B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine

Young Scientist Council
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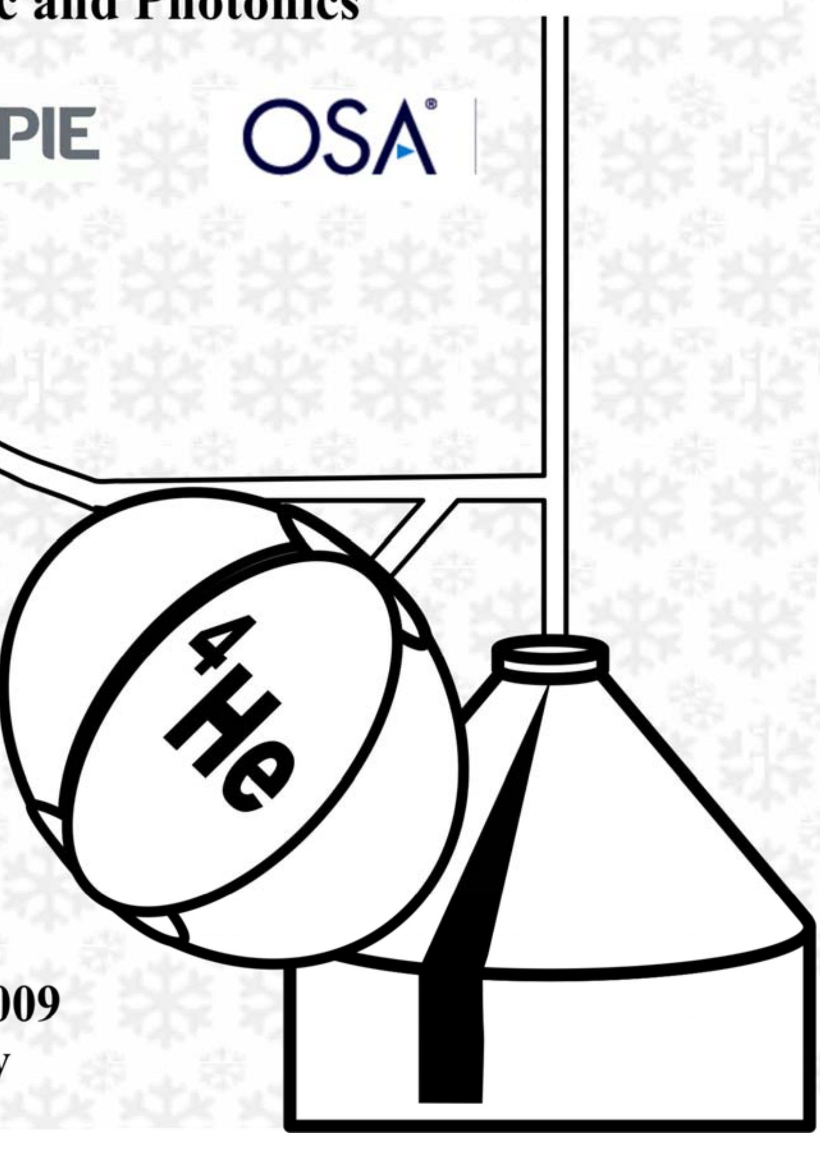
2-nd All-Ukrainian Young scientist conference On

LOW TEMPERATURE PHYSICS (YSC-LTP-2009)

Session on Optic and Photonics



June 1-5, 2009
Kharkiv

June 2 , Tuesday

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OPTICAL METAMATERIALS FORMED BY MULTILAYERED METAL-DIELECTRIC NANOSTRUCTURES

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The most of optical realizations of double-negative media employ a nano-fishnet geometry [1-7]. The structures consist of perforated metal-dielectric-metal stacks (nano-fishnet pairs). Usually, single nano-fishent pairs are studied and it is assumed that the actual metamaterial can be created by stacking these building blocks. This approach is dictated by the fact that the manufacturing of experimental samples consisting of more than one nano-fishnet pairs remains a challenge. There are only few reports actually dealing with multilayered nano-fishnets [6,7]. In this paper we consider multilayered structures consisting of several nano-fishnet pairs and systematically analyze their properties.

The extraction of material parameters from reflection and transmission coefficients [8,9] is a common technique in processing of experimental data for nano-fishnet pairs. However, the obtained material parameters usually can be hardly attributed to a particular three-dimensional optical metamaterial which can be composed out of the nano-fishnet pairs. We refine conventional procedure of material parameters extraction by incorporating the thickness of inter-block spacer into the procedure and assess the applicability of such material parameters for description of real three-dimensional metamaterials through comparison with material parameters extracted from reflection and transmission coefficients of multilayered structures. We consider multilayered structures consisting of several nano-fishnets and study convergence of material parameters extracted from reflection and transmission coefficients of the structures if the number of building blocks increases. If material parameters converge to some values then we assume that these values can be treated as material parameters of infinite metamaterial. If convergence is not observed then we conclude that the infinite metamaterial cannot be described by local material parameters at all. The comparison of the material parameters obtained this way with ones extracted from reflection and transmission coefficients of a single nano-fishnet pair allows to formulate general restrictions on applicability of latter ones for prediction of properties of bulk metamaterials.

