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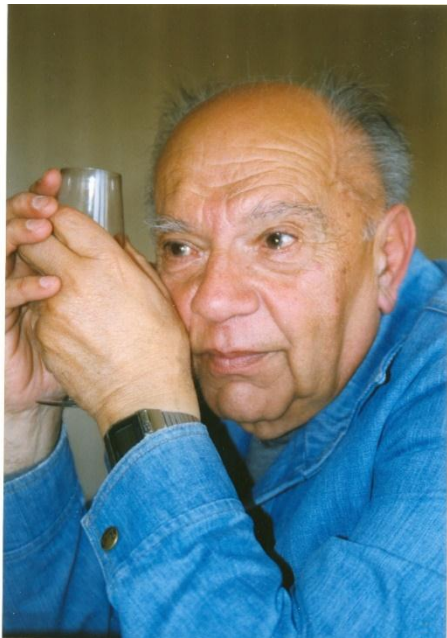
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In 1954, **M.L. Ter-Mikaelian** predicted that due to the polarization of the medium or due to the difference of the light velocity in condensed matter from that in vacuum the Bethe–Heitler bremsstrahlung spectrum will be suppressed in certain spectral regions just as the Landau–Pomeranchuk–Migdal effect operates in another region. This influence of the medium now known as Ter-Mikaelian or longitudinal density effect is very similar to the Fermi density effect and has been experimentally studied initially by the Armenian physicists and recently more extensively by a SLAC—Stanford University–UCSC—American University, Washington collaboration. In 1954–1963 he

worked in YerPhI sometime as the head of the theoretical department and for some time as deputy director. His interest in elementary particle physics grew in connection with the design and construction work of Yerevan 6 GeV Electron Synchrotron under the guidance of the institute director academician A.I. Alikhanian. Approaching the transition radiation theory from the point of view of coherence phenomena, in 1960–1961 M.L. Ter-Mikaelian has developed the theory of X-ray transition radiation (XTR) produced in a stack of plates, consisting of two types of alternating thin materials. In 1961 M.L. Ter-Mikaelian defended his second (doctoral) dissertation in the Moscow Lebedev Institute and started to generalize all the achievements in the above mentioned monograph, published in Russian in 1969 and in English in 1972 due to the efforts of F. Dyson and R. Marshak with whom a close friendship was established during their meetings in Yerevan and elsewhere. In 1963, Ter-Mikaelian he left YerPhI and high-energy physics and begun his work devoted to quantum electronics and laser physics in Yerevan State University. He became the dean of physics faculty, and 8 new chairs, including the chair of quantum electronics, were opened during this period. In 1963 he organized the Radiation Laboratory of Yerevan State University, where a brilliant group of young and already known physicists under his leadership studied various theoretical and experimental problems of laser light generation and

amplification and balance equations for laser construction have been formulated, the operation of cw and pulse solid state lasers have been considered, etc. On the basis of these works ruby lasers were prepared, and taking into account the world achievement and experience of the young laser physics in 1967 M.L. Ter-Mikaelian together with A.L. Ter-Mikaelian and Yu.G. Turkov published the first monograph in Soviet Union "Solid State Optical Lasers". This book is of interest even today and served as textbook for the first generation physicists and engineers. Due to efforts of M.L. Ter-Mikaelian the production of ruby and other single crystals as well as industrial lasers has been organized and Armenia has become an exporter of such—in today's language—high technology products. For these works, M.L. Ter-Mikaelian was awarded the highest state prize and became a corresponding member of the Academy of science of Armenia.

*In 1968 M.L. Ter-Mikaelian founded in Ashtarak (30 km far from Yerevan) the **Institute of Physical Research (IPR) of Academy of Science of Armenia**, where research on laser physics, non-linear and quantum optics, crystal growth and superconductivity has been carried out. Being director and head of the theoretical department of this institute M.L. Ter-Mikaelian published works on resonance interaction of laser radiation with atomic systems. Part of these works has been generalized in his review article published in 1997 in Uspekhi of Fizicheskikh Nauk.*

Optical generation of continuous-wave (coherent phonons flow) in ruby at ambient temperature

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Many microscopic mechanisms are involved in the photogeneration processes of GHz–THz coherent acoustic phonons induced by an ultrafast laser pulse [1], or by continuous-wave laser [2,3].

Sources of coherent acoustic phonons are useful for non-destructive optoacoustic techniques testing, for studying the processes of energy transfer in crystals, and for application in the field of high technologies.

We report on the first experimental evidence for the direct excitation of coherent high frequency coherent phonons flow (ultrasonic waves) in ruby laser crystal upon optical pumping of the 2T_1 state by a coherent source.

A discrete blue shift of the luminescence peaks of 2E state R_1 and R_2 lines was observed, which depends on the LD 660 laser wavelength and intensity. This phenomenon is explained by the dependence of these line displacements on the number of generated and absorbed phonons during the irradiation of the 2T_1 state due to multi-phonon absorption. The blue shift of luminescence maxima locations goes on discretely. The displacement of luminescence intensity maxima of R_1 and R_2 lines $\cong n \times 0.52 \text{ cm}^{-1}$, where n is an integer.

Relative to the luminescence peaks location obtained by irradiation with halogen lamp at 300 K, the maximum blue shift under irradiation of ruby rod by LD 660 $\cong 6 \times 0.52 \text{ cm}^{-1}$ for R_1 line and $\cong 6 \times 0.52 \text{ cm}^{-1}$ for R_2 line, respectively.

The presence of a continuous-wave coherent phonons flow was determined from the displacement of the luminescence R_1 and R_2 lines by monitoring the Brillouin scattering.

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SPDC field in the atmosphere: two photon speckle, mode analysis, aberration analysis

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The spatial entanglement of the state of twin photons prepared by spontaneous parametric down-conversion (SPDC) process can be observed through correlation measurements. We derive analytical expression for the fourth-order correlation function for the two-photon field, pumped with Hermite-Gauss (HG) and Laguerre-Gauss (LG) coherent as well as partially coherent beams, propagating through a strong turbulent medium. We show that fourth-order correlation functions have, under certain conditions, expressions similar to those of intensities of classical beams and are degraded by turbulence in a similar way as the classical beams. Additionally, the expression for the partially coherent pump case is shown to be a convex sum of that of HG or LG pumps [1].

Choosing, e.g., a Hermite-Gaussian (HG) set of spatial modes as a basis to represent the down-converted two-photon field, one can observe correlations present in their spatial degrees of freedom. Analytic expression for two-photon detection probability in terms of HG modes, taking into account the effects of the turbulent atmosphere, has been derived [2]. Finally, we study different aberrations on the wavefront of the two-photon SPDC wave, induced by the turbulence, with the help of Zernike polynomials. This is still under investigation.

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The Ti, Li, B, Na, Mg stable isotopes concentration change in water under the influence of acoustic oscillations

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The paper presents the results of experimental studies of the stable isotopes composition of some chemical elements in ordinary water under the influence of acoustic oscillations and a possible explanation of the mechanism of the obtained results. As the source of the ultrasonic oscillator, piezoceramic washers with a titanium concentrator were used. At resonance, the sound level was about 120dB. The change in the concentration of stable isotopes Ti, Li, B, Na, Mg in distilled water samples subjected to sharp mechanical action with an acoustic frequency of 25 kHz during three and six hours of exposure has been revealed. The results of the measurements were compared with the data of the samples not subjected to acoustic influence. In the process of such an impact on the water, gamma radiation was recorded with the DKS-04 dosimeter, the RUP-1 radiometer, and a precision low-background gamma spectrometer with a semiconductor germanium detector from Camverra. The fact of the presence of γ -radiation indicates the probable occurrence of nuclear processes, a possible mechanism of which is given in [1, 2]. The concentration of stable isotopes in the water samples under study was measured with a NexION 2000 mass spectrometer from PerkinElmer. The results of measurements showed a significant change in the ratio of stable isotopes of titanium depend on the duration of the action of acoustic oscillations in comparison with the concentration of titanium isotopes in the initial water. Such a complex change in the concentration of titanium isotopes is probably due to the difference in

the cross section of the reaction (n, γ) . Significant changes for the concentration of stable isotopes of boron, sodium, magnesium, and lithium are also recorded. To substantiate these processes, schemes of nuclear transformations of the type $(A, Z) + n \rightarrow (A + 1, Z) + \gamma$ and $(A + 1, Z)^* \rightarrow (A + 1, Z + 1) + \beta^- + \tilde{\nu}$ are proposed, which allow us to describe and justify the obtained experimental results. However, if the explanation for the change in the concentration in the water of the stable isotopes of the chemical elements Ti, B, Na, Mg is based on the mechanism for the formation of quasineutrons and the decay conditions of radioactive isotopes, then this approach is incomplete for the case of stable isotopes of Li. This is based on the fact that there is no chemical element by means of which it is possible to realize the (n, γ) reaction and obtain the Li isotope. Therefore, the conclusion is made that the emerging quasineutron, striving to neutralize the mass defect, can enter into a relationship not only with the nearest nucleus, but it is possible that complexes consisting of two, three or more quasineutrons can form. the formation of diquasineutrons, triquasineutrons ($0n^{*2}, 0n^{*3}$), and so on. This allows us to explain the formation of stable lithium isotopes with the help of helium isotopes according to the following scheme: ${}^2\text{He}^4 (0n^{*2}, \gamma) {}^3\text{Li}^6$ and ${}^2\text{He}^4 (0n^{*3}, \gamma) {}^3\text{Li}^7$.

Thus, the very complex nature of the effect of mechanical vibrations on the change in the concentration in water of stable isotopes of the chemical elements Ti, Li, B, Na, Mg is shown.

