nanomatryoshka structures, using nonlinear finite difference time domain method [3]. Results of the simulation as depicted in figure 1, show the generation of third harmonic (210 nm) of excitation wavelength (630 nm) and its localization around the structure. The localization of generated wavelengths in UV region can be fruitful in applications such as fluorescent imaging and cell killing.

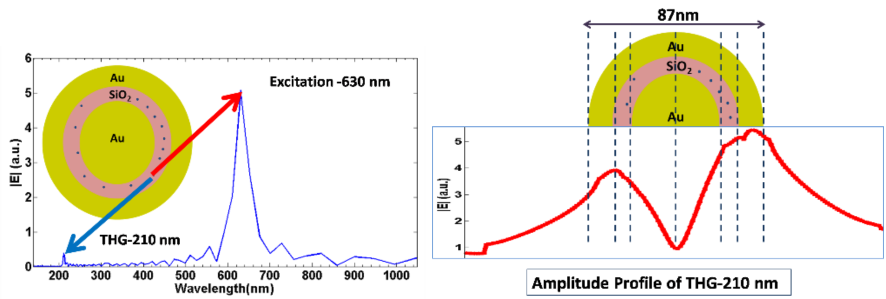

Figure 1. Spectrum of Electric Field (Left) and Amplitude Profile of Third Harmonic Generation (Right).

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Periodically-driven exciton-photon systems

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We consider the system consisting of a large individual quantum dot with excitonic resonance coupled to a single mode photonic cavity in the nonlinear regime when exciton- exciton interaction becomes important. The novelty of our scheme stems from the idea that quantum systems can display qualitatively new forms of behavior when driven by fast time-periodic modulations. In this way, we show that in the presence of time-modulated external coherent pumping the system demonstrates essentially non- classical behavior reflected in sub-Poissonian statistics of exciton- and photon-modes and the Wigner functions with negative values in phase-space for time- intervals exceeding the characteristic time of dissipative processes. It is shown that these results are cardinally different from the analogous results in cw regime of excitation.

Down-conversion in nonlinear structured fiber

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One of the challenges in the fields of quantum optics and quantum information processing is generation of new sources of quantum light, such as entangled photons with controllable spectral and temporal properties. In this direction, engineering of quantum states of light distributed between several modes of optical waveguides which involve nonlinear media seems to be promising candidate [1, 2].

In particular, of considerable interest is preparation of biphoton wave-packets with small correlation times between two-photons as well as with broad frequency spectra by using method of quasi-phase-matching (QPM) that provides a feasible alternative to conventional phase matching for many optical parametric process applications. There are two principally different methods for calculation of the biphoton spectra in chirped structures. The first is phenomenological approach that describes wave vector in these structures as a function of the light propagation coordinate $k(z) = k_0 + \alpha z$ [3] (allowing to represent the biphoton spectra as error function), whereas in the second approach the chirp is achieved using a sequential structure of discrete layers, which leads to representation of the biphoton spectra via Gauss sums [4].

This report represents analysis of biphoton generation in multilayered waveguides of different structures. Light spatial properties are calculated in layered waveguides. It is shown that biphoton spectrum depends on the waveguide height as well as on the chirp parameter of the structure. It is shown that broadband spectra can be obtained, the dependence of spectrum form on different parameters is studied. Biphotons in different modes are considered, leading to analysis of quantum entanglements.

These results prove that sources for broadband biphoton generation can be found in nonlinear fibers as well allowing the propagation of ultra-broadband down converted light in longer directions.

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YAG:ce crystals: optimization and radiation hardness study for calorimetry applications

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The extremely harsh conditions, in which the detectors will have to operate during the High Luminosity phase of the Large Hadron Collider at CERN, set stringent requirements on the properties of the scintillators which can be used.

Beside high density, fast response and high light yield, the scintillators are required to withstand very high levels of radiation, especially in the forward region of the detectors [1,2].

Among different scintillating materials under study, inorganic crystals YAG:Ce represents a good candidate for such application.

A detailed investigation of the radiation hardness YAG:Ce crystal samples (1x1x1 cm^3 cubes) is presented in this study. Given their potential in many calorimeter designs, YAG:Ce samples with high aspect ratio (1x1x14 cm^3) have also been tested. Optical and scintillating properties of the samples were studied before and after irradiation with different sources and at different intensities.

Irradiation with gamma-rays to the doses of 1 and 50 kGy and with 24 GeV protons up to an integrated fluence of 10^{14} cm^{-2} were performed at CERN.

The scintillating properties of the crystals, as emission and excitation spectra and light yield remained unchanged after irradiation and only small levels of induced absorption were observed. The results obtained in this test confirm the potential of

YAG:Ce crystals as good candidates for calorimetry applications in future high energy physics experiments.

Sampling calorimeter prototypes made of YAG:Ce fibers are being developed and tested with high energy beams at the CERN SPS facility. Preliminary results are reported in this work.

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Optical properties of plasmonic metal nanostructures on the dielectric and semiconductor surfaces

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Optical properties of metal nanostuctures that may be obtained in the form of thin inhomogeneous layers on the surfaces of different materials attract considerable interest of researchers. This interest is due to the intense absorption of light by metal nanoparticles accompanied by the resonance enhancement of electromagnetic fields in the particles neighborhood provided the incident field is in resonance with the surface plasmons localized in the nanoparticles. In this contribution we present the results of our experimental investigations of different composite materials comprising metal nanoparticles deposited on different solid surfaces and a manifold of resonant absorber including organic dye molecules and semiconductor quantum dots. We show that absorption of organic dyes [1] and semiconductor quantum dots [2] may be considerably enhanced in the presence of silver or gold nanoparticles possessing plasmon resonances in the spectral vicinity of absorption bands of dye molecules or quantum dots. On the other hand, the fluorescence intensity may be enhanced as well as quenched due to the radiationless process induced by the metal nanoparticles.

Metal nanostructures modify also the photoinduced transformations of the organic dye molecular layers. They occurred under much smaller fluences than in the pure dye layers. Moreover, contrary to the case of pure dye layers, laser irradiation leads to the buildup of molecular aggregates, in particular, J-aggregates and dimers. It seems plausible that the laser-induced transformations of organic dye molecules in the enhanced near fields of plasmonic nanoparticles proceed via excited electronic states without excessive heating of the layer as a whole [3].

Silver is shown to form granular films not only on transparent dielectric materials like sapphire and quartz but also on semiconductor materials, in particular, gallium arsenide. While SEM images confirm the formation of separated silver nanoparticles, reflection spectroscopy shows that they possess plasmon absorption band in visible and near IR.