Our studies have shown that the material parameters extracted from reflection and transmission coefficients of a nano-fishnet pairs provide reasonable prediction about material parameters of infinite metamaterial only if the spacing between its constituent nano-fishnet pairs is large enough. In the opposite case the material parameters significantly diverge from each other.

P. Belov acknowledges financial support by EPSRC Advanced Research Fellowship EP/E053025/1.

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INVESTIGATION OF VIBRATION SPECTRUM OF CRYSTAL $TbFe_3(BO_3)_4$

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The rare-earth borates with the common formula $RM_3(BO_3)_4$ (R = a rare earth (RE), M = Al, Ga, Sc, Cr, or Fe) are intensively synthesized and investigated. They are interesting first of all as materials which are used in nonlinear optics and laser techniques. It is well known that crystals $RFe_3(BO_3)_4$ show various magnetoelastic and magnetoelectric effects depending on the certain rare-earth element R [1]. Usually, the structural phase transition with symmetry reduction occurs in this type of crystals. For example, in the crystal $TbFe_3(BO_3)_4$ at T=192K there is a first order structural phase transition with symmetry reduction R32 → $P3_121$, as well as in $GdFe_3(BO_3)_4$ crystal [2].

In $TbFe_3(BO_3)_4$ crystal the mechanism of structural phase transition is not completely clarified. Therefore in this work IR reflectance spectrum of monocrystal $TbFe_3(BO_3)_4$ had been investigated by methods of IR spectroscopy for clearing of the mechanism of structural phase transition and characteristics of crystal lattice dynamics. The plate of single crystal $TbFe_3(BO_3)_4$ was cut out perpendicular to trigonal crystal axis *c*. Plate dimensions were 3*mm* x 3*mm* x 1*mm*.

In a temperature interval 10-300K the reflectance spectra of monocrystal $TbFe_3(BO_3)_4$ were measured in a frequency interval of 200-1500 cm^{-1} at polarization E, which was perpendicular to *c* axis. Spectrum was interpreted as internal vibrations of complexes BO_3^{3-}. It was established that well developed structure of a vibrational spectrum was related to nonequivalent crystallographic positions occupied by complexes BO_3^{3-}. At temperatures below structural phase transition the weak changes of frequencies of vibrational modes occur due to that phase transition. It is caused by anharmonicity on external freedom degrees of complexes BO_3^{3-}. Evidently, phase transition occurs without multiplication of an elementary cell of a high-temperature phase of crystal $TbFe_3(BO_3)_4$, because the quantity of vibrational modes below temperature of phase transition is not increased. Also, the weak reflection bands were observed in a spectrum. Those bands can not be explained by internal vibrational frequencies of complexes BO_3^{3-}. We assume that those bands are caused by anharmonicity on internal vibrations of BO_3^{3-}.

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CHANGE OF PHOTOLUMINESCENCE PROPERTIES OF $Cd_{1-x}Zn_xTe$ SINGLE CRYSTALS AT $T = 5\ K$ BY γ – IRRADIATION OF ^{60}Co SOURCE

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The study of influence of high-energy particles on the photoluminescence of semiconductors gives an important information about the generation of radiation defects, their physical properties and interaction with initial ones [1]. In this paper we present data about the influence of γ-quantum radiation on the low-temperature photoluminescence (LTPL) of $Cd_{1-x}Zn_xTe$ crystals. $Cd_{1-x}Zn_xTe$ crystals with the zinc molar concentration $x \le 0.05$ have been studied. The crystals have been irradiated using ^{60}Co source (which has quantum energy of about 12 MeV) in dose range of 10 – 100 kGy. LTPL spectra of the CdZnTe crystals were studied at 5 *K*. During analysis of getting spectra were established that gamma-quantum stream leads to the following changes in the spectra:

a). The intensity of excitonic line D^0X decreases more than 10 times. It is probably related to expulsing reaction of cadmium atoms and III – VII groups elements (which are components of isolated donors) by gamma-quanta to interstitial space [2]. The excitonic line A^0X quenches but the new line $A^0{}_1\,X$ appears. This line is shifted in a low energy side for ≈ 2 meV and formed by acceptor complexes like a cadmium vacancy – exciton ($V_{Cd} – X$). $A^0{}_1\,X$ line intensity increases with increasing of irradiation dose. It can be explained by increasing of new radiation recombination centers and it is related with increasing of V_{Cd}. .

b). The intensity of D^0A^0-eA^0 increases too and it is explained by increasing of acceptor levels concentration too.

c). Deep level defects line intensity quenches and it is related to deep level transformation or destruction.