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Hyperfine level structure in nitrogen-vacancy centers near the ground-state level anticrossing

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In this study the energy levels of the NV centers in diamond were investigated using the method of ODMR spectroscopy [1] near the electronic GSLAC at an axial magnetic field around 102.4 mT in diamond samples with low (1 ppm) and high (200 ppm) nitrogen concentration [2]. By applying microwaves in the frequency ranges from 0 to 40 MHz and from 5.6 to 5.9 GHz, we observed transitions that involve eigenstates mixed by the hyperfine interactions. We developed a theoretical model that describes the level mixing, transition energies, and transition strengths between the ground-state sublevels, including coupling to the nuclear spin of the NV centers ¹⁴N nucleus. The calculations were combined with the results from a fitting procedure that extracted information about the polarization of nuclear spin.

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Nitrogen-vacancy centers in diamond: physics and some applications

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Beauty is often found not in perfection but rather in defects. This is especially true for diamond, where color-center defects are responsible not only for the fascinating coloration of gemstones, but also for making diamond a precious system for fundamental quantum physics and for applications including measurements of electromagnetic fields and temperature with a unique combination of sensitivity, spatial resolution, and a broad range of operating conditions such as temperature and pressure. I will present a brief introduction into the physics of the most “popular” nitrogen-vacancy (NV) defect in diamond and describe various applications pursued by our group and collaborators [1].

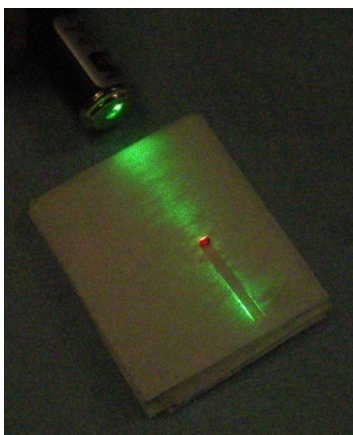


Figure 1. An NV-diamond experiment that can be done with just a laser pointer. The particular crystal shown here has dimensions of $3\times3\times0.5$ mm³ and contains the NV centers at a concentration on the order of 10^{18} cm⁻³. Upon excitation with green light, the centers fluoresce in (infra)red as seen in the figure.

References

[1] See: <https://budker.uni-mainz.de/> and <http://budker.berkeley.edu/>

Composition dependence of the electro-optic properties of iron doped lithium niobate crystals

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The synthetic crystal Lithium Niobate (LN) plays a key role in integrated optical devices, such as for second harmonic generation (SHG), optical switches, optical modulators, volume holographic memories at different wavelength beams thanks to outstanding electro-optical, large piezoelectric, acoustic-optical properties and nonlinear optical coefficients. For the main part of the mentioned applications, it is very important to measure the electro-optic coefficients of the material, which in the case of LN crystal is very sensitive to the composition, the type, concentration and site occupation of introduced impurity ions. The Pockels EO coefficients in various opto-geometric configurations have been measured for LN:Fe crystals with different Li content in the melt (48.2%, 48.45%, 50%, and 54.5%) with the fixed iron concentration (0.11 mol%). In general the coefficients of third column of EO tensor r_{13} , r_{33} as well as combined EO coefficient r_c illustrate the decrease with the increase of Li content. Furthermore EO Pockels coefficient for r_{22} opto-geometrical configuration varies non-monotonously as a function of crystal composition.

With the variation of crystal composition from congruent to near-stoichiometric due to the increase of Li content in its "own" site Fe ions mainly incorporate onto main site of Nb ions decreasing the polarizability of Nb ions in their "own" site consequently decreasing also above mentioned EO coefficients. A contribution for EO coefficient r_{22} is related mainly to the elasto-optic coefficient C_{44} , which illustrates the same non-symmetric dependence on the amount of intrinsic defects as mentioned coefficients [1]. The non-monotonous variation is related to the presence of dislocations of main ions from their

crystallographic positions due to the introduction of iron ions or density fluctuations.

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Generation of extended rubidium plasma by ultra-short quasi-resonant laser radiation: Experiment and Theory

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We present recent results on generation of plasma channel in rubidium vapors by strong laser pulses from a Ti:Sa laser system in femtosecond duration range. The results of characterization of the produced plasma channel for different peak intensities of the ionizing pulses and different temperatures (densities) of the Rb vapors are presented and compared for two different types of diagnostics. One of the diagnostic schemes is based on the resonant absorption spectroscopy in transverse direction. It allows understanding the physics of transverse extension of the plasma channel allowing measuring of the extension velocity and the local density of the plasma. The second diagnostic scheme is based on the interferometry in the longitudinal direction of propagation of the ionizing laser pulses. It allows measurements of the average value of the plasma density and recombination time constants of the plasma.

A 3D numerical code for propagation of a quasi-resonant ionizing laser pulse in Rb vapor taking into account nonlinear optical effects is developed and simulated aiming to model the creation of the extended plasma channel and its time and space behavior. The back-action of the medium on the propagating laser pulses is taken into account by simultaneous solution of Schrödinger equations for the relevant multilevel system of the Rb model atom and wave equation for the electric strength amplitude of the laser pulse propagating in the Rb vapor. The multi-photon and tunneling models of ionization are utilized in

calculations of the ionization probabilities from different atomic states of Rb atoms.

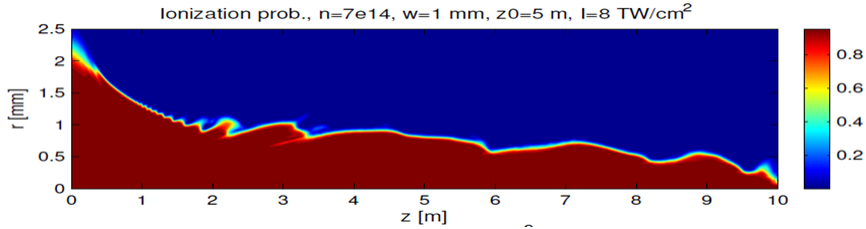


Fig.1. *The plasma channel formed in the 10 m long steel tube filled by Rb vapor (AWAKE experiment)*

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The Performance Investigation of the Bulk Heterojunction Organic Solar Cells by a Drift-diffusion Model

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Organic solar cells (OSCs) have attracted considerable attention in the last two decades because they possess several advantages such as easy, fast and low-cost fabrication, flexibility and lightweight, and the potential of optical transparency [1-3]. In the photocurrent generation process of OSCs (i) the photon absorption results in an exciton, (ii) the exciton diffuses towards the donor-acceptor interface, (iii) the bound electron hole pair dissociates into free carriers, and (iv) the free carriers transport towards the electrodes for collection [4].

Among the various existing architectures of OSCs, the bulk heterojunction (BHJ) is today the most common one due to the efficient exciton harvesting leading to higher power conversion efficiencies. The active layer of the cell in such architecture is composed of a blend of the donor and acceptor materials

allowing an efficient generation of free charges [4]. The numerical approaches that model the behavior of BHJ cells seem to be valuable tools to better understand the various mechanisms taking place within the cell or to optimize their performance [2].

In this work, we present an optoelectronic drift-diffusion model in order to investigate the performance of the BHJ organic solar cells. In this method, both drift and diffusion of the charge carriers are incorporated and the continuity equations for electron, hole, exciton, and polaron, coupled with the Poisson equation are solved numerically [2-4]. We simulate the effect of the various recombination, electron and hole mobilities as well as the donor and acceptor domain area on the performance of the BHJ organic solar cells. Results are discussed in relation with experimental observations. The results demonstrate that the increased and more balanced charge mobilities suggests better charge transfer capability of the BHJ active layer. The optimum motilities cooperated with an enhanced absorption and the reduced charge carrier recombination could be collectively responsible for the improved performance of the devices.

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The development of non-volatile memory structures and investigation of their properties

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The aim of study is the development of non-volatile memory with resistive switching mechanism in the structures based on ferroelectric and

semiconductor ZnOLi and La_2O_3 films. The tasks of the study include:

- Optimization of synthesis of the $\text{La}_2\text{O}_3\text{-OH}$ and ZnOLi films with e-beam evaporation method and adjustment of electrode deposition option according to existing technologies.
- The measurement of structural, transport and optical characteristics of the MOM and MOS structures based on ZnOLi and $\text{La}_2\text{O}_3\text{-OH}$ films depending on the impurity content and electrode materials to reveal new resistive memory elements.
- Determination of the main characteristics of memristors: the data retention time, the ratio of resistance change, resistance switching current, and the number of write/erase that could happen without element degradation.
- Study of the mechanisms of resistive switching and electric transport in the MOM and MOS structure in different resistance states.
- Revelation of structures with optimal RRAM parameters.

Practical significance

The data obtained during the study allow to widen the scientific information about RRAM properties and to develop guidelines on film preparation with properties needed for applications. The scientific value of this research is that some studied structures based on ZnOLi can be simultaneously function as diode selector and switching element (1D1R). Such structures have the ability of 3D integration for crossbar creation, which is necessary for high memory capacity.

A hierarchy of Schrödinger potentials solvable via a two-term Hermite-function ansatz

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I present a hierarchy of potentials for which the solution of the Schrödinger equation is written in terms of the Hermite functions. The hierarchy is derived

by a two-term ansatz presenting a linear combination with polynomial coefficients of two Hermite functions of generally non-integer order. All members of the hierarchy belong to the five bi-confluent Heun families first presented by Lemieux and Bose. The list starts with the classical harmonic oscillator potential (plus the potential of a uniform field) and the two conditionally integrable potentials by Stillingner. For these three potentials the coefficient of the second term is equal to zero so that the solution is actually one-term. The next two potentials of the list, for which the coefficients of the ansatz are constants, have been first indicated by Exton. The hierarchy is presumably infinite. I explicitly list the first eleven potentials. Six of these potentials are presented for the first time [1-5].