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Abstracts: Posters

New approach studying manipulation of qubits by train of pulses

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We present a systematic approach based on Bloch vector's treatment and the Magnus quantum electrodynamical formalism to study qubit manipulation by a train of pulses. These investigations include one of the basic processes involved in quantum computation. The concrete calculations are performed for tunneling quantum dynamics and multiple resonant excitations of qubit driven by Gaussian pulses. In this way, the populations of qubit states due to multiple resonant interactions are investigated for various operational regimes including: single-pulse excitation, two-pulse excitation with phase shift between pulse envelopes being controlling parameter and for excitation with sequential pulses. In the last case, we demonstrate the formation of quasienergetic states and quasienergies of qubit driven by train of identical pulses. In this case the transition probability of qubit exhibits aperiodic oscillations, but also becomes periodically regular for definite values of the quasienergy. The part of these results is presented in Ref. [1].

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Peculiarities of Cs atomic transition behavior in strong transverse magnetic fields

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This research demonstrates that compared to an ordinary cell, the use of the nano-metric thickness cell allows one to effectively study individual atomic transitions of alkali atoms. The method is based on strong narrowing of the absorption spectrum (which provides sub-Doppler resolution) of the L thick ($L = \lambda/2 = 426$ nm) nano-cell filled with Cs.

In case of hyperfine Paschen–Back regime (when applied strong magnetic field is strong enough to decouple the total electronic angular momentum J and nuclear momentum I) and π-polarization of laser radiation, only 16 atomic transitions remain out of initial transitions [1-2]. These 16 atomic transitions are contained within two groups of eight atomic transitions each and the groups are completely separated for B > 8 kG. Developed theoretical model very well describes the experiment [2].

Acknowledgement: The research was conducted in the scope of the International Associated Laboratory IRMAS (CNRS-France & SCS-Armenia). A. S. thanks to ANSEF OPT 3700 grant for financial support.

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The Silicon to Aluminum Conversion Phenomenon in Electrolytic Cells

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When a direct electrical current applied to a water a substantial heating was observed. These phenomena cannot be explained only by heat due to the electric current contribution and exothermic chemical entities stipulated by reacting the hydrogen ions and the hydroxyl group with the electrode material. This result indicates the existence unexplored physical processes which lead to significant heating of water. Furthermore, as a result of repeated experiments, there was an obvious difference in cathode surface color. Compared to the anode, which is essentially keeps its color, the cathode obtain a dark gray color. Also, it is find out a big difference in the electrical resistance of the surface of electrodes. The surface resistance of cathode increased by about 10^7 - 10^8 times, which indicates the formation of new chemical compounds. At the same time the anode resistance does not change. Were made the measurements with a scanning electron microscope in order to identify the composition of gray coatings. The measurements showed a large change in the amount of silicon on the surface of the cathode (from 0,28 weight percent to 8,45 weight percent). Consequently, we can assume that silicon formation is possible due to the nuclear processes occurring at the cathode, wherein the aluminum atoms are transformed to the silicon atoms. On the basis of experimental facts it is made a hypothesis about a possible nuclear transformation scheme Al (n, γ) - Si. Stable isotopes of aluminum and silicon are elements with nuclei and ${}_{13}Al^{27}$ and ${}_{14}Si^{28}$ respectively. When neutron captured by nucleus of aluminum, it forms a heavy isotope of aluminum ${}_{13}Al^{28*}$, which is unstable with respect to beta decay. Due to the beta decay of the isotope ${}_{13}Al^{28*}$ with a half-life 2,24 min, it is obtained a following atomic number of the element - silicon (Si).

I-V characteristics of Pt-$Ba_{0.25}Sr_{0.75}$ TiO_3-Pt thin films with oxygen vacancies

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A new model for calculation of leakage/injection current in ferroelectric perovskite (BST, PZT) metal-ferroelectric-metal structure thin film is considered under the assumption that: a) a high concentration of oxygen vacancies is presence in the interfaced region of metal-ferroelectric contacts which are created corresponding electron trap levels in the band gap of ferroelectric, and b) the dielectric permittivity of ferroelectric materials have nonlinear dependence on applied electric field. The results of proposed model was compared with the experiment and receive a good agreement.

Optical and Scintillation Properties of GGG:Ce Single Crystals

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Single crystals of gadolinium gallium garnet GGG ($Gd_3Ga_5O_{12}$) doped with rare-earth and transition-metal ions are used in the quantum electronic, microelectronics, as phosphors for LEDs production, ceramic and polycrystalline ceramic in medical and industrial X-ray detectors. But utilization of GGG:Ce single crystals as scintillation materials excited by high-energy rays is in abeyance. These crystals don’t exhibit any visible luminescence because of resonant location of the lowest $5d^1$ level in the conduction band [1]. Application of hydrostatic pressure (8 GPa) allows restoring the quite strong Ce^{3+} luminescence in GGG:Ce crystals at 20 K due to the increase of the crystal band-gap and simultaneous lowering of $4f^1$–$5d^1$ transition energy [2].

Aims of this study were the investigation of peculiarities of Ce^{3+} ions absorption in our, Czochralski grown, GGG:Ce single crystals and possibilities of obtaining the visible luminescence of Ce^{3+} and scintillation parameters refinement in these crystals.

Analysis of received experimental results allowed to define:

- the presence at least of four major components of the lowest $5d^1$ energy level of Ce^{3+} in GGG:Ce, the energy positions of which are not depend on the activator concentration;

- visible luminescence on 5d-4f transition of Ce^{3+} in GGG:Ce (0.1 at.%) crystal has been recorded at 300 K. The luminescence bands spectral position (459, 529 and 537 nm), their form and linewigth depend on the wavelength of excitation light (300 – 600 nm);

- scintillation of GGG:Ce crystals at 550 nm have been recorded. Scintillation light yield, excited by X-ray radiation (22.16 KeV) in GGG:Ce crystals activated by 0.03 and 0.3 at % of Ce^{3+} ions are equal 1800 and 23000 ph/MeV, respectively. Examination of scintillation characteristics of GGG:Ce crystals has shown that this material completely meet demands for application in the X-ray image detectors

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Photoconductivity of iron doped $LiNbO_3$ crystals of different stoichiometry

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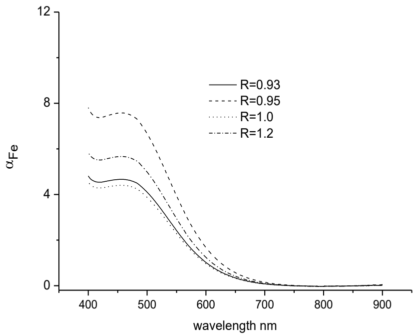
The photorefractive properties of iron – doped lithium niobate (Fe:LN) crystals are controlled by two main compositional parameters: the concentration of the impurity ions (Fe^{2+}) and the ratio of main components of the system (Li/Nb). In this work we try to investigate the interplay between these two parameters. Optical absorption measurements of iron doped lithium niobate crystals with the same content of the impurity ion (0.06wt%) but different composition (Li_2O=0.492, 0.486, 0.50, 0.545) were performed in order to measure the Fe^{2+} absorption at 532 nm. Results are given in the figure 1.