When the irradiation dose is 50 кGy < D < 100 кGy the intensity of all lines decreases which can be explained by the effective generation of new radiationless recombination centers.
Similar changes are observed for LTPL spectra of CdTe, CdTe:Cl crystals under influence of gamma-quantum irradiation [3]. Although decreasing of photoluminescence intensity which is related to additional radiationless recombination centers introduction is observed for CdTe, CdTe:Cl crystals already at values D > 3 кGy [2, 3].

Consequently, γ-rays leads to substantial changes in LTPL spectra of CdZnTe single crystals. Namely to sharp changes of proper lines, emission centers concentrations, initial centers transformation, formation and introduction of new radiation and radiationless recombination centers, that is related to Cd vacancy generation and the process of atomic expulsing in the interstitial space from the lattice points.

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ANALYSIS OF THE LOW TEMPERATURE PHASE TRANSITIONS AND MECHANISMS OF ENERGY TRANSFER IN DMAGS:Cr^{3+} CRYSTALS BY LUMINESCENCE SPECTROSCOPY METHOD

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Crystalline ferroics with alkylammonium cations and inorganic anions evoke considerable interest among scientists during last decades because of theirs interesting physical properies and the sequence of phase transitions (PTs). Dimethylammonium gallium sulfate hexahydrate $NH_2(CH_3)_2Ga(SO_4)_2\times 6H_2O$ (DMAGS) crystal at room temperature belongs to $P112_1/n$ space group and is ferroelastic with crystal lattice parameters: a=6.373 Å, b=10.726 Å, c=11.367 Å, β=100.86 ^{0} , Z=2 [1]. DMAGS crystal underdoes PTs: antiferroelectric → ferroelectric at T_{c1} = 119 K, ferroelectric → ferroelastic at T_{c2} = 136 K [2].

Complicated structure of DMAGS puzzles unambiguous identification of the bands in the vibrational spectra and analysis of their changes at PTs. In order to elucidate the nature of structural changes at PTs, specially regarded to the metallo-hydrate sublattice, DMAGS crystal doped with 6.5 % chromium was grown. Here Cr^{3+} isomorphically substitute Ga^{3+} ions. The temperature evolution of the photoluminescence spectra in 132÷300 K temperature range with detailed analysis in the vicinity of the ferroelectric PT was studied (Fig. 1). The obtained spectra were approximated by the Lorentz contours using the method of the derivative spectrophotometry. The band, similar to the R-band of ruby, and its phonon replicas were identified. The activation energy was calculated using Mott`s formula (E_T=0.146 eV) describes intracenter luminescence quenching.

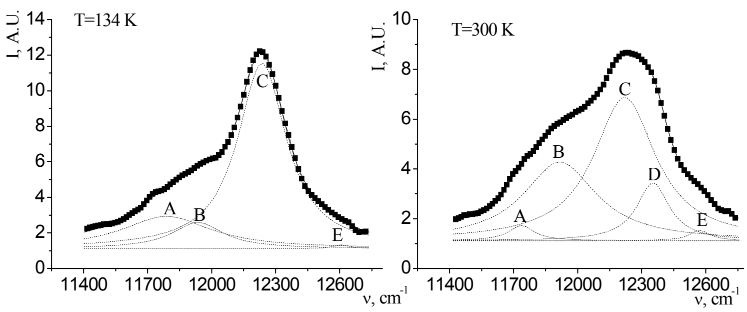

Fig.1. Photoluminescence spectra approximated by Lorentz contours, obtained at different temperatures.

Table. Bands identification of the DMAGS:Cr photoluminescence spectra at T=300 K.

Band	Band position, cm^{-1}	Identification	Phonon frequency (Raman and IR spectra), cm^{-1}	Identification of vibrational mode
A	11762	R-464 (cm^{-1})	465	$\nu_2(SO_4)^{2-}$
B	11942	R-284 (cm^{-1})	270	rotation of CH_3
C	12227	R		
D	12358	R-132 (cm^{-1})	120	lattice vibration
E	12563	R-336 (cm^{-1})	345	$\nu_6(Me-H_2O)$

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INFLUENCE OF TEMPERATURE ON PROPERTIES OF SURFACE OSCILLATIONS IN THE STRUCTURE MAGNETO-PHOTONIC CRYSTAL/SEMICONDUCTOR

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Last years the research of propagation of electromagnetic waves in magneto-photonic crystals (MPC) in EHF range is attracted a great attention. Those MPCs can be used for development of devices that controlled with static magnetic field (broadband filters, attenuators, antennas, etc.) [1]. Special interest represents research of effect of surface oscillations ("Tamm states") on the interface of MPC and medium with negative material parameters which can be used for development magnetic field controlled narrow-band filters, resonators, etc. [2-4]. In the given work spectral properties of the structure MPC/semiconductor have been investigated. In this structure occurrence of surface oscillations on the interface of MPC, due to negative permittivity of the semiconductor in EHF range, is possible.