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Self-consistent theory of selective reflection for a dilute Fabry-Perot interferometer

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Reflection of radiation from the boundary between a dielectric and atomic vapor, when laser field is detuned in the vicinity of atomic transition frequencies is termed as selective reflection (SR) [1]. SR spectroscopy has many applications, such as retrieval of group refractive index [2] locking a diode laser

frequency to atomic resonance lines [3], marking atomic transitions [4], determination of the homogeneous width and the shift of resonance lines and atom-wall interactions [5].

In this work we developed a self-consistent theory of selective reflection by using the density matrix formalism and Maxwell equations. We obtained formulas for single and multiple selective reflection. Also, the effective complex refractive index for a single selective reflection was obtained. In Fig.1 we demonstrate the spectrum of rubidium D_1 line calculated by our obtained formula.

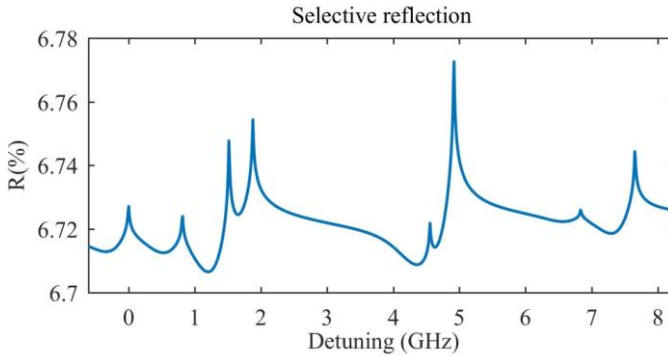


Fig. 1 The spectrum of rubidium D_1 line.

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Optical Magnetometry using alkali Nanocells

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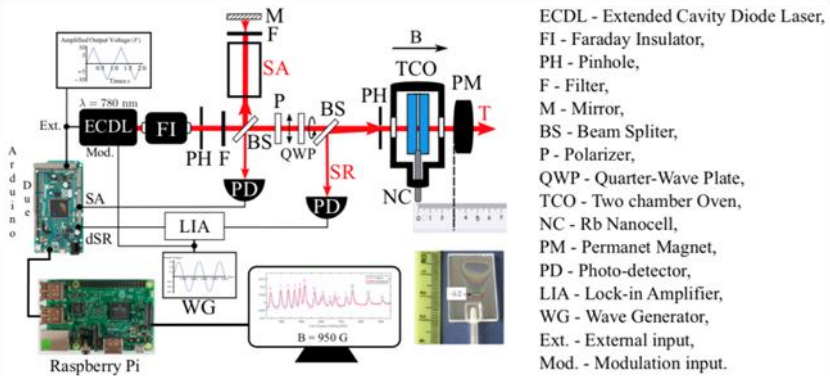
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In the past decade, optical nanocells (NC) of ~ 40 nm to $1 \mu\text{m}$ thickness in light propagation direction have proven to be efficient spectroscopic tool, allowing to perform linear Doppler-free spectroscopy with a simple one-beam experimental setup. We have recently shown that the derivative of selective reflection (dSR) from NC allows one to record atomic spectra with a ~ 50 MHz linewidth [1]. The sub-Doppler nature of recorded signals and the linearity with respect to the atomic transitions strength make the NC-based dSR technique an extremely convenient tool to study the splitting of hyperfine atomic transitions in a longitudinal magnetic field and modification of their transition probabilities [2]. Our theoretical model, based on the articles [3,4], has shown a very good agreement with the recorded experimental spectra in a wide range of B -field variation covering evolution from Zeeman to hyperfine Paschen-Back regime.



Based on these studies, we have explored the feasibility of designing a nanocell-based optical magnetometer having a measurement range of 100 - 5000 G with a precision of ~ 1 G. To do so, a Raspberry Pi computer coupled to an Arduino

Due board records the Rb D₂ line from a NC exposed to the magnetic field to be measured. After fitting the experimental spectrum by minimizing the residuals between experiment and theory, our Mathematica program returns the measured B -field value. The sketch of the magnetometer is depicted on the figure.

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Low-frequency electromagnetic radiation of hydrogen molecular gas

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We calculate the rate of the spontaneous magnetic dipole radiative transitions from ortho- to para-states of the hydrogen molecule at room temperature with the radiation wavelengths about 0.01 – 0.1 cm. Exponentially small differences between the rotational energies and heat capacities of parahydrogen and orthohydrogen molecules and also diatomic molecules consisting of different hydrogen atoms are derived for high temperatures.

The hydrogen molecule is one of the most fundamental molecules in chemistry, biology and astrophysics. It exists as two distinct nuclear-spin isomers, para- and orthohydrogen. Methods to separate hydrogen molecules into para- and ortho-isomers have allowed important insights into the different physical properties of these two spin isomers. We calculate the rate of the spontaneous magnetic dipole radiation transitions from ortho- to para-states of the dilute hydrogen gas at the room temperature.

Authors of Ref. [1] reported the results of an experimental study related to the relaxation of the nuclear spin isomers of the water molecule in a supersonic expansion. In Ref. [2] the authors study the possibility of observing strongly forbidden vibrational–rotational transitions between ortho and para isotopomers for water. These are yet to be observed experimentally. From such an observation it would be possible to develop reliable models describing the ortho and para interconversion mechanism. This is important, for example, in the study of astrophysical cometary problems. In the dense hydrogen gas collisions between molecules lead to the transitions between para- and ortho-states [3].

Spin flip and dipole transition of the spatial part of the molecular wave function lead to nonzero transition matrix element. The transition rate does not depend on the frequency of the small proton oscillations around their equilibrium positions. We obtained also simple analytic expression for the exponentially small difference in thermodynamic energies and heat capacities between orthohydrogen and parahydrogen at high temperatures. The asymptotic limit is achieved for temperatures that are higher compared to the room temperature.

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Comparison of Specifications of Thermoelectric Single-Photon Detector on the Base of Lanthanum and Cerium Hexaborides

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Single-photon detectors (SPD) operating from infrared to X-ray wavelengths with high count rate, energy resolution and detection efficiency have many applications in science and technology. Thermoelectric single-photon detectors (TSPD) with single layer or multilayer architecture of detection pixel can register photons with energy resolution of not worse than 1% and gigahertz of count rate in the wide range of electromagnetic spectrum [1, 2]. In these works lanthanum-cerium ($\text{La}_{0.99}\text{Ce}_{0.01}\text{B}_6$) and cerium (CeB_6) hexaborides as sensors and

tungsten (W) as absorber and heat sink of TSPD detection pixel were considered.

Detection efficiency as well as counting rate and energy resolution is the important parameter of SPD. W is a good absorber for X-ray and hard UV photons, but it has a high reflection coefficient for near IR and near UV photons. So for the registration of photons of this rang the absorbers with low reflection coefficient should be used. At the same time for the production of high-quality multilayer structures it is important for the compounds of layers to have close lattice parameters and coefficients of thermal expansion. In this work the results of computer simulation of heat distribution processes in $\text{LaB}_6/\text{La}_{0.99}\text{Ce}_{0.01}\text{B}_6/\text{LaB}_6/\text{Al}_2\text{O}_3$ and $\text{LaB}_6/\text{CeB}_6/\text{LaB}_6/\text{Al}_2\text{O}_3$ multilayer and single layer detection pixels of TSPD containing $\text{La}_{0.99}\text{Ce}_{0.01}\text{B}_6$, CeB_6 thermoelectric bridge and LaB_6 absorber after 0.5-4.13 eV photon absorption are presented. A comparison of specifications of detection pixels of different geometries is carried out. It is shown that TSPD using such materials can have high characteristics.

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Non-equivalence of traveling wave and standing wave bases for the quantized field-two level atom system in the free space

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Electromagnetic field quantizations on the bases of running-waves and standing-waves bases are completely equivalent in the free space. It has been shown [1, 2], however, that the difference in kinds of resonators forming these mode structures, ring and flat correspondingly, distorts this equivalence. As the physical foundation of this difference it is regarded the loss of momentum conservation in the standing wave-flat resonator case. At that, one of modes, $\cos(kz)$ for instance, falls away due to the boundary conditions.

In this report, we reexamine the question around the equivalence between the quantization modes, restricting mathematics in the frame of adiabatic following approximation with the Raman-Nath regime of interaction. We consider the possibly simpler system: the free electromagnetic field and a two-level atom. It states the problem in a general form: preserves both $\cos(kz)$ and $\sin(kz)$ modes and removes boundary conditions from the problem.

Our study shows that the difference between the bases of quantization is a general principle in the quantum optics: interaction of the free electromagnetic field with a single atom is thoroughly sufficient for the induction of the non-equivalence between the quantization bases. At that, non-equivalence treats both non-degenerate stationary states as well the temporal evolution of the atom-field system.

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Mirrorless degenerate lasing in $F_e > F_g$ atomic system: the overview of ongoing experiments

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The resonant interaction of linearly polarized laser light with an alkali atom on $F_g = F \rightarrow F_e = F+1$ cycling hyperfine transition of D₂ line may result in the population inversion on $|m_{Fg}| = n \rightarrow |m_{Fg}| = n+1$ Zeeman transitions (n is non-negative integer) due to the redistribution of atomic population towards $m_F = 0$ magnetic sublevels of the ground and excited states in the steady-state interaction regime. This inversion, which is established over certain threshold of incident light intensity, results in generation of an orthogonally polarized amplified radiation observed along the laser beam both in forward and backward directions. The underlying physical processes will be addressed, along with the presentation of the ongoing experiments and expected applications.