The effect of composition was investigated by performing photorefractive measurements as a function of temperature in the range between 100 and 300 K. The Arrhenius plots of the photoconductivity show a change of slope at low temperature (Figure 2), indicating the onset of different conduction mechanisms. It should be noted that these curves show a marked difference between samples with different composition.



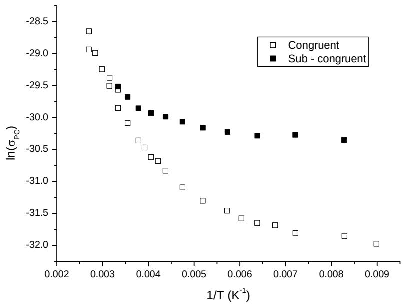


Figure 1: Transmission of the iron doped lithium niobate crystals of different composition.

Figure 2: Arrhenius plots of two samples with different compositions (Li_2O=0.492 sub – congruent, Li_2O= 0.486 congruent)

Formation of Metastable Molecular States at the Resonance Scattering of Two Atoms in a Laser Radiation Field

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By using Dirac's method, the formation of metastable molecular states by the resonance scattering of two atoms in the laser radiation field was considered. Expressions for metastable level populations and resonance scattering cross section are received. In case of exact resonance of laser radiation and due to the Autler-Townes effect, graphics for populations and resonance scattering cross section, which have two peaks, are produced. The results play an important role in the study of controlled chemical reactions, in the understanding of the processes in the quantum systems of the Bose-Einstein condensate at low temperatures, and in various optical processes in atomic gases. Fig. 1 shows that the population of the levels g and e occurs in two ways. The population of level *g* occurs by a direct transition from the continuous state of incident particles to the state |g>and by a transition from the continuous state to the excited state |e> followed by a transition to the state |g>. The population of the state |e> also occurs in two ways. These transitions interfere with each other and cause the Autler-Townes effect. The double peak is also observed in the cross sections of resonant scattering [2-4].

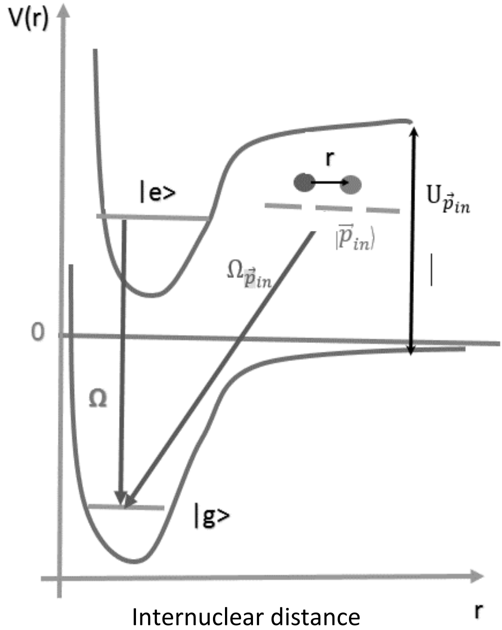

Fig.1. Schematic diagram of atom-atom collision in the laser radiation filed.

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Resonant and non resonant approximation for three level system

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The purpose of this work is to clarify the limits of duration, in which the resonance approximation is quite a good description of coherent processes in a three-level atom. To do this, the simplest case is observed. The dynamics of atomic population of three level system interacting with the one femtosecond laser pulse has been investigated numerically in general case, and analytically in the case of pulses with small area [1,2]. The results, obtained in both resonant and non-resonant approximation, are compared.

Actually, the three-level approximation can fail for very short pulses. This is the case if the spectrum of such a short pulse contains the atomic transition frequencies to a number of levels. Nevertheless, in this paper we restrict ourselves to this model.

Our study of the behavior of an atom interacting with Gaussian pulse showed a significant difference in the results obtained in the framework of the resonance approximation and outside the framework. It is shown that the difference of those two approximations is not only quantitative, but also a qualitative.

We demonstrate that non-resonant corrections could significantly disrupt known coherent processes such as coherent population trapping (CPT) [3] and electromagnetically induced transparency (EIT) [4]. In particular, the destruction of the maximal coherent state and effective excitation of the upper atomic levels occur in the situation where the theory of resonance approximation predicts the EIT and formation of stable qubits (see figure). The change in the behavior of the three level atoms occurs when the duration of pulses is extremely short. In future, a more detailed study, depending on the shape of the pulse, the magnitude of the dipole moments of transitions, multilevel structure of atom, as well as interaction with two femtosecond pulses of different duration will be conducted.

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Efficient adiabatic tracking for molecular Bose-Einstein condensate production with Kerr nonlinearities

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Nonlinear quantum systems are at the heart of contemporary applications such as non-linear optics and Bose-Einstein condensation [1]. The formation of molecules from ultracold atom gases by external fields and more generally the coherent oscillations between the atomic and molecular Bose-Einstein condensates (BEC) feature nonlinearities in their quantum description. We consider third-order nonlinearities, describing atom-atom, atom-molecule and molecule-molecule elastic scatterings:

$$ic_{1t} = \frac{\Omega}{\sqrt{2}} c_1^* c_2 + \left[-\frac{\Delta}{3} + \Lambda_{11} |c_1|^2 + \Lambda_{12} |c_2|^2 \right] c_1,$$

$$ic_{2t} = \frac{\Omega}{2\sqrt{2}} c_1^2 + \left[\frac{\Delta}{3} + \Lambda_{21} |c_1|^2 + \Lambda_{22} |c_2|^2 \right] c_2$$

$c_{1,2}$ are atomic and molecular state probability amplitudes, respectively, $\Omega(t)$ is the Rabi frequency, and $\Delta(t)$ is the detuning. For the initial condition $c_2(t_0) = 0$ we obtain:

$$P(t) = 2|c_2|^2 = \tanh^2 \left[\int_{t_i}^{t_f} \frac{\Omega(s)}{2} \sin\alpha(s) ds \right].$$

We prove that this nonlinear system does not have any solution leading exactly to a complete population transfer. It can only be reached asymptotically for an infinite pulse area. The same result we have without Kerr terms [2].