Elementary cell of MPC consisted of layers: air, ferrite and quartz. Parameters of layers are: 1) a ferrite layer (1SCH4 brand) - permittivity $\varepsilon_f = 11.1$, magnetization of saturation $4\pi Ms = 4800G$, damping factor $\alpha = 0.024$ and thickness of a layer is $d_f = 0.5$ mm; 2) a quartz layer - $\varepsilon_q = 4.5$ and $d_q = 1$ mm. 3) an air layer - $d_{air} = 1.5$ mm. The semiconductor layer (InSb) had following parameters - $d_{sc} = 0.5$ mm, collision frequency ($\nu_{77K} = 2\cdot 10^{11}\, s^{-1}$), $\nu_{300K} = 1.73\cdot 10^{12}\, s^{-1}$, electron concentration ($n_{77K} = 1.2\cdot 10^{14}\, sm^{-3}$) $n_{300K} = 2\cdot 10^{16}\, cm^{-3}$. The InSb-layer contacted to quartz layer boundary of MPC. The spectrum of transmission coefficient was measured in a frequency range of 22-40 GHz in a range of magnetic fields 0-13000 Oe at temperatures 300 ºK and 77 ºK. Spectrum calculation was carried out by a transfer matrix method taking into account limitation of structure along a direction of propagation of an electromagnetic wave.

Appearance in a spectrum of structure MPC/semiconductor of resonant peak near to edge of MPC forbidden zone for cases of perpendicular and parallel orientations of a constant magnetic field and magnetic components variable EHF fields is shown theoretically and experimentally. This peak specified with surface oscillation. For the first case (parallel orientation) peak displacement in area of higher frequencies was observed at magnetic field increase that is caused by dependence of ferrite permeability on a magnetic field. For the second case (perpendicular orientation) peak displacement in area of lower frequencies was observed at magnetic field increase. In the area of magnetic fields (above 7000) in the spectrum one more peak of resonant transmittance caused by effect of a ferromagnetic resonance was observed. At nitrogen temperatures falling of peak quality and its displacement in area of lower frequencies was observed. The given work is supported by STCU grant (№4912).

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EHF PROPERTIES OF THINLAYER STRUCTURES, PLASED IN A WAVEGUIDE

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Last years, increasing attention is paid to the study of media with negative index of refraction («left-handed media» - LHM) [1]. The use of LHM will allow developing a new class of narrow-band frequency filters, transparent coatings in microwave and optical range and superresolution lenses - superlenses [2]. Present work is devoted to experimental study of microwave propagation in a composite material (LHM model) placed into waveguide.

The material under study consists of alternating layers of ferridielectric and metal, deposited on mica. Each layer is partially transparent for the used frequency range. These composite structures were studied in the frequency range of 22-40 GHz under the influence of the external magnetic field, $H = 0 \div 7$ кOe. The thickness of the ferrite layer is $d_z^f = 0{,}5$ mm and the dielectric permittivity is $\varepsilon'_f = 11{,}1$. Copper and nickel layers, with thickness $d_z^{Cu,Ni} = 50 - 70$ nm, deposited on mica, with thickness $d_z^{mica} = 0{,}03$ mm and permittivity $\varepsilon'_{mica} = 10$. The results of the measurements are presented in Fig. 1 (a) and (b).

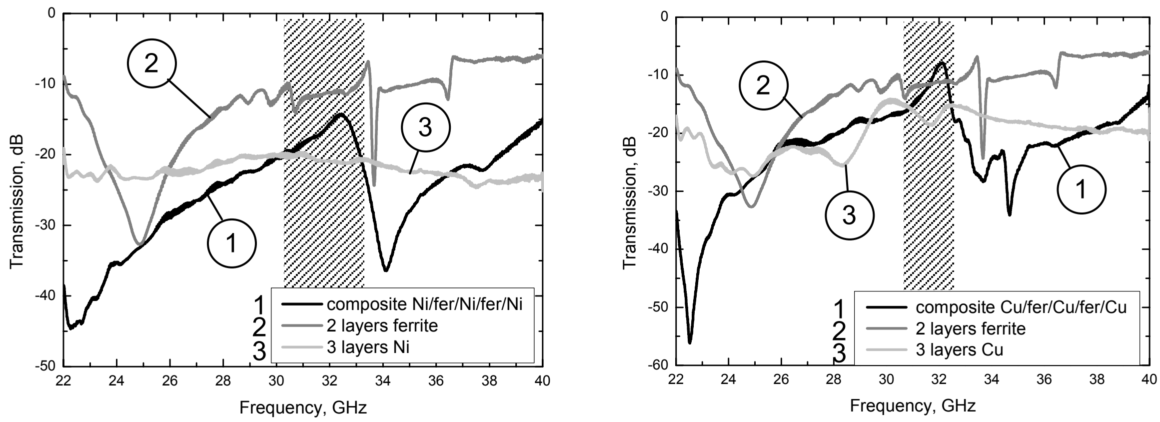

Fig. 1 Transmission factor of the ferrite/metal film structures: (a) ferrite/nickel film; (b) ferrite/copper film.