Defect behavior in Ce-doped garnet scintillators with aliovalent impurities

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Aliovalent co-doping by optically non-active ions is one of the major tools to improve the time response and the light yield of various scintillator materials [1]. The positive role of co-doping of oxide materials with Ca^{2+} or Mg^{2+} , when substituting for 3^+ lattice sites, was demonstrated in Ce-doped orthosilicates [2] and garnets [3] and related to transition of a considerable fraction of Ce^{3+} to the Ce^{4+} state. Monovalent impurities involving a charge difference -2 (e.g. Li^+) are also of interest to favor Ce^{4+} states, however they may exhibit dissimilar behavior in various garnets; e.g. Li^+ ions in LuAG:Ce substitute for Lu^{3+} sites and favor Ce^{4+} states, while in YAG:Ce they go mainly to interstitials reducing for charge compensation the amount of anion vacancies [4].

In this study incorporation preferences and the functional role of aliovalent impurities have been studied and compared in various Ce-doped garnet compositions. Ce-free YAG crystals were also studied to estimate to what extent introduction of monovalent impurities can be efficient to decrease the trap density and improve transparency in the UV range and the radiation tolerance important for their potential application as Cherenkov emitters. Single crystals were grown by the vertical directional crystallization under controlled conditions. Experimental studies have included absorbance, response to gamma-ray irradiation (^{60}Co , 1-10 kGy) and radioluminescence decay measurements.

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Study of Hyperfine Paschen–Back regime of potassium D2 line

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We have used the selective reflection of a laser radiation from an interface formed by a dielectric window and a potassium atomic vapour confined in a nanocell to study the atomic transitions of K D₂ line in external magnetic fields [1]. There are 44 individual Zeeman transitions in moderate magnetic fields which reduce to two groups (one formed by σ^+ , the other one by σ^- circularly-polarised light), each containing eight atomic transitions, as the magnetic field increases.

Each of these groups contains one so-called ‘guiding’ transition whose particularities are to have a probability as well as a frequency shift slope that are constant in the whole range of 0–1T magnetic fields. We have demonstrated that for B-fields > 200 G a complete hyperfine Paschen–Back regime is observed. A very good agreement between theoretical calculations and experiment is achieved. Other peculiarities of K D₂ line behaviour in magnetic field also will be presented.

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Peculiarities of Dark Resonances on ^{87}Rb , D_2 line using “forbidden” atomic transitions

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Atomic optical transitions between hyperfine levels with $\Delta F = \pm 2$, which are forbidden by selection rules for an atom total momentum F at zero magnetic field, may undergo giant enhancement with application of a strong magnetic field (so called Magnetically Induced (MI) transitions).

We have revealed a general rule applicable for D_2 lines of all alkali atoms, which states that strong magnetic field enhancement occurs for transitions from the ground state with $\Delta F = +2$ for the case of σ^+ excitation, and with $\Delta F = -2$ for the case of σ^- excitation [1-4]. This general rule is valid for alkali atoms, particularly, for of common isotopes ^{133}Cs (24), ^{85}Rb (16), ^{87}Rb (8), ^{39}K (8), ^{41}K (8), ^{23}Na (8). In total there are 72 MI transitions.

We have revealed that for Dark Resonance (DR) formation via the electromagnetically induced transmission (EIT) process in a Λ -system there are the following rules: when MI transition is created between hyperfine levels with $\Delta F = +2$ for the case of σ^+ excitation, then for the DR formation the couple radiation with $\Delta F = 1$ must be also of σ^+ excitation. In contrary, when MI transition is created with $\Delta F = -2$ for the case of σ^- excitation, then for the DR formation the couple radiation with $\Delta F = -1$ must be also of σ^- excitation.

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Far-Infrared Optics of Pair-Interacting Few-Particle Harmonium Atom

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We discuss the problem of far infrared optical absorption in the parabolic quantum dot contained few-particle gas. In the frame of pair-interacting harmonium model [1] we calculate the energetic spectrum and wave function of such system. If this system under action of a far infrared long-wave radiation, then the conditions for realization of generalized Kohn's theorem are present [2-4]: for discussed model we show, that it is possible to separate the center of mass motion and relative motion. Comparison of theoretical calculations with the experimental results of FIR-absorption of the hole gas localized in the lens-shape quantum dot [5] are presented.

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Relativistic laser plasma dynamics and particle acceleration

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The development of ultrahigh-power laser systems in the last two decades has led to increasing attention and enormous scientific activities in the field of laser-plasma interactions. It aims to produce a large spatiotemporal energy concentration of a laser beam. A laser peak power can reach several petawatts (PW) and the intensity above 10^{22} W/cm² can become available for experiments. Thus, an entirely new area of research, the regime of relativistic plasma physics became accessible in the lab. To explore the interaction physics in these novel intensity regime is one of the most exciting goals of current high field research.

We will discuss the laser plasma ion acceleration phenomena in particular by careful study of complex dynamics of laser-plasma processes through characteristics of the ion source and accelerated beam properties. Will be discussed the recent experimental findings on ion acceleration obtained on PW laser.

This presentation is closely related to recent development or imminently anticipated development of laser technology to bring the existing laser power to a multi-PW level to study relativistic plasma phenomena and, ion acceleration in this new regime. The new findings pave a way to achieving an ion source and beam desire parameters for applications (e.g. cancer radiotherapy) and they encourage further activities for optimisation of laser plasma-based accelerators.

Regular light patterns formation by a Gaussian beam in a photorefractive LiNbO₃:Fe crystal

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Lithium niobate (LN) crystals are very promising materials for holographic data storage and readout, light driven manipulation phenomena and optical communication systems due to their excellent photorefractive properties. We

report for the first time a regular optical patterns formation in a laser beam passed through a Fe doped LN crystal (LN:Fe).

The experiments were performed with the use of single mode He-Ne laser Thorlabs HP-100 generating at 632.8 nm wavelength laser beam for reduced powers of ≤ 2 mW. The C-axis of the crystal was oriented in vertical Z direction. The laser beam was focused to the size of $72\ \mu\text{m}$ at the input face of the LN:Fe crystal. The forward traveling laser beam at the output face of the crystal was projected by lens to the entrance of CCD camera, which provides the registration and measurements of beam transverse profile time evolution.

The results of experiments on the laser beam profile evolution during propagation through the LN crystal of 10 mm length at fixed time of $t = 211$ sec after switching on the laser beam for input beam powers of 0.02, 0.08, 0.5, 1, 2 mW are shown in Fig.1(a)-(e).

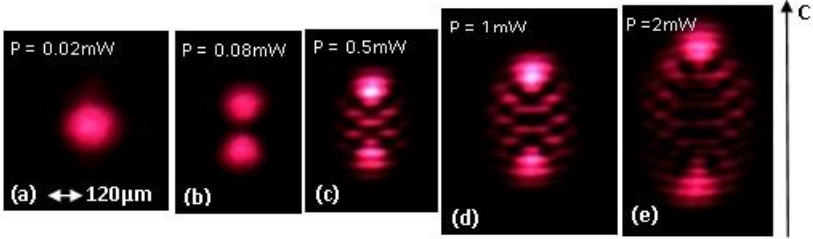


Fig.1. Evolution of the laser beam profile at the exit of LN crystal for different input beam powers

Evolution of the beam intensity profile shows the splitting of a Gaussian beam (Fig.1a) into two beams (Fig.1b) and then formation of regular pattern of focal spots (Fig.1 c-e).

Observed phenomenon of optical pattern formation can be connected with the light induced complex refractive index variation with a central minimum (negative lens) and side maxima (positive lenses) [1]. Complex lens structure produces beam defocusing from the beam centre and focusing on the periphery. Mutual interference of the beams with different phases leads to the regular light pattern formation. The low beam power provides slow evolution of nonlinear lens to observe all details of intensity distributions in a beam. The induced refractive index distribution inside the LN crystal is quasi-crystalline photonic structure because has no translation symmetry but 2-fold rotation symmetry.

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Preparation and Investigation of Multifunctional “Core-Shell” Magnetic Nanoparticles for Medical Applications

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Carbon-coated ferromagnetic (Fe-Fe₃O₄)@C “core-shell” nanocomposites have been synthesized using solid-phase pyrolysis (SPP) of metal-organic compounds. The structure, morphology and magnetic characteristics of synthesized nanocomposites were investigated by methods of electron microscopy, X-ray diffraction, Raman spectroscopy and magnetometry. Changing the pyrolysis conditions, it is possible to vary sizes of nanoparticles from 5 to 100 nm. The magnetic characteristics such as saturation magnetization and coercivity as well as the specific absorption rate (SAR) make these materials attractive for magnetic hyperthermia applications. The characteristics of magnetic heating of water-based solution with different concentrations of synthesized nanocomposites under the influence of an external magnetic field have been studied. Carbon coating fixes nanoparticles at a certain distance and prevent their from oxidation and agglomeration.

Concentration Effects of Er³⁺ Ion on Upconversion Luminescence in YAG Crystals

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In recent years, there has been a continuous interest in lasers operating in near-

and mid-infrared spectral regions. Among the rare earth ion-doped materials, YAG:Er³⁺ crystals radiating at wavelengths near 1.5 and 3 μm are of particular attention due to their wide applications in optical communications systems, medicine, remote sensing and ranging, etc. A thorough investigation of upconversion processes in impurity subsystem of YAG [1, 2] is extremely important when improving the near- and mid-infrared generation efficiency of laser crystal.