Further, we present analysis, which shows that an efficient adiabatic transfer can be achieved by the adiabatic tracking approach also with Kerr nonlinearities. We propose an efficient and robust adiabatic passage technique for a driven nonlinear quantum two-state system, describing the transfer to a molecular BEC. The technique is based on the tracking of a desired solution rather than imposing the parameters. Notably, of the two possible choices of the detuning for tracking, only one leads to a stable adiabatic transfer. For the other one, there is an unavoidable crossing of fixed points, thus destroying the adiabaticity, which degrades the quality of the transfer. The effect of this crossing can be made negligible by taking strong enough pulses, compared with Kerr terms [3].

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Phase locking in parametrically driven nonlinear Kerr resonator

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Quantum oscillatory devises showing phase-locking possess wide-ranging applications in both fundamental and applied sciences, particular, for experimental implementation of quantum optical systems and for a core component of quantum computers. Indeed, most recently the Josephson parametric phase-locked oscillator has been demonstrated with its application to detect binary signals and store digital information in the form of two oscillatory distinct phases [1]. In this Report, we present complete discussion of phase-locking phenomenon for parametrically driven nonlinear Kerr resonator (PDNR) considering both regular and chaotic pulsed regimes. Particularly, we demonstrate phase-locking phenomenon by calculation of the Wigner function of oscillatory mode that displays two-fold symmetry of in its rotation around the origin of the phase space. Phase-locking in order-to-chaos transition is also investigated.

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Nonlinear optical properties of $Zn_4B_6O_{13}$

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Investigations of new materials are a permanent process in which we are interested in many aspects such as economical, ecological and especially their functional properties. New nonlinear optical materials are of great interest nowadays. A good examples are samples with $4ZnO*3(B_2O_3)$ composition that were prepared by the method of solid-phase synthesis at different temperatures and time of crystallization. X-ray phased analysis revealed the presence of 3 phases ZnB_4O_7, $Zn_3B_2O_6$ and $Zn_4B_6O_{13}$, the ratio of which varies depending on time and temperature of the synthesis. In addition, it was found that with increasing of the time of synthesis at a temperature of 850^0C the first two phases are shrunk and the phase $Zn_4B_6O_{13}$ becomes dominant. The dependence of the intensity of Second Harmonic Generation (SHG) on the size of the powder granules was estimated by Kurtz method [1,2]. The value of SHG measured from the powders of produced samples was comparable with well-known nonlinear optical materials.

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On Scattering Phase Shifts in 2D Electron Systems

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Using the lowest-order perturbation theory (Born approximation), we organize a sum rule for the scattering phase shifts in weakly disordered two-dimensional (2D) electron systems [1]. Although the 2D Born scattering amplitude [2] exhibits a divergent behavior in the low-energy $(E \to 0)$ domain, the central role in this rule is performed by the phase shift of the scattering event taking place in the *s*-wave channel with zero collision energy [3]. In the limit of geometrical optics (eikonal ray-trajectories of 2D electrons), the salient features of the sum rule are described in an impact parameter representation. The obtained picture is applied to analysis of the impurity screening problem in semiconductor quantum well structures characterized by a strong dielectric confinement effect [4-6].

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Toward to effective photon blockade: pulse-shape dependent and temperature effects

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The realization of quantum devices with photon-photon interaction has become an interesting and important research topic in quantum optics and quantum information processing with photonic qubits. Photon blockade [1], in which the capture of a single photon into the system affects the probability that a second photon is admitted, is one of the few photon-photon interactions that have been demonstrated experimentally to date. Recently, the occurrence of two- photon blockade was also predicted [2, 3]. It was also demonstrated [3] that for pulse driven Kerr nonlinear resonator (KNR) the efficiency of one-photon blockade can reaches to 90% in difference from 50% limit established for the photon blockade due to cw driving.

In this Report, we present results on multiphoton blockades realizing in KNR driven by a sequence of Gaussian pulses. We analyze optimal pulse regimes of KNR for on demand realization of one-photon and two-photon blockades considering pulse-shape effects. On the other side, we investigate as effects coming from thermal reservoirs affect photon blockade in comparison with the zero-temperature case. These effects are interesting for performing more realistic approach to photon blockade and for study of phenomena connecting quantum engineering and temperature.

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Detection of IR Laser Pulses in the Transparent Ferromagnet

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Ferromagnetic materials are widely used in electronics due to its extremely varied physical properties. In addition to the daily use of low-frequency devices based on them, there are created a lot of microwave and optoelectronic devices. They are one of the basic materials for recording and storing of the information [1, 2]

There are different ferromagnetic materials that are transparent in the infrared and visible regions and are successfully used for radiation control [2]. In [3] it was reported about the optical detection of infrared radiation in transparent ferromagnetic crystals.

In present work the detection of neodymium laser radiation in the magnetized transparent ferromagnetic yttrium iron garnet (YIG) at room temperature is experimentally investigated. Dependence of detected signal on the applied external magnetic field for the different forms of the magnetization curve was measured. It was shown that the efficiency of nonlinear interaction (detection) strongly depends on the shape of the magnetization curve of the ferromagnetic.

The detection process in a magnetized ferromagnetic material, based on the non-linearity of the magnetization curve, was simulated. The experimental results for the samples of monocrystalline YIG are well correlated with the simulation results.

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Numerical Study of the Spectron Phase Peculiarities

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The spectron pulse, which images its spectrum, is a one shaped in the "far zone of dispersion" in the temporal analogy of Fraunhofer diffraction [1-3]. The spectron shaping process, known in its applications as dispersive Fourier transformation [4,5] or real-time Fourier transformation [6,7], is a unique measurement technique that overcomes the speed limitations of traditional optical instruments and enables fast continuous single-shot measurements in optical sensing, spectroscopy and imaging. Dispersive Fourier transformation, due to chromatic dispersion, maps the spectrum of an optical pulse to a temporal waveform whose intensity records the spectrum, thus allowing a single-pixel photo-detector to capture the spectrum at a scan rate significantly beyond what is possible with conventional space-domain spectrometers.

The objective of our research is the study of spectron phase peculiarities. The general question is if the dispersive Fourier transformation works for the phase also, i.e. if the phase of specton pulse images the spectral phase, and under what conditions. In our numerical experiments, we first studied the spectron shaping from the two-peak pulses with various amplitudes and time shifts. Afterwards, we studied the process for pulses with the sine-cosine type initial spectral phases, with various amplitudes and frequencies. We have found the optimal conditions under which the phase of spectron images the spectral phase. Our research has shown that for two-peak pulses the requested dispersion for the phase-imaging is the same as for amplitude. In the second case, the phase-imaging requests less dispersion than for the amplitude.