Effective constructive parameters of composite structures are theoretically calculated [2]. The bandwidths of transmittance have been found in the spectrum of composite structures (Fig. 1 (a), (b)), which are the result of simultaneous negative values of effective permittivity and permeability of composite (26-34 GHz) - the region with left-handed properties. The position tuning of this region under the magnetic field influence has been shown. The obtained results for two types of composite structures have been analyzed.

This work was partially supported by STCU project no. 4912.

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INVESTIGATION METHOD OF FERROMAGNETIC RESONANCE EFFECT BY SURFACE OSCILLATIONS IN PHOTONIC CRYSTAL IN MILLIMETER WAVEBAND

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Now there are many various investigation methods of Ferromagnetic resonance effect (FMR) in magnetic nanostructures, based on using of open resonators[1], cavities[2], micro strip lines[3] and planar microresonators[4] etc. In this paper the new investigation method of FMR effect in magnetic nanostructures, based on using of structure (photonic crystal(PC)/metallic film) as resonator was proposed. In such structure there is the electromagnetic field concentration on the PC interface, caused by appearance of resonant surface oscillation in the PC forbidden zone [5]. PC bilayer consisted of quartz and teflon layers. Magnetic specimen under study was placed between PC and metallic film. Transmission spectrum through the structure in the waveguide was measured in the frequency range of 22-40 GHz in the magnetic field range of 0-15000 Oe. The possibility of application of such resonant cell with unity filling factor for FMR investigation at room and low temperatures was shown.

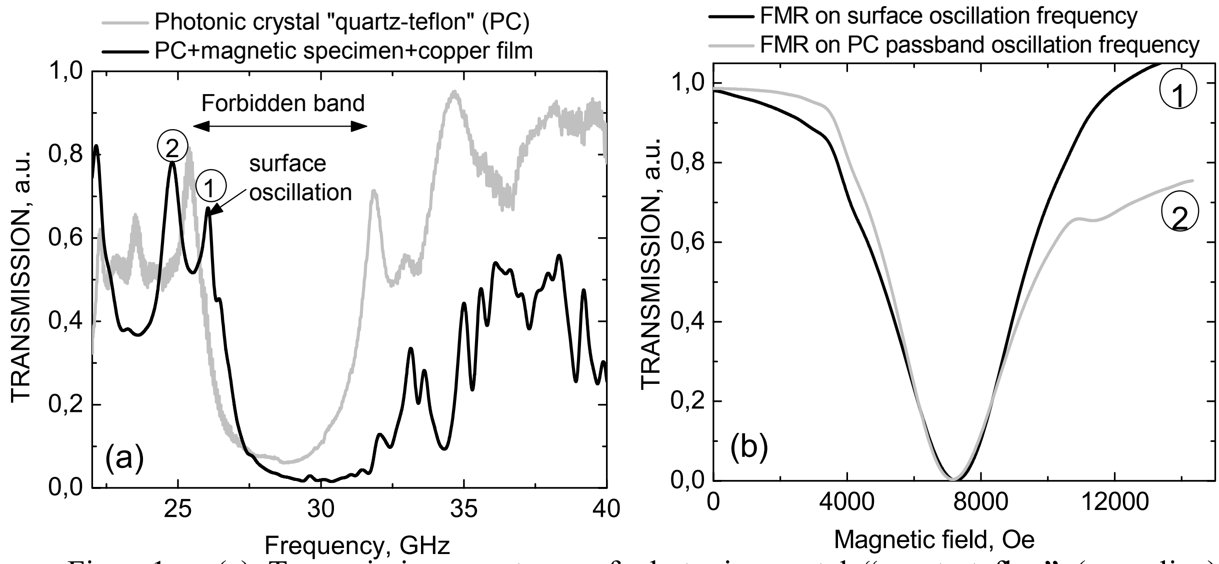

Figure1 – (a) Transmission spectrum of photonic crystal “quartz-teflon” (grey line) and structure PC+ magnetic specimen +copper film(black line); (b) FMR spectrum on surface oscillation frequency (black line) and on the first oscillation frequency of PC passband (grey line).
This work was partially supported by STCU project (№4912)

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LOW FREQUENCY VIBRATIONAL SPECTRUM OF CRYSTAL $KYb(MoO_4)_2$

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Crystal $KYb(MoO_4)_2$ belongs to a family of double alkali-rare earth molybdates with the general formula $KRe(MoO_4)_2$, where Re is a rare-earth metal ion. These compounds have an orthorhombic crystallographic structure (D^{14}_{2h}, z=4) [1]. Their common features are low temperature phase transitions induced by the cooperative Jahn-Teller effect (CJTE) [2, 3]. The compounds have a layered crystalline structure formed by the weakly-bonded K^+-layers and the $Re(MoO_4)_2^-$ layer packets with stronger bond. It induces low-frequency vibrational modes in the excitation spectrum and a strong electron-phonon coupling between the electron excitations of the rare-earth ions and the lattice vibrations, provided that their energies coincide.