We have studied the concentration effects of Er³⁺ ion on measured upconversion luminescence in YAG over a range of dopant concentrations (1%, 5%, 13% and 100%) at room temperature. Two upconversion processes are considered: excited state absorption and energy transfer upconversion. Evolution of green and red upconversion luminescence emissions from the thermally coupled $^4\text{S}_{3/2} + ^2\text{H}_{11/2}$ and $^4\text{F}_{9/2}$ bands of Er³⁺ are studied under CW excitation by 808 and 980 nm laser diodes. In addition, the conventional luminescence from $^4\text{S}_{3/2} + ^2\text{H}_{11/2}$ and $^4\text{F}_{9/2}$ bands is measured under 445 nm excitation.

Observation of dynamics of the upconversion luminescence bands allows determining the relative influence of the excited state absorption and energy transfer upconversion processes on the excitation energy redistribution in impurity subsystem of erbium-doped YAG. Comparison of conventional and upconversion luminescence spectra makes it possible to separate the aforementioned processes. The effects of various Er³⁺ concentrations on the luminescence quenching have been also discussed.

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Bi-confluent Heun potentials for a stationary relativistic wave equation for a spinless particle

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The variety of bi-confluent Heun potentials for a stationary relativistic wave equation for a spinless particle is presented. The physical potentials and energy spectrum of this wave equation are related to those for a corresponding Schrödinger equation in the sense that all the potentials derived for the latter equation are also applicable for the wave equation under consideration. We show that in contrast to the Schrödinger equation the characteristic spatial length of the potential imposes a restriction on the energy spectrum that directly reflects the uncertainty principle. Studying the inverse-square-root bi-confluent Heun potential, it is shown that the uncertainty principle limits, from below, the principal quantum number for the bound states, i.e., physically feasible states have an infimum cut so that the ground state adopts a higher quantum number as compared to the Schrödinger case.

PACS numbers: 02.30.Gp Special functions, 02.30.Mv Approximations and expansions, 03.65.Ge Solutions of wave equations: bound states, 02.30.Ik Integrable systems

Keywords: Relativistic wave equation, integrable potential, bi-confluent Heun equation, Hermite function

Characteristics of photonic band gap edge lasing in Cholesteric Liquid Crystals

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Chiral Nematic Liquid Crystals (CLC) are spontaneously forming a helical structure with large modulation of refractive index. These structures lead to a Photonic Band Gap (PBG), which is the wavelength range where light with a particular circular polarization is totally reflected. Thus CLC-s often are regarded as 1D Photonic structures. Fluorescent dye-doped CLC (DDCLC) structures enable tunable mirror-less lasing from the short and long wavelength edges of the PBG, where the density of photonic states is strongly increased. This lasing is obtained usually by optical pumping (usually by pulsed UV or 532 nm) and it is possible to obtain lasing lines within a 70 nm wide wavelength range in the visible part of the spectrum. Also, the lasing wavelength can be tuned by external factors. The lasing wavelength tuning can be obtained by means of temperature, pressure, flow, electric fields and light.

In this work we study lasing spectral characteristics of dye-doped CLC structures with a pitch gradient. We experimentally demonstrate that even 1 nm difference in a helical pitch of the CLC structure can bring to totally different lasing characteristics.

Abstracts: Posters

Investigation of Faraday Rotation effect in Cs nano-layers

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Magneto-optical processes occur when the light interacts with a medium placed in a magnetic field. These effects are observed in usual cm length cells and are widely used in metrology, atomic spectroscopy, quantum information, etc. Among these processes in the study [1], the rotation of plane of polarization of the light, also known as Faraday Rotation (FR) was studied with use of a Cs atomic vapor contained in a nano-cell placed in a longitudinal magnetic field. The theoretical FR model for strong magnetic fields applicable for a nano-cell has been elaborated using [2-4] and it shows a good agreement with the experiments. We have shown that the FR spectra are very sensible to the thickness of the cell, particularly the collapse and revival of the Coherent Dicke Narrowing effect is predicted by the model. Hereafter we present the evolution of the Cs D_1 line spectrum versus thickness L , where L varies from $L = \lambda/2$ to $L = 2\lambda$ with a step of $\lambda/2$ in an external magnetic field of $B = 10$ G.

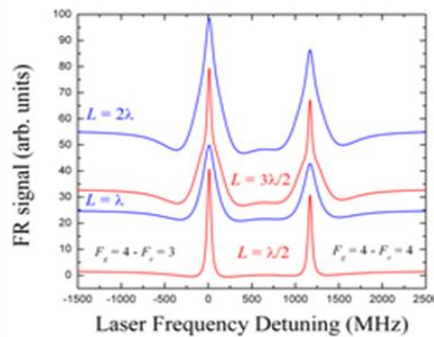


Fig. 1. FR spectra of the Cs D₁ line $F_g = 4 \rightarrow F_e = 3$, 4 transitions at $B = 10$ G magnetic field for the thicknesses $L = \lambda/2 = 447.5$ nm (curve 1), $L = \lambda = 895$ nm (curve 2), $L = 3\lambda/2 = 1342.5$ nm (curve 3), and $L = 2\lambda = 1790$ nm (curve 4). For convenience, the curves have been shifted vertically

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Raman spectrometry characterization of iron doped different composition lithium niobate crystals

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Due to the number of important applications such as phase-conjugation, holographic storage, electro-optics, acousto-optics, frequency conversion, SAW sensors, etc lithium niobate (LN) crystals are one of the mostly investigated crystals among oxide materials. One of the important property of LN, that is, photorefractivity, is a semi-permanent modulation of the crystal's refractive index induced by an inhomogeneous illumination of the last. The phenomena is

due to photo-induced charge transport, which leads to a redistribution of mobile charges inside the crystal. The charge separation leads to a creation of an intense electric field, which change the refractive index via electro optic effect. So, comprehending the processes of charge transfer in the matrix of an LN crystal is an important issue.

Raman spectroscopy is a powerful tool, which can be successfully utilized for the physico-chemical characterization of different materials, including crystals. Moreover, it has been shown that photorefractive effect can affect a Raman spectrum in LN.

LN crystals of different composition (from sub-congruent to near stoichiometric) were analyzed by polarized Raman time dependence measurements. Our attention was particularly oriented to $A_1[TO_4]$ mode as this mode is well intense, separated from others and has a relatively high frequency of nearly 632cm^{-1} which makes it particularly sensitive to any perturbation of the lattice structure. The mentioned mode is active in X(ZZ)X Raman configuration according to selection rules. Series of measurements were performed at different temperatures from -50°C to 150°C . The time step between two consecutive measurements was set 1s. $A_1[TO_4]$ Raman mode's frequency was fitted using a damped oscillator model and issued results were plotted as a function on time. The obtained positive frequency shift with time of Raman modes is attributed to the strain which is originated by the space charge field through inverse piezo-electric effect. Using obtained data saturation values of space charge field for each experiment has been calculated.

Raman spectroscopy and luminescence of Ho-doped lithium niobate crystals

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Due to various excellent properties such as nonlinear optical, electro-optical, piezoelectric, photorefractive ones Lithium Niobate (LN) is one of the most used ferroelectrics having a wide number of applications such as frequency doubling, phase-conjugation, holographic storage, SAW sensors [1-3]. Furthermore, the possibility of doping with rare-earth ions leads to laser applications. Moreover, recently it has been shown that doping of LN with Ho^{3+} impurity ions leads to the essential reduction of optical damage at 532nm [4].

Raman spectroscopy is a important spectroscopic technique providing a possibility to investigate physico-chemical, structural as well as optical properties of materials under study [5,6]. Polarized Raman measurements were carried out on Ho-doped LN crystals with excitation wavelength of 532nm and 785nm. For measurements with green light in obtained Raman anti-Stokes spectra expected modes were detected which obey the Raman selection rules. In a contrast, Raman Stokes spectra are significantly different with comparison to what one expects according to selection rules. Well defined additional forbidden lines appeared having quite high intensity. It should be noted, that the intensity of mentioned lines increases with an increase of Ho concentration in the crystal. We attribute these to emission lines. So we can confirm that in the same Stokes spectrum we were able with a good resolution to detect, the transitions between the electronic states, and the vibrational states as well. Currently we present the analysis of these data as function of Ho content in the crystal, for the cases with different polarization and wavelengths of the incident laser beam.

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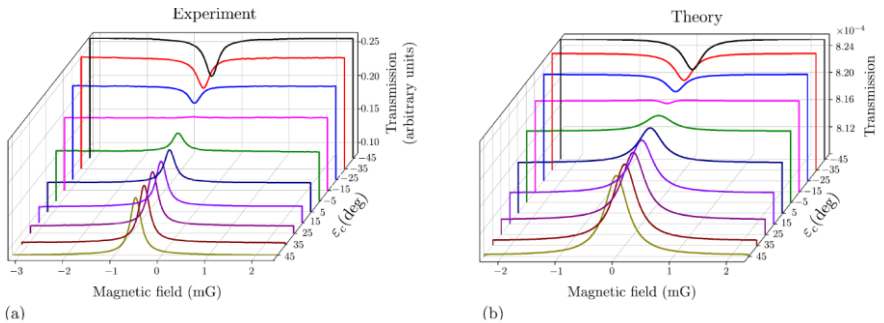
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Tuning of the Hanle effect from EIT to EIA using spatially separated probe and control beams

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We demonstrate a technique for continuous tuning of the Hanle effect from electromagnetically induced transparency (EIT) to electromagnetically induced absorption (EIA) by changing the polarization ellipticity of a control beam from parallel to opposite circular polarization with respect to that of the probe [1](shown in the figure). In contrast to previous work in this field [2,3], we use spatially separated probe and control beams. The experiments are done using magnetic sublevels of the $F_g = 4 \rightarrow F_e = 5$ closed hyperfine transition in the 852 nm D_2 line of ^{133}Cs . The atoms are contained in a room temperature vapor cell with anti-relaxation (paraffin) coating on the walls. The paraffin coating is necessary for the atomic coherence to be transported between the beams. The experimental results are supported by a density-matrix analysis of the system,



which also explains the observed amplitude and zero-crossing of the

resonances. Such continuous tuning of the sign of a resonance has important applications in quantum memory and other precision measurements.