The results of our studies can be prospective for a pulse spectral phase temporal imaging and measurement [8], and for the femtosecond pulse complete characterization, alternatively to spectral interferometry [9].

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Multilayer Sensor of Thermoelectric Single Photon Detectors

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The results of computer simulation of processes of heat distribution in the multilayer sensor of thermoelectric detector after X-ray/UV single photon absorption are presented. The multilayer sensor consists of a photon absorber (tungsten or another heavy metal), which is deposited on the thermoelectric layer (thermoelectric with high figure of merit at helium temperatures [1, 2]) and the latter is deposited on the electrically conductive layer of heat sink. This "sandwich" is located on a dielectric substrate, on which are also set electrical contacts to count the potential difference ΔU, generated between the absorber and the heat sink by the absorbed photon.

It is shown, that the multilayer sensor has advantages over the planar architecture of the sensor, in which the photon absorber, thermoelectric and heat sink are located on the same plane [3, 4]. The achievement of high count rate and independence of the waveform of $\Delta U(t)$ from the area of photon absorption can be noted among the advantages of the multilayer sensor.

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Spectral Peculiarities of Nonlinear-Dispersive Similariton

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We report the detailed studies on spectral broadening of nonlinear-dispersive similariton shaped in passive fiber, with an objective to develop a simple diagnostic technique of femtosecond pulses.

Similariton pulses with the distinctive property of self-similar propagation, attract the attention of researchers, due to prospective applications in ultrafast optics and photonics [1,2]. The self-similar propagation of the high-power pulse with parabolic temporal, spectral, and phase profiles was predicted theoretically in the 90's [3]. In practice, the generation of such parabolic similaritons is possible in active fibers [4-7]. Another type of similariton is generated in a conventional uniform and passive (without gain) fiber under the combined impacts of Kerr-nonlinearity and dispersion [8]. This nonlinear-dispersive similariton has only parabolic phase but maintains its temporal (and spectral) shape during the propagation, as well.

The bandwidth of nonlinear-dispersive similariton is given by the input pulse power, with varying coefficients given by the input pulse shape [8]. This property of nonlinear-dispersive similariton, is the subject of our detailed studies, aimed to measurement of pulse duration at the femtosecond time scale, as an alternative to the autocorrelation technique.

During our study we first found that the bandwidth of such a similariton is also conditioned by its energy and initial bandwidth. This makes possible to have a precise rule for retrieving the pulse duration, independently from the initial pulse shape. This rule is applicable for pulses with both symmetric and asimmetric temporal profiles. Additionally, the optimal lengths of the fiber and the areas of application of this rule have been ascertained.

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Temperature Dependence of Current–Voltage Characteristic of Pulsed Laser Deposited (p)InSb/(n)CdTe Heterostructure

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By the vacuum pulsed laser deposition of CdTe film onto «hot» (p)InSb substrate was fabricated (p)InSb/(n)CdTe heterostructure. Temperature dependence of dark current–voltage characteristic was investigated from room up to liquid nitrogen temperature. Rectifying properties of the heterostructure appears below the temperature 140 K. Forward-bias current–voltage characteristics of the heterostructures from 0.05 to 0.35 V satisfactorily approximated by the relation for current I = CV2 at liquid nitrogen temperature, which indicates the predominance of the space-charge-limited current.

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of worsening of vortex beam parameters in the hole region is an important practical problem [3].

For studies of characteristics of light beams diffracted in SPP, a software has been developed. The Fresnel integral in the observation surface is computed, when a Gaussian beam is incident at SPP. It is shown that when the radial step height is ideal the pure helical m=1 mode is generated with the deep hole at beam axis. But when a height deviation occurs, the part of incident beam does not generate a vortex radiation and has a Gaussian profile. For small height deviations from the ideal value the contrast factor can be well approximated by the corresponding function – $9.35/\sin^2(1.4\pi\Delta s/s_0)$, where Δs is the deviation of the radial step height of SPP from the ideal value s_0. From a practical point of view it is important that this function accurately fits the contrast factor profile when $\Delta s/s_0 \to 0$.

The computing results show that in order to get the contrast factor $\geq 10^6$ it is necessary to ensure the accuracy of radial step height – $\Delta s/s_0 \leq 10^{-3}$. For example, if SPP is made by glass, and incident He-Ne laser is applied (λ=0.63μm), we need the accuracy of $\Delta s \approx$1nm for almost pure helical m=1 mode generation.

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Ho^{3+} ions doped lithium niobate: Electro-optic and dielectric properties

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Measurements of electro-optic and dielectric coefficients of Ho^{3+} impurity ions doped lithium niobate (LN:Ho) single crystals of congruent composition were carried out as function of the dopant concentration. The clamped and unclamped electro-optic coefficients r_{222} as well as the corresponding dielectric permittivity of LN:Ho crystals, have been experimentally determined. The obtained results were compared with the ones for nominally pure congruent LN crystals.

It has been shown, that both the electro-optic and dielectric properties present similar behavior versus the dopant concentration, with a big decrease for highly doped crystals. This behavior was previously observed with less amplitude for Zr^{4+} doped LN crystals, where the electro-optic and dielectric properties have shown a kink a concentration of ZrO_2 around 2 mol%, which corresponds to the “threshold” concentration required for a strong reduction of the photorefractive effect. In the case of Ho^{3+} doped crystals the threshold concentration was not defined and additional experiments are required for that. Nevertheless, reported results in combination with the ones on reduction of the photorefractive effect in LN:Ho crystals [1] confirm that the mentioned crystal could be considered as a very promising candidate for a use in advance nonlinear devices, including for balanced laser systems.

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The Investigation of Laser Irradiation Influence on the Properties of CuO Single Crystals, Coated by Metal Film

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Laser irradiation is one of the promising methods of obtaining materials with new properties by the surface modification [1–3]. The influence of laser irradiation on the surface of the semiconductor may be accompanied by a change in its structural, morphological and electrical properties [4–6]. In the present work the effect of YAG: Nd^{3+} laser radiation (λ = 1.06 μm) on the properties of copper oxides (CuO) single crystals, coated by thin metal film (Cu or Ag) is discussed. Some of the samples were exposed to radiation with energy density F = 1.9 J/cm^2, pulse duration $\tau = 3x10^{-8}$ s, others – to radiation with higher energy density F = 30 J/cm^2, pulse duration $\tau = 250x10^{-6}$ s by scanning a laser beam on crystal surface. The drastic changes in the surface microstructure, elemental composition and electrical properties of the investigated single crystals with increasing in energy density of laser radiation were observed. The surface morphology of the samples was studied by scanning electron microscope "VEGA TS5130MM", elemental composition was investigated by EDX method using X-ray microanalysis system INCA Energy 300. The temperature dependence of the resistance R(T) was measured by four-probe method. The features corresponding to granular samples were not detected on the CuO single crystals temperature dependence of the resistance. All measurements were performed before and after laser treatment.