To identify the structure of the low-energy vibrational and electron excitation spectrum of $KYb(MoO_4)_2$ we measured the long-wavelength IR transmission. Two absorption bands with the energies 25,3 $см^{-1}$ in the polarization E||c and 16,8 $см^{-1}$ in the polarization E||a were detected. They are interpreted as interlayer vibrational modes. The acoustic and optico-acoustic vibrational branches of the crystal $KYb(MoO_4)_2$ in the Brillouin zone were calculated using a one-dimensional model [4].

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STUDY OF STATISTICS OF PHOTOCOUNTS FOR "SCHRÖDINGER'S CAT" STATES OBTAINED USING NON-IDEAL PHOTODETECTOR

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"Schrödinger's cat" states [1] are supposed to be convenient objects for carrying out quantum computations and implementation of quantum cryptographic systems. Modern quantum optics gives possibility of realizing such states using laser radiation or squeezed states of light. Realization of "cat states" offers the great challenge for their practical applications because they are the states that could be resistant to decoherence in spite of their quantum character.

During studying and application such states of system, a lot of important tasks appear, one of which is detection of created state. The dilemma takes place due to non-ideality of photodetector – on the one hand, any real device hasn't 100% effectiveness; while the experiment is being performed, superposition of states in which the signal under study could be found is destroyed because of detector's non-ideality. On the other hand, the bigger efficiency factor is, the worse statistics of photocounts is derived, distorted by noise measured simultaneous with valid signal. By these reasons study of the influence of photodetector's non-ideality on statistics of photocounts seems to be interesting and topical problem that is necessary for correct interpretation of measurement data.

In this paper statistics of photocounts is analyzed for the "Schrödinger's cat" signal state. It is assumed that measurements are performed using the scheme of balanced homodyne detection with two equal non-ideal detectors. Existing formalism allows carrying out computations of probability distribution of difference photocounts [2] versus different values of efficiency factors of photodetectors. Especially interesting case of phase of coherent state being $\pi/2$ is analyzed in detail. As the result of interference such values of difference events appear in this case that could be obtained with zero probability (considering ideal measurement). If the measurement is non-ideal, statistics of photocounts changes due to destruction of interference of states. Also study of the influence of thermal noise on system was held. It shows spreading of statistics that could make detection of signal state unrealizable.

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КВАНТОВЫЙ КРИПТОГРАФИЧЕСКИЙ ПРОТОКОЛ COW (COHERENT ONE WAY): ДЕТЕКТИРОВАНИЕ КОГЕРЕНТНЫХ КВАНТОВЫХ СОСТОЯНИЙ ПРИ НАЛИЧИИ ШУМА

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На сегодняшний день эффективная защита секретной информации осуществляется не только на математическом уровне, но и физическими методами. В частности, квантовые криптографические протоколы позволяют генерировать ключ, секретность которого обеспечивается квантовыми свойствами носителей информации (в данном случае, квантовыми оптическими сигналами). Одна из последних идей в этой области - протоколы с использованием когерентных состояний, которые позволяют не только обеспечить секретность сообщения, но, и, в перспективе, увеличить емкость информационного канала за счет супераддитивности. С другой стороны, использование когерентных сигналов существенно усложняет процесс считывания информации, особенно с учетом неидеальности детекторов. Таким образом, актуальной задачей является исследование устойчивости и надежности таких протоколов в реальных условиях. В данной работе анализируется недавно предложенный [1] протокол COW, в котором кодирование информации осуществляется на парах когерентных состояний $|0\rangle|\alpha\rangle$ (логический «0») и $|\alpha\rangle|0\rangle$ (логическая «1»). Мы изучаем процесс детектирование таких состояний при наличии шума. Исходя из известного выражения [2] для оператора обобщенного измерения (POWM) получены выражения для вероятности срабатывания фотодетекторов, служащих как для идентификации сигнала, так и для выявления злоумышленника. Вычислена вероятность ошибок, вносимых наличием «приманки» (состояние $|\alpha\rangle|\alpha\rangle$), а также связанных с неидеальностью детектора [3]. Сделана оценка минимального количества кубитов, необходимых для надежной генерации ключа длиной k символов.

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SOME EFFECTS IN THE ULTRASLOW LIGHT PHENOMENON IN BOSE-EINSTEIN CONDENSATES OF ALKALI-METAL ATOMS

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We propose a microscopic approach for a description of processes of interaction of the ideal gas of alkali-metal atoms with a weak electromagnetic radiation. The description is constructed in the framework of the Green-function formalism that is based on a new formulation of the second quantization method in case of the presence of bound states of particles (atoms). For a gas with the Bose-Einstein condensate (BEC) the dependencies of the propagation velocity and damping rate on the microscopic characteristics of the system are studied [1].

On the basis of the proposed approach the influence of the external homogeneous and static magnetic field on the slowing of electromagnetic waves in the condensate is studied. It is shown that the velocity of the pulses can be effectively controlled by the bias field [2].