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Photodesorption of alkali metal atoms from the glass and sapphire surfaces

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The results of experimental studies of photodesorption of potassium atoms from the glass and sapphire surfaces and rubidium atoms from the glass surface are presented. The dependence of the desorption probability on the laser pulse intensity is obtained. The power density at which thermal desorption prevails over photodesorption was found. The sticking probability of the atoms colliding with the surface is determined. The adsorption energies of rubidium and potassium atoms on glass were measured.

Alkali metal atoms are used in magnetometers [1] and frequency standards [2]. It is possible to implement rubidium vapor lasers [3]. Alkali metals are used as a material to create Bose-Einstein condensate [4]. Also, they have good prospects for application in quantum computer elements [5].

In connection with the miniaturization of devices, it is necessary to study the interaction of the atom with the surface as in the nanoscale devices atoms frequently interact with surfaces. Frequent collisions of the atoms with the surfaces lead to a loss of their polarization. As a comprehensive theory of the atom-surface interaction is still lacking, experimental studies of the interaction of alkali atoms with the surfaces of wide-band dielectrics becomes of great importance.

Potassium and rubidium atoms were chosen for our experimental studies because their resonance transitions lie in the optical and near IR- ranges and

the high enough vapor pressure of these atoms may be achieved at relatively low temperatures. The glass and sapphire surfaces are chemical inertness to alkali metals and transparent in such wavelength range. The desorption of alkali metal atoms from the surface was studied using the time-of-flight technique. Rubidium or potassium atoms were desorbed from glass/sapphire surface by the second-harmonic radiation of a neodymium laser operating in the pulse mode ($\lambda = 532$ nm, pulse duration 10 ns). The beam diameter was 3 mm. The registration of the flux of desorbed atoms was carried out by measuring the changes in the absorption of radiation of a continuous narrow-band semiconductor laser, tuned to the D₂-line of Rb atom ($\lambda=780$ nm) or D₁-line of K atom ($\lambda=770$ nm).

The dependences of the desorption probability on the intensity of laser pulses were determined. The threshold energy density at which thermal desorption prevails over photodesorption was found for Rb and K atoms on different surfaces. The dependence of the amount of the desorbed atoms on the repetition rate of the desorbing pulses is obtained. There is a sharp decrease in surface concentration of adsorbed atoms at frequencies above 1 Hz. The sticking probability of the atoms colliding with the surface is determined. The adsorption energies of rubidium and potassium on glass were measured and compared with the known values for sodium [6].

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Effects of non-isovalent impurities on optical absorption and gamma-ray induced coloration in YAG single crystals

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Since the first report of 1951 [1], yttrium aluminium garnet ($\text{Y}_3\text{Al}_5\text{O}_{12}$ or YAG) has found many applications as a laser, scintillator or phosphor host and substrate material. High transparency over a wide range of wavelengths, especially in the UV, and high radiation hardness are most desirable for most applications of un-doped YAG including possible future application as a Cherenkov emitter. Available data from the literature show that there is a considerable variability in UV absorption depending on the crystal purity, applied growth method and ambient atmosphere. Absorption bands in this range are commonly attributed to defects associated with anion vacancies and trace impurities. In the previous study [2] it was suggested that Li^+ impurity ions introduced to YAG do not substitute for any lattice site but go preferentially to interstitials with charge compensation maintained by reduction of anion vacancies. In this study the amount of introduced Li^+ ions was varied over a wide range to obtain more information on the growth behaviour and influence of Li^+ on the trap density. All single crystals were grown by the vertical directional crystallization under Ar/H_2 atmosphere and using starting oxides of the same purity. Absorption in the UV-visible range is characterized in as-grown and γ -ray irradiated (^{60}Co ; 1-10 kGy) samples. The results from the present work show that the UV absorption in as-grown crystals can be controlled by the Li^+ concentration: in optimized crystal compositions the absorption coefficient at 225 nm goes down to 1.5-2 cm^{-1} , in comparison to 5-6 cm^{-1} measured in un-doped YAG. The γ -ray irradiation induced absorption bands appear at 210, 267, 310 and 405 nm with relative intensities dependent on the concentration of added Li^+ . Results on Ca^{2+} - and Na^+ -doped YAG crystals containing larger amounts of anion vacancies are included for comparison.

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Optical Properties of Polymer-Dispersed Cholesteric Liquid-Crystalline Wedge-Cell

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Polymer-dispersed cholesteric liquid-crystalline (PDCLC) structures are important class of electro-optical materials [1]. They are used for making displays, optical shutters, switchable windows, in mirror-less lasing and etc. Nowadays the role of the PDCLCs in bistable liquid-crystalline technology is especially indisputable due to the photonic bandgap (PBG) peculiarity of cholesterics.

In this work we investigate spectral and polarization properties of PDCLCs in wedge-cells of different thicknesses depending on concentration of components. By means of polarizing microscope studies pitch variation of the CLC and formation of the disclination lines are observed. Due to the pitch jumps of cholesteric in wedge-cell polarization plane rotation of light shows an interesting behavior. Besides, we can control and broaden PBG in such systems. The cholesteric droplets in the polymer matrix are formed due to photopolymerization phase separation technique. We investigate the behavior of the reflection band of such a composite material in wedge-cell after UV curing under the influence of an electric field as well. The PDCLC samples become opaque under the influence of an external electric field and transparent in the absence of electric field. We measure transmission coefficient and polarization plane rotation angle dependences on the thickness of wedge-cell, concentration of composite materials and the value of applied electric field.

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A new exactly integrable hypergeometric potential for the Schrödinger equation

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We introduce a new exactly integrable potential for the Schrödinger equation for which the solution of the problem may be expressed in terms of the Gauss hypergeometric functions. This is a potential step with variable height and steepness. We present the general solution of the problem, discuss the transmission of a quantum particle above the barrier, and derive explicit expressions for the reflection and transmission coefficients.

On the Born-approximation scattering of zero-energy particles

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In wave-mechanical collision problems involving a static central potential in three space dimensions ($D=3$), the scattering of zero-energy particles [1] can be described via Born approximation under the following weak-coupling condition, $\nu \sim (ma^2 / \hbar^2) |U_0| \ll 1$ (Ref. 2), where m is the effective mass of the particle, and a the influence range of the potential with characteristic strength U_0 . In the present contribution, a computation procedure is outlined for examining the salient features of zero-energy Born collisions in continuous $2 < D$ dimensions [3]. Our approach uses the transformation properties of the radial wave equation for s waves [4] and the relation between dimension and angular momentum. The analytical structure of $\nu = \nu(D)$ is analyzed in the asymptotic limit $D \rightarrow 2^+$ (Refs. 2, 3) by invoking the notion of quantum anti-centrifugal force [4]. In the opposite extreme, $D \rightarrow \infty$, some general aspects of perturbative forward scattering of zero-energy waves [1, 4] are discussed from the standpoint of Bargmann-type inequalities. The results are applied to the study of the “Born approximation” form of Friedel’s theorem in electronic theory of alloys.

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Effects of Growth Environment on Optical Properties of YAP:Yb Laser Crystals

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YAlO₃ (YAP) doped with Yb³⁺ is recently considered as very promising laser crystal for ultrafast lasers due to high thermo-optical properties, relatively broad absorption and stimulated emission cross-sections, as well as easy accommodation of Yb³⁺ within the lattice [1,2]. The achieved cw and mode-locked laser operation parameters of YAP:Yb (0.6 at%) [1] can be further improved by optimization of Yb concentration. YAP is biaxial orthorhombic crystal (D_{2h}¹⁶-Pbnm) stable in the 1875-1835° C range [3]. While growth of crack- and twin-free YAP crystals is well-documented since many years, the color centers with tails extending to the IR range are still under active studies, as they may introduce additional losses. The origin of color centers is commonly attributed to defects associated with anion vacancies and trace impurities. In this work b-axis single crystals of YAP:Yb in a wide (1.5-8 at%) range of Yb concentrations were grown by Czochralski and vertical Bridgman methods. Strong correlation was observed between the amplitude of color centers and the growth environment. The involved mechanisms are considered basing on transmission in as-grown, heat-treated and gamma-ray irradiated crystals. Optimized growth conditions were formulated for preparation of color center-free single crystals. Emission lifetime measurements were carried out with fine powdered YAP:Yb crystals immersed in ethylene glycol in order to

suppress reabsorption. Luminescence quenching was observed for Yb doping concentrations of 5 at% and 8 at%.

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Characteristics of W and CeB₆ Thin Films and Single-Photon Detector's Detection Pixels Based on Them

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Tungsten (W) and cerium hexaboride (CeB₆) thin films are promising materials to be used in detection pixel of thermoelectric single photon detector (TSPD) [1, 2]. W and CeB₆ thin films were fabricated by electron-beam deposition. Thin films' depositions were carried out from composite (W) and ceramic (CeB₆) targets on the insulator, semiconductor, and metal substrates at different temperatures. The microstructure, elemental and phase compositions, thickness and roughness of films, as well as some physical properties are studied. The conditions for the preparation of high quality films are determined.