The studies revealed the possibility of changes in a wide range of elemental composition and the activation energy of investigated samples under the influence of laser radiation. Modification of copper oxides properties by the laser irradiation influence can be used to improve the characteristics of the various devices and systems for optoelectronic and quantum electronic applications.

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Non-linear spectroscopy of Rb vapor in a nanocell: The role played by excited atom-wall collisions in blue light generation

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Interactions between excited atoms and solid surfaces play an important role in modern technologies. An invention of spectroscopic nanocells [1] opens up a new avenue for studying these processes. As the nanocell (NC) thickness is much smaller than the free path of the atoms, atom-wall collisions are much more frequent than the collisions between the atoms. Hence the atom-wall interactions may be studied in much more details. On the other hand, frequent collisions with the walls require new theoretical approaches to adequate description of linear [2] and non-linear [3,4] optical phenomena in NC.

In our experiments a NC filled with the natural mixture of Rb isotopes was excited by two diode lasers tuned on the ladder transitions from the ground state $5S_{1/2}$ to $5P_{3/2}$ to $5D_{5/2}$ excited levels. An intense radiation at the wavelength of 420 nm corresponding to the transition from the $6P_{3/2}$ level to the ground state was observed. While in the ordinary spectroscopic cells this radiation was explained by the four wave mixing [4], in NC this process seems to be of minor importance as compared to the non-adiabatic transitions at the cell walls [5].

To get an insight on the dynamics of the optical transitions inside the NC and the processes on its walls we calculated the spatial distribution of populations of different excited levels of Rb atoms accounting for quenching at the solid surfaces as well as for subsequent build up the populations in the course of free flight of the atoms between the walls.

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Photoelectric properties of granular ZnO films

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We studied experimentally the granular structures prepared on the base of ZnO thin films, doped with different impurities. The influence of acceptor or donor complex, caused by oxygen vacancy and interstitial zinc atom, and impurities (Li or Ga) on the crystallite structure conductivity has been investigated. The effect of granule size and crystallite structure on conductivity and photoconductivity was studied.

We have proposed and experimentally realized a principally new method for determination of electric current dependence on spatial coordinates in thin conducting films, which allowed to diagnose a one-dimensional conductivity in thin films and to determine the size of the conductivity clusters in granular structures. The measurements of granule sizes by a scanning electron microscope showed that the granule size and size of conductivity cluster in ZnO:Ga film don't correlate. It was found that dark conductivity and photoconductivity in ZnO:Li films have different conductivity structure: if for dark current there are no percolation clusters, for photocurrent the percolation clusters have a 9.4 microns characteristic size.

The experimental results are interpreted on the basis of the scaling hypothesis and the percolation theory.

EIT resonances inverted in a transverse magnetic field

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The electromagnetically induced transparency (EIT) phenomenon has been investigated in a Λ-system of the ^{87}Rb D_1 line in an external transverse magnetic field. Two cw narrow-band (~1 MHz) diode-laser radiations have been used: one laser radiation has fixed frequency (so called the coupling laser), while the second laser frequency is tunable and it is a probe laser. Two spectroscopic cells having strongly different values of the relaxation rates are used: a L ≈1 cm long Rb cell having antirelaxation coating and a Rb nanometric-thin cell with thickness of the atomic vapor column *L*=794nm. For the EIT in the nano-cell (nano-cell temperature is of 120 ^{0}C), we have the usual EIT resonances characterized by a reduction in the absorption (i.e. Dark Resonance (DR)), whereas for the EIT in the Rb cell with the antirelaxation coating (the temperature is of 50 ^{0}C), the resonances demonstrate an increase in the absorption (i.e. bright resonances). Such unusual behavior of the EIT resonances (i.e. the reversal of the sign from DR to BR) is caused by the influence of the alignment process [1]. That's why we call it a Resonance Inverted by the alignment (RIA). The influence of the alignment strongly depends on the configuration of the coupling and probe frequencies as well as on the configuration of the magnetic field. The best configuration to detect RIA is as follows: the coupling radiation frequency is in resonance with the ^{87}Rb, $5S_{1/2}$, Fg=1 →$5P_{1/2}$, Fe=1 atomic transition; the probe is scanned through the $5S_{1/2}$, Fg=2 →$5P_{1/2}$, Fe=1 atomic transition.

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Splitting of EIT resonance in longitudinal and transverse magnetic fields realized in Potassium buffered cell

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The process of electromagnetically induced transparency (EIT) was studied in atomic vapor of Potassium ^{39}K, D_1 line with the usage of two cw narrowband (~ 1 MHz) tunable diode lasers and 1 centimeter -long the cell, which contains additional buffer gas neon. The EIT- resonances which have ~ 3 MHz sub-natural line-width were observed (the natural line-width of ^{39}K is 6 MHz). The coupling laser power was ~ 4 mW, while the probe power was ~0.1 mW. The cell temperature was 60 ^{0}C. The splitting of the EIT resonance in a longitudinal (up to 50 G) and transverse magnetic fields (up to 100 G) were registered. In a longitudinal magnetic field there are 3 EIT –resonances. In a transverse magnetic fields 4 EIT- resonances are well detected, which have a sub-natural line-width, too. In the both cases the frequencies position of the EIT –components depends on the magnetic filed. It is shown that the small value of the ground state hyperfine coupling coefficient A_{HFS} for the ^{39}K allows us to study the peculiarities of the EIT at much lower magnetic fields, than that in the case of Rb, Cs, Na atoms. Particularly, at moderate magnetic fields (>45 G), for the ^{39}K atom the beginning of the hyperfine Paschen-Back regime (i.e. the effect of the decoupling of the total angular momentum of electrons **J** and the nuclear spin **I** starts) was recorded. Practical applications are mentioned. The theoretical model very well describes the experiment.

The study of computational ghost imaging in presence of turbulence

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Ghost imaging is a nonlocal technique of imaging that has attracted much attention nearly two decades. This method of imaging which doesn’t need an object positioning in front of camera and is done via correlated beams, was proposed by Pittman et al in 1995 for first time [1].Turbulence consists of changes in refractive index through a beam propagation distance [2].