The approach is generalized on the case on nonzero temperatures. We analyze the influence of the temperature effects on the slowing and absorption parameters of a BEC. It is shown that in the present experimental conditions the group velocity of pulses practically do not depend on the temperature in the region from the absolute zero to the critical temperature. We find the cases when the temperature effects in a BEC can play a significant role.

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LUMINESCENCE-KINETIC ANALYSIS OF RADIATION-INDUCED PROCESSES OF ATOMIC CRYOCRYSTALS STRUCTURE MODIFICATION

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The irradiation of atomic cryocrystals by electrons and photons results in point defect formation (manly Frenkel pairs: vacancy and interstitial atom) induced by excitons and holes self-trapping. The experimental study of subthreshold defect formation processes by methods of low temperature time-resolved analytical VUV-spectroscopy, revealed the microscopic mechanisms of creation of defect states in atomic cryocrystals. Recently on the base of experiments on atomic cryocrystals selective photoexcitation by synchrotron radiation at SUPERLUMI experimental station (at HASYLAB, Hamburg) the kinetic model of low temperature process of Frenkel pair creation induced by electronic excitations has been proposed using the standard chemical kinetics approach [1]. Application of this kinetic model allows to propose the new luminescence-kinetic analytical method of nondestructive inspection of structural condition of the sample; to obtain the experimental evidences of defect phase growth in the crystal; and to propose the analytical description of this process.

At the beginning of selective irradiation by VUV-photons the growth of the intensity of characteristic luminescence bands reflects the accumulation of the stable point defects in the lattice of the crystal, which are formed as a result of excitation and self-trapping of excitons in the consecutive process $E + T \leftrightarrow MTE \rightarrow D$, where E – is the mobile electronic excitation (free exciton), which is trapped at the trapping center T and induces the formation of metastable excited local center MTE [1]. Radiation decay of short-live MTE-center either returns the lattice into the initial state, or creates the stable defect D (Frenkel pair). The kinetics of growth of characteristic luminescence intensity under steady-state conditions of irradiation may be expressed as $I(t) = I_0 + K{\cdot}t{\cdot}(L + t)^{-1}$, where $I_0 = I(0)$ – initial intensity of characteristic luminescence of the sample; K – value of $(I(t) - I_0)$ at $t \rightarrow \infty$; $L \sim n_E n_T (n_{MTE})^{-1}$ – the sample specific constant; n – concentration [1]. Numerical fitting of experimental dose curves for the samples of solid xenon and neon allows to obtain the values of these constants $K_{\mathrm{Xe}} = 1600$ cps, $K_{\mathrm{Ne}} = 600$ cps, $L_{\mathrm{Xe}} = 2.4{\cdot}10^3$ s, $L_{\mathrm{Ne}} = 1.4{\cdot}10^4$ s. After long exposure, when the point defect concentration in the sample, n_D, will exceed the critical value, the exciton self-trapping near existent defects will not stimulate the creation of the new defect, but will induce the aggregation of the existent defects in the process $MTE + D \rightarrow DD$. In this case the fading kinetics of the characteristic luminescence may be expressed as $I(t) = K{\cdot}L'{\cdot}(L' + t)^{-1}$, where $L' \sim n_{MTE} n_D (n_{DD})^{-1}$. Numerical fitting of the dose curves allows to determine the value of this constant $L' = 4.8{\cdot}10^3$ s for the particular case of xenon cryocrystal.

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ПРОЦЕССЫ АВТОЛОКАЛИЗАЦИИ В J-АГРЕГАТАХ КАК СЛЕДСТВИЕ ЭКСИТОН-ФОНОННОГО ВЗАИМОДЕЙСТВИЯ

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J-агрегаты - это кластеры нековалентно связанных люминофоров, организованных в виде линейных замкнутых цепочек. J-агрегаты могут образовываться в результате самоупорядочения молекул красителя в водных растворах или используя различные контролируемые шаблоны, такие как ДНК, РНК, поверхностно-активные вещества.

Процессы электронных возбуждений в J-агрегатах хорошо описаны в экситонной модели Френкеля. На протяжении долгого времени J-агрегаты использовались как хороший объект исследования фундаментальных аспектов динамики экситонных возбуждений в малоразмерных системах, таких как: локализация экситонов, сверхизлучение экситонов, экситонный транспорт, нелинейные свойства экситонов.

Известно, что взаимодействие J-агрегатов цианиновых красителей с различного вида шаблонами приводит к эффекту сильного возрастания квантового выхода люминесценции. Такой эффект объясняется ограничением вращения молекул красителя состоящих в J-агрегате, и как следствие – перекрытие каналов безилучательной релаксации. Несмотря на то, что вращение молекул красителя в J-агрегатах строго запрещено, квантовый выход люминесценции J-агрегатов в водных растворах очень низкий, поскольку в данном случае мы сталкиваемся с эффектом сильного тушения экситонных состояний,

Причины и механизмы потери квантового выхода люминесценции в данном случае на данный момент не раскрыты.