CeB₆ films have characteristic structure of hexaboride CaB₆ and elemental composition close to stoichiometric. At low temperatures, resistivity of the films is somewhat higher than that of single-crystal samples, and the Seebeck coefficient is close to the corresponding coefficient for bulk samples. W films have granular structure with about 200 nm size granules. The granules of CeB₆ films deposited on W films have the same size. At the same time, CeB₆ films deposited on insulator or semiconductor substrates with smooth surfaces consist of granules with smaller sizes. Of course, CeB₆ films of the both cases have different roughness.

The characteristics of TSPD detection pixel consisting of the obtained thin films

are investigated by the means of computer simulation. It was shown that while detecting photons from NIR to NUV wavelengths, the detection pixel with both single layer and multi-layer architecture may provide microvolt level signal and terahertz count rate.

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Single-Layer Detection Pixel of Thermoelectric Single-Photon Detector on the Base of (La,Ce)B₆ Sensor and LaB₆ Absorber

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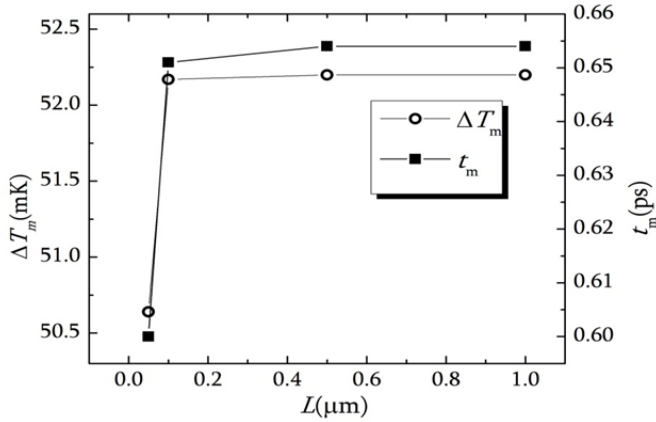
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Sources and detectors of single photons have attracted significant research attention in the recent years due to their wide use in different areas of science and technology. The thermoelectric single-photon detector (TSPD) with tungsten absorber may compete with superconducting detectors, since they are better in some properties and characteristics [1].



Further research has shown that the use of superconductor absorbers instead of heavy metals (namely Nb, Pb and YBCO) is a way to increase the count rate of TSPD [2]. LaB₆ hexaborade is a superconductor at low temperatures and together with low temperature thermoelectric (La_{0.99}Ce_{0.01})B₆ can be used in detection pixel of TSPD. Figure presents the results of computer simulation of heat distribution processes after 0.8 eV energy photon absorption in the middle region of LaB₆ absorber surface which is connected with heat sink by (La_{0.99}Ce_{0.01})B₆ thermoelectric bridge of L length. It can be seen that maximum temperature difference at the ends of the bridge (ΔT_m) and the time in which this maximum is reached (t_m) are sharply reduced when the length of the bridge becomes less than 0.1 μm .

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Electro-optic properties of rare earth ions doped lithium niobate

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Congruent lithium niobate (LN) doped with rare-earth ions is a promising material for integrated optic applications combining the properties straightforwardly associated to the dopant with lasing and good electro-optic (EO) properties. By direct technique based on optical arrangement of Mach-Zehnder interferometer associated to the Modulation Depth Method using He-Ne laser with the beam at the wavelength of 633 nm and at room temperature, we have experimentally determined the figure of merit $F = n^3 r_{\text{eff}}$, (n is the refractive index and r_{eff} , the effective EO coefficient) and finally calculated the EO coefficients r_{eff} of the third-column of the unclamped electro-optic tensor of singly (Yb^{3+} , Ho^{3+} , Tm^{3+}) and doubly (Er^{3+} - Yb^{3+}) doped LN crystals. It is found that in all the studied opto-geometric configurations, the unclamped figure of merit and consequently the corresponding electro-optic coefficients of the crystals under study remain quasi-constant in the considered dopant concentration range (0-1mol%). As the figure of merit, F qualifies crystals for electro-optic modulation and laser applications, all reported results confirm that the LN doped and/or co-doped with rare-earth elements are very promising versatile candidates for several multifunctional nonlinear devices in optoelectronic and laser applications.

Ho-doped lithium niobate thin films: creation and characterization

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Different concentration of Ho^{3+} ions doped lithium niobate powders and alkoxides were synthesized by solid and wet reactions respectively. Obtained powders and fired alkoxides were investigated by means of X-ray diffraction analyses and corresponding lattice parameters were calculated. Thin films of $\text{LiNbO}_3:\text{Ho}^{3+}$ were grown by Sol-Gel method on a sapphire substrate of (001) orientation.

Structural modifications of obtained thin films were investigated by high-resolution x-ray reciprocal space mapping. The reciprocal space maps were collected in the proximity of the symmetric (006) and asymmetric (018) Bragg reflections of the sapphire substrate. By comparing the maps obtained from different independent Bragg reflections, the deformation matrix was solved and lattice parameters of thin films were calculated.

Ground-state angular-momentum alignment-to-orientation conversion

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We studied angular momentum spatial symmetry transformation in rubidium ground-state caused by combined action of linearly polarized exciting laser radiation and an external magnetic field. The linearly polarized light first creates an aligned state and the external magnetic field transforms the angular momentum spatial distribution into an oriented state. It means that the aligned state, which had a determined axis, now has also preferred spatial direction. This angular momentum spatial symmetry transformation is also known as alignment-to-orientation conversion (AOC). We present results from a theoretical investigation of ground-state angular momentum alignment-to-orientation conversion (AOC) by observing laser-induced fluorescence (LIF) signals of rubidium atoms at D_1 excitation. This can be detected by observing circularly polarized light as circularity is direct evidence of angular momentum orientation. The excitation and observation geometry for creating and observing AOC stands as follows: the magnetic field $\mathbf{B}$ defines the quantization axis and the exciting linearly polarized laser radiation $\mathbf{E}$ forms an angle of $\pi/4$ with respect to the magnetic field $\mathbf{B}$, observation direction is in the direction perpendicular to both $\mathbf{E}$ and $\mathbf{B}$. In the previous work [1], where the same excitation and observation geometry was used, the AOC phenomenon was

studied in the excited state where due to the nonlinear Zeeman effect of the excited state magnetic sublevel crossings occurred thus allowing for linearly polarized light to create coherence among sublevels that differ in value by 1 ($\Delta m_F = 1$). In contrast, there is no magnetic sublevel crossings in the ground state and one would not expect to observe AOC. But due to the nonlinear dependencies of the energies of ground-state magnetic sublevels, the angular momentum alignment, created by linearly polarized light, can be partially converted to orientation. The ground-state AOC occurs at relatively high magnetic field values around 2000 gauss, because of relatively large hyperfine splitting in the ground-state – 3.0 GHz for ^{85}Rb .

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Copper oxide targets for pulsed laser deposition of thin films: synthesis and investigation

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Copper oxides sputtering targets with the highest possible density and smallest possible average grain sizes are used in semiconductor, chemical vapor deposition (CVD), physical vapor deposition (PVD) and optical applications [1,2]. In this paper we consider the synthesis technology and structural properties of sputtering targets formed from pure (99.9%) powders of copper oxides (CuO and Cu_2O) followed by annealing at temperatures 800, 900 and 1100 °C. Thin films on sapphire and glass substrates were fabricated by laser vacuum sputtering. Our goal is to study the properties of synthesized materials and improve them for photovoltaic use.

Laser sputtering experiments were carried out by Nd:YAG laser operating at 1064 nm. The morphology and structure of targets and thin films were analysed

by SEM, EDX, XRD techniques and RS. The results obtained show that CuO target are most stoichiometric opposite to the Cu₂O target. According to the EDX analysis both phases CuO and Cu₂O coexist in Cu₂O target after annealing. The SEM images are presented on the Fig. 1 below.

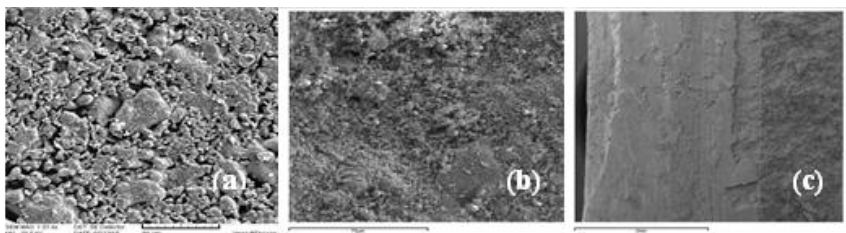


FIGURE 1. The SEM images of Cu₂O target: (a) – before annealing, (b) – after annealing, (c) – cross-section.

It is of interest to compare structural properties and composition of the obtained targets, and the parameters of films formed depend to large extent on this. It's shown that to obtain thin films with a crystal structure by changing of substrate temperature and evaporated laser pulse intensity is possible. The optical characteristics of prepared films are discussed too. The analysis of the results will allow choosing the methods of formation of copper oxide based layers suitable for photovoltaic applications.

The author would like to thank for helping with SEM measurements to G. Badalyan.