In this paper, the atmospheric turbulence effect on computational ghost imaging have been studied experimentally. Our experimental results show that, atmospheric turbulence has destructive effect on ghost imaging which is in good agreement with equations predictions.

$$G(x_t, x_r) = c_0 I_0^2 \sqrt{\frac{\pi^3}{\beta(\alpha^2 - \gamma_1^2)}} \int d\zeta |t(\zeta)|^2 e^{\frac{-2\alpha\gamma_1^2\zeta^2}{\alpha^2-\gamma_1^2}} e^{\frac{-\gamma_2^2}{4\beta}(\zeta - \frac{x_t}{M})}$$

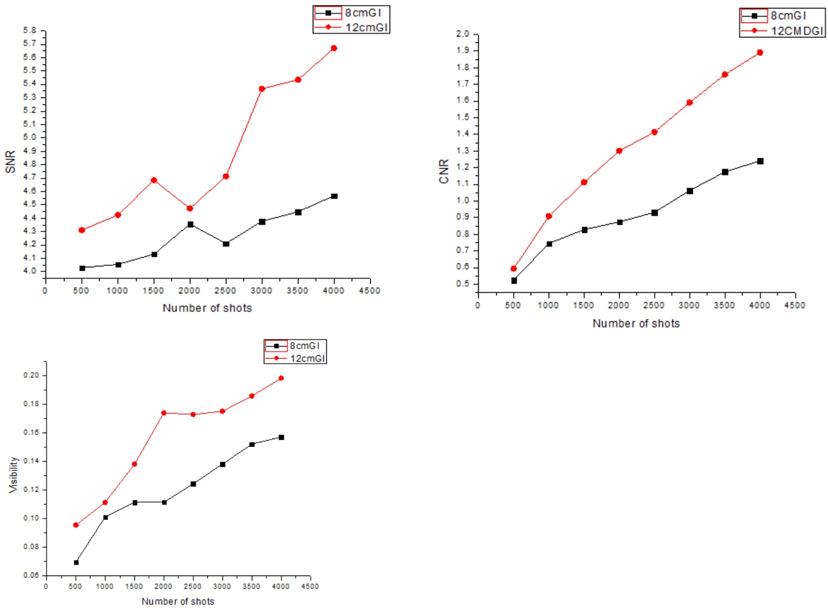

Figure 1:

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Solitonic Spectral Self-Compression of Randomly Modulated Pulses

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We report the nonlinear process of the spectral self-compression of coherent and randomly modulated pulses in a medium with anomalous dispersion, the spectral analogue of the soliton effect compression, based on the experimental observation and detailed numerical analysis.

The nonlinear process of pulse self-compression, benefitted from the technology of photonic crystal fibers and nanowires, recently demonstrates generation of laser pulses down to a single cycle [1-4]. The process, associated with the shaping of high-order solitons, and also called as soliton-effect compression, occurs under the combined impact of strong self-phase modulation (SPM) and weak negative group velocity dispersion (GVD) [5,6]. In [7], we reported the spectral analogue of this process for transform limited laser pulses, the spectral self-compression, under the conditions when the impact of anomalous GVD exceeds the impact of nonlinear SPM. In this report, we generalize our studies for randomly modulated pulses. The spectro-temporal analogy led to the invention of spectral compression (SC) [8,9], a process with prospective applications in ultrafast optics and laser physics [10-13]. In the SC system, the GVD of the dispersive delay line stretches and negatively chirps the pulse, and the pulse SPM in the nonlinear fiber results in the chirp compensation and spectral narrowing [8,9]. For the self-SC process, the factors of GVD and nonlinear SPM are combined in a single material, e.g., fiber. We observed the self-SC process from 9.62 nm to 7.4 nm in a 2-m hollow-core fiber (HCF; ThorLabs HCF-800) with anomalous dispersion at 800 nm. To study the process nature and peculiarities, we carried out numerical simulations for transform-limited and randomly modulated pulses, based on the solution of the nonlinear Schrödinger equation considering the factors of GVD and Kerr-nonlinearity. We have demonstrated more than 30X self-SC in the result of our numerical studies.

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Laser-induced modification of copper oxide nanoparticles synthesized by laser ablation technique

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In the last decades laser assisted techniques based on laser ablation (LA) and laser-induced modification (LM) has been recognized as a simple and contaminant-free methods for fabrication of nanostructures, which can be applied for a large number of materials. In the frame of these techniques one can combine particle synthesis with functionalization, encapsulation and stabilization of products. Post-ablation irradiation of nanoparticles (NPs) with laser light at frequencies of the surface plasmon resonances may provide an effective way to alter the size and shape of the particles. In the present paper capabilities of LA and LM methods for preparation of copper oxide NPs are discussed. Copper oxides due to their safety, photovoltaic and antiferromagnetic properties are promising materials for various devices, such as lithium-ion batteries, gas sensors, catalysts, emitters, polarizers, modulators, etc.

Experiments were carried out by focusing of radiation of a Nd:YAG laser (LOTIS TII, LS2134), operating at 1064 nm (energy 50–80 mJ/pulse, repetition rate 10 Hz, pulse duration 10 ns), on the surface of the copper sample placed in the cell filled with liquid (water, acetone, ethanol). Synthesized NPs were subjected to laser-induced modification. Changes in the nanoparticles morphology were monitored by UV-visible absorption spectroscopy and transmission electron microscopy (TEM).

The spherical nanoparticles with mean diameter of 10 nm were produced by underwater laser ablation of a copper target in the presence of sodium dodecyl sulfate (SDS). Irradiation of NPs in aqueous solution by a pulsed Nd:YAG laser at 532 nm was found to cause the changes in shape and size of nanoparticles. The TEM and UV-Vis spectroscopy data revealed that the irradiation at laser fluence of 0.3 J/cm^2 caused laser-induced fragmentation followed by coalescence after a day of aging. The faceted particles with mean size of 34 nm were formed after irradiation of colloids, whereas the morphology of non-irradiated nanoparticles remained almost unchanged during several days. A correlation was found between the changes in morphology of NPs and their absorption spectra. The chemical composition, structure, stability and optical properties of synthesized NPs were investigated in dependence of type of solvent, laser parameters and post ablation irradiation conditions. The developed LA technique was shown to be suitable for preparation of oxide NPs with desired compositions and morphologies.

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Behavior of D_1 line atomic transitions of ^{39}K isotope in the presence of strong external magnetic fields

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To decouple the total electronic angular momentum *J* and nuclear spin *I* external magnetic field is required. Depending on type (as well as isotopes) of atoms different magnetic field shall be implemented. The threshold for complete decoupling (Hyperfine Paschen Back regime (HPB)) is given by $B >> B_0 = A_{hfs}/\mu_B$, where A_{hfs} is the ground-state hyperfine coupling coefficient, μ_B is the Bohr magneton. HPB regime for ^{39}K starts at $B >> B_0(^{39}\mathrm{K}) = 160$ G, while for ^{85}Rb $B_0 \sim 0.7$ kG and ^{87}Rb $B_0 \sim 2.4$ kG. There is significant difference in the study of alkali atoms D1 and D2 lines. This difference depends also on the polarization of the resonant radiation (linear or circular). The investigation has been performed for ^{39}K D1 line for the different resonant light polarizations. Only in the case of linear polarization and for

D1 line there are 2 transitions that maintain their probabilities and frequency slops. These transitions are so called guiding transitions (GT). In HPB regime the transitions are coming together to those GTs, making 2 groups (4 in each). Each transition in the group has the same frequency slop and probability as the GT in their group. To study this phenomena [1] nano metric thin cell (NC) filled with potassium has been used for its remarkable feature. NC gives opportunity to resolve all individual atomic transitions. Used thickness of atomic vapor column in the NC is *λ/2* (*λ=770nm* is the resonant light wavelength).

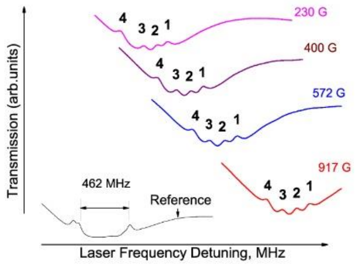

Figure 1: *Transmission spectrum of 39K vapor contained in the nano-cell with L = 770 nm for B = 230, 400, 572 and 917 G and* σ^+*excitation.*

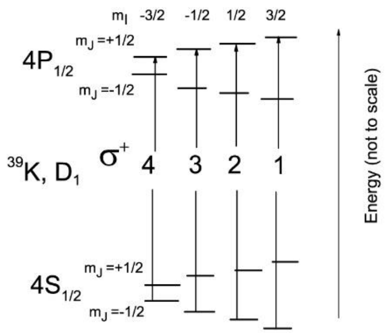

Figure 2: *The diagram of the hyperfine structure of the D1 line of the 39K HPB regime, the selection rules are* $\Delta m_J = 1$, $\Delta m_I = 0$.

It is experimentally demonstrated that from 12 Zeeman transitions allowed at low B-field only 4 transitions remain in absorption spectra at B > 200 G (Fig.1). A complete HPB regime for relatively low magnetic fields B ≥ 1.6 kG has been observed. The theoretical model very well describes the experiment.

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Transport properties of $CaLaBaCu_3O_x$ and $SrLaBaCu_3O_x$ ceramics

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The ceramic samples of $CaLaBaCu_3O_x$ and $SrLaBaCu_3O_x$ compositions with several oxygen contents were prepared using different heat treatment conditions. The contents of main elements and impurities were carried out by Energy Dispersive X-ray Microanalysis using INCA Energy 300 microanalysis system. The temperature dependence of resistance was measured by the standard four-probe method in the range of $3.8 \div 300$ K. Some of the samples after the transition to the superconducting state by further lowering of the temperature showed reentrant-like transport phenomena.

The reentrant system has possibility of application for Transition Edge Sensor (TES) detectors built on reentrant branch of the temperature dependence of the resistance [1].

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Influence of Ce ion on $^4I_{13/2}\rightarrow{}^4I_{15/2}$ transition luminescence kinetics under varying pumping durations in Er,Ce:YAG crystals

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The efficiency of laser radiation of YAG:Er^{3+} crystal near 1.5 μm is of great interest due to its applications in remote sensing, laser range finding, optical communication systems, medicine, etc. Trivalent cerium ions (Ce^{3+}) can be good sensitizers for active Er^{3+} ions in various crystals and glasses as well as in widely used YAG crystals due to their dipole-allowed interconfigurational f→d transitions and effective channels of optical excitation energy nonradiative transfer to the active Er^{3+} ions. Study of the spectroscopic properties and pumping regimes of Er^{3+} ions in YAG:Er^{3+},Ce^{3+} crystals are important for further improvement of their laser capabilities.

In current work we investigated the dependence of 1.5 μm luminescence kinetic properties on pumping pulse duration for various excitation wavelengths (445nm, 808nm and 980nm) in the YAG:Er^{3+},Ce^{3+} crystals. The measurements are carried out for various concentrations of Er^{3+} ions in the host keeping the same the Ce^{3+} ion concentration. During measurements a pinhole technique is used to minimize the radiation trapping effect on the registered luminescence signals. The registered luminescence decay curves strongly depend on pump durations and wavelengths with tendency to shorten the luminescence decay time from $^4I_{13/2}$ level. Luminescence decay form deviation from exponential law is registered for higher concentrations of Er^{3+} and longer excitation durations. The presence of Ce^{3+} ions makes this phenomenon more obvious and decreases the luminescence decay time of Er^{3+} ions. Different nonradiative energy transfer processes between Er^{3+} ions as well as from Ce^{3+} to Er^{3+} ions are discussed. Taking into account these considerations a mathematical model is suggested which allows to estimate the corresponding coefficients of nonradiative energy transfer probabilities. The proposed model shows close similarity between calculated and experimental results.

Electron-Beam Deposition of Lanthanum-Magnesium-Hexaaluminate

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The existence of Lanthanum-Magnesium-Hexaaluminate compounds with the formula $LaMgAI_{11}0_{19}$ (LMH) and magnetoplumbite structure was mentioned for the first time by Verstegen, Sommerdijk and Verriet [I]. The authors of [2] have shown that the compound $La_{0.9}Nd_{0.1}MgAI_{11}0_{19}$ exhibit optical properties which make it a promising candidate for high power laser material. Also, oxides having magnetoplumbite structure are promising candidate materials for applications as high temperature thermal barrier coatings because of their high thermal stability, high thermal expansion, and low thermal conductivity [3]. So, we can conclude that LMH with a magnetoplumbite structure has superior thermo-chemical stability at temperatures higher than 1200 °C and is a promising competitor to Y-ZrO_2-based thermal barrier coatings as well as scintillation material.

Magnetoplumbite structure through its interlocking grain morphology and unique crystal structure provides essentially a sintering resistant. The complex structures of these compounds make it difficult to realize by conventional methods and requires careful adjustment of process parameters [4]. LMH ceramic top coat thermal barrier coatings with the potential application in advanced gas-turbines and diesel engines to realize improved efficiency and durability, as well as crystalline scintillator were prepared by electron-beam deposition. The morphology, chemistry of these coatings and the conditions of controlling of elemental composition are highlighted.

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For Notes