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Faraday Rotation in Rb atomic vapor layers with the thickness of few tens of nm

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The interaction of rubidium atoms with sapphire cell windows at a distance L between the cell windows in the range of 40-100 nm was studied experimentally. We used the Faraday rotation (FR) effect (rotation of the polarization plane of radiation in a magnetic field) in a thin column of rubidium vapor atoms for Rb $D_{1,2}$ lines [1,2]. With a decrease of L from 100 to 40 nm, a "red" frequency shift of the FR signal is recorded which increases up to 250 MHz, with the broadening of the low-frequency wing extended to ~ 1 GHz. It is shown that for this type of research the atomic transition ^{85}Rb , D_1 of the $F_g = 3 \rightarrow F_e = 2$ line is more convenient, since in this case it is possible to separate it spectrally from other strongly broadened atomic transitions. It was demonstrated that at thicknesses of the nanocell $L < 100$ nm with an increase in the density of Rb atoms, an additional frequency "red" shift occurs, which is absent for large L . Practical applications of the FR signal for measuring strong magnetic fields (of several kGs) are given.

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Lasing in Cholesteric-Polymer Wedge-Cell System

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Polymer dispersed cholesteric liquid crystals (PDCLC) and polymer stabilized cholesteric liquid crystals (PSCLC) recently are actively used as lasing structures [1]. The unique photonic bandgap (PBG) property makes cholesterics attractive since from the edges of the PBG it is possible to obtain lasing.

Here, we experimentally and theoretically investigate the lasing possibilities from dye-doped PDCLC and PSCLC wedge-cell in the visible wavelength range. Besides, we investigate lasing possibilities in three-layer cholesteric-polymer wedge-cell system (cholesteric-polymer film-cholesteric), namely lasing possibilities on the observing photonic defect modes. To the best of our knowledge there are no studies, which report on the lasing from these structures in wedge-cell. We show that it is possible to control the lasing wavelength from wedge-cell cholesteric-polymer system. We have also studied these structures under the influence of an external electric field aiming to control them in case of different polymer concentrations.

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High Efficiency LaB6/CeB6/LaB6/Al2O3 Detection Pixel of Single-photon Detector with Operating Temperature 9 K

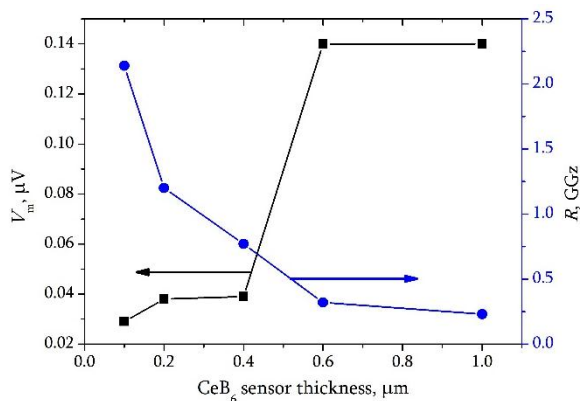
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Single photon detectors capable to determine the photon energy and to provide high count rates are demanded in quantum electronics, astrophysics, high energy physics, quantum informatics, telecommunication systems, quantum metrology, measuring systems for applications in medicine, homeland security and other fields [1]. The thermoelectric single-photon detector (TSPD) with CeB₆ sensor and W absorber possesses high count rate and are able to register photons in a wide range of the electromagnetic spectrum [2]. However, tungsten has a high reflection coefficient in the near-UV – near-IR region, as a



result of which it can not provide high detection efficiency of TSPD. To ensure high efficiency of the system

other absorber material it must be used for detection of photons of telecommunication wavelength windows around 0.95 – 0.8 eV. Such an absorber can be lanthanum hexaboride. Absorber LaB₆ and thermoelectric CeB₆ have the same crystal structure ($Pm\bar{3}m$) with a very close lattice parameter, which will make it possible to obtain multilayer structures of these materials of high quality [3]. Also LaB₆ nanoparticulate coatings has a low reflection coefficient in the near-IR wavelengths [4].

In this work the results of computer simulation of heat distribution processes in LaB₆/CeB₆/LaB₆/Al₂O₃ detection pixels of TSPD after 0.5-4.13 eV photon absorption are presented. We calculated the the maximum of voltage on the sensor (V_m) and photon count rates (R) of TSPD of different geometries. Figure presented results for 0.8 eV energy photons. It is concluded that the TSPD can achieve higher specifications, as compared to the best single-photon detector, for usage in telecommunication systems.

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Single-Photon Detector on the Base of LaB₆/(La,Ce)B₆/LaB₆/Al₂O₃ Multi-Layer Detection Pixel with Operating Temperature 0.5 K

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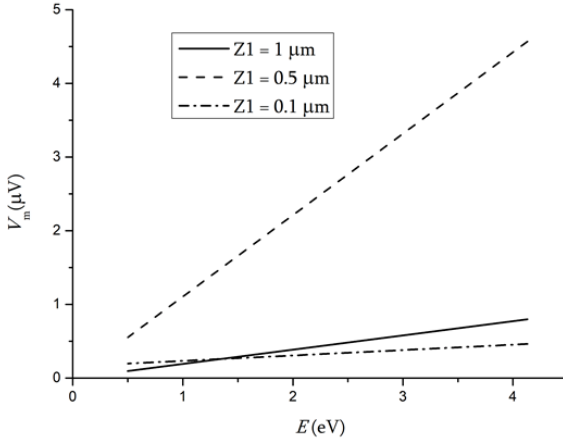
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Computer simulation of heat distribution processes in the detection pixel of thermoelectric single-photon detector (TSPD) has shown that the multilayer architecture of detection pixel has some advantages over the single layer [1, 2].

In these works lanthanum-cerium ($\text{La}_{1-x}\text{Ce}_x\text{B}_6$) and cerium (CeB_6) hexaborides as sensors and tungsten (W) as absorber and heat sink of TSPD detection pixel were considered. Hexaboride $\text{La}_{0.99}\text{Ce}_{0.01}\text{B}_6$ has high Seebeck coefficient at 0.5 K ($S = 85 \mu\text{V/K}$) and can be used as a sensor. Heavy metal W is a good absorber for X-ray and hard UV photons. But for the registration of photons with lower energies other absorbers can be used. For the production of high-quality multilayer structures it is important for the compounds of layers to have close



lattice parameter and close coefficient of thermal expansion in order to avoid cracking upon cooling up to temperatures below 1 K. LaB_6 can be an appropriate absorber for the multilayer structure of TSPD detection pixel as it has the same structural and physical properties that

$\text{La}_{0.99}\text{Ce}_{0.01}\text{B}_6$ sensor has. In this work the

results of computer simulation of heat distribution processes in $\text{LaB}_6/\text{La}_{0.99}\text{Ce}_{0.01}\text{B}_6/\text{LaB}_6/\text{Al}_2\text{O}_3$ detection pixels of TSPD after photon absorption are presented. The figure shows the values of maximum voltage (V_m) that appears on the sensor when 0.5-4.13 eV photons are absorbed in the absorber with $Z1$ thickness. As can be seen the parameter V_m increases linearly with photon energy (E) increase. The values of the parameter V_m and the slope of the dependence $V_m(E)$ is straightly connected with the thickness of the absorber $Z1$. The optimal thickness is $Z1 = 0.5 \mu\text{m}$ because at $Z1 = 1$ or $0.1 \mu\text{m}$ the parameter V_m has smaller values.

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Monochromatic Waves as Trains of Pulses

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Among various aspects of Physics the term ‘localization’ applies to, perhaps the basic one is Heisenberg’s uncertainty relation, and the minimal value is realized for coherent states. Here, ‘localization’ is understood as at an arbitrary point in quantum phase space. For another form of localization, namely, the one with respect to von Neumann lattice, or Gabor frame, the product of the uncertainties is infinite, because of the incompatibility of orthogonality and localization, and that infinity is the statement of Balian-Low theorem [1], [2]. While the former notion of localization fits fairly well the problems in atomic physics and related areas, there are many problems where its stronger form is needed. Those restrictions can be circumvented, as shown in [3-5], and one may deal with states exponentially localized in the quantum phase space, or in the time-frequency plane, and or in the quantum Hall effect regime in a 2D electron gas. The key feature here is non-commutative geometry of the plane, and a doubled in size von Neumann lattice (Gabor frame).

While dealing with the hole of the Hilbert space of states, in the terms of non-commutative plane compatible with Weyl-Heisenberg symmetry group, the methods mentioned above lead to rapidly converging double-series expansions. Those methods can be applied, for instance, to minimalist’s fully shift-invariant subspaces, like important for applications in classical information band-limited signals, described conventionally with ‘sinc’ functions, and many other problems too. The main purpose of such an application is to deal with strongly localized descriptions, and, therefore, in circumventing the ‘windowing’ problems.

The latter features are illustrated best when applied to the simplest ever object

in the field: a monochromatic wave. Remarkably, a train composed of only two exponentially localized alternating waveforms, as contrasted with the long tails of ‘sinc’ functions, gives a nice representation of the monochromatic wave. The approach opens up new possibilities in the control of the phase of the wave, which then may be effectively synchronized with a clock.

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Investigation of possibilities for remotely detection of unmanned aerial vehicles using electrooptical equipment of visible and infrared spectral ranges

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Small size UAVs and surrounding environment radiation parameters are investigated. Those parameters are analyzed both for visual and IR spectral ranges in terms of small UAVs detection capabilities. The ORBITER-2 surveillance device has been chosen as a typical target. Using mathematical models UAVs detection and recognition possible ranges both in passive and active modes are calculated. UAVs acquisition, lock-on and precise tracking possibilities in real time mode are estimated. As a result of investigations system preliminary construction are designed and key components technical requirements are defined.

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For Notes