В данной работе впервые показана связь между квантовым выходом люминесценции J-агрегатов и величиной экситон-фононного взаимодействия. Данный феномен был рассмотрен для нескольких видов J-агрегатов цианиновых красителей (PIC, JC-1, L-21). Также было рассмотрено правило Урбаха. Для этого использовались коротковолновые фрагменты спектров поглощения всех видов J-агрегатов, полученных при разных температурах в присутствии и отсутствии шаблона ПАВ. Это позволило получить величину экситон-фононного взаимодействия для J-агрегатов. Наблюдалось аномальное увеличение абсолютного квантового выхода люминесценции (в некоторых случаях больше чем в 20 раз) в присутствии ПАВ. Детальный анализ данных процессов, а также и процессов автолокализации экситонов изучен в данной работе.

ION IMPLANTATION OF B IONS INTO CMT SUBSTRATES AND DETERMINATION OF OPTIMUM OPTICAL CHARACTERISTICS FOR MAKING PHOTODIODE P-N STRUCTURES IN NARROW (-BAND-) GAP SEMICONDUCTOR MATERIAL.

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The successful application of ion implantation is determined primarily capacity to predict and control electrical and mechanical properties of formed elements in the given circumstances implanted. Ion implantation B into CMT was carried out, with different thickness (CdTe / CdHgTe / CdZnTe, CdHgTe / CdZnTe, CdTe / CdHgTe / CdTeZnTe / GaAs). Calculations ion distribution, ionization, recoils and determined maximum concentration B ions. Find the optimal dose and energy of implantation for the creation of p-n transitions in narrow (-band-) gap semiconductors.[1] There were optimal concentrations of ions B in the CMT structure that allows you to create high-quality photodiodes having photosensitivity infrared (3-5 microns) (9-12 microns). B ion implantation into CMT film substrate was made with purpose of investigation of volt-ampere characteristics and defects formation.

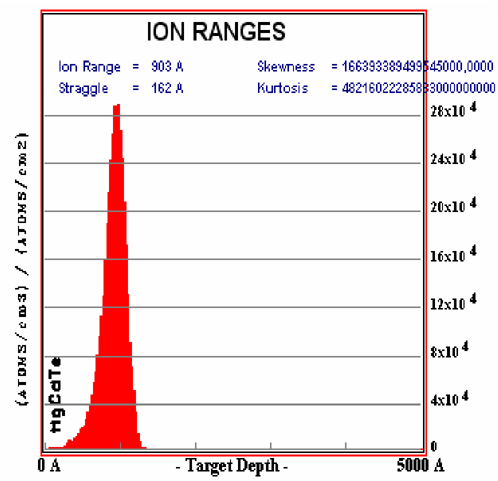

Fig 1 Profiles of distribution of Impurity in structure KRT(1)

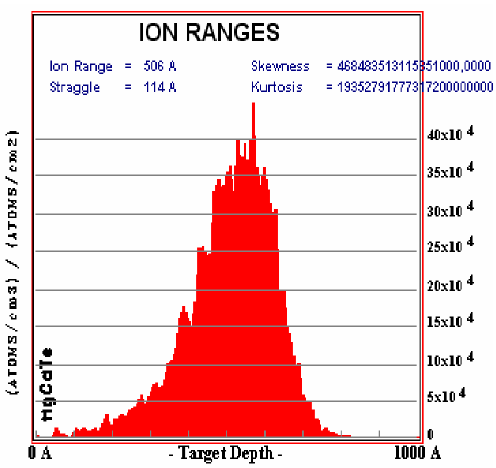

Fig 2 Profiles of distribution of Impurity in structure KRT(2)

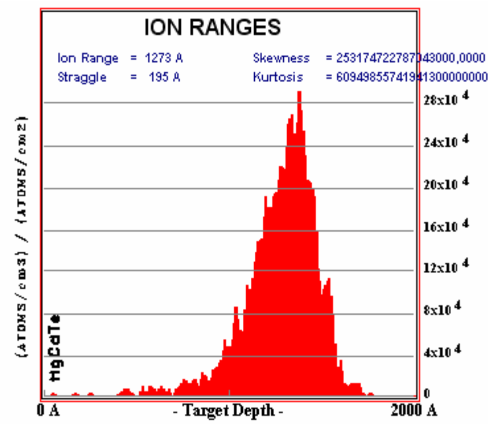

Fig 3 Profiles of distribution of Impurity in structure KRT(3)

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COMPRESSION OF QUADRATICALLY PHASE-MODULATED FEW-CYCLE PULSES IN DISPERSIVE MEDIUM

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Extremely short optical pulses, containing few electromagnetic field oscillations, find increasing application in nonlinear optics, medicine, spectroscopy and diagnostics of ultrafast processes and materials, laser physics (interaction of light with matter), telecommunication systems, and other fields [1]. Pulses containing only three to five field oscillations were experimentally obtained in the near-IR range using parametric generators [2]. Extremely short pulses are obtained using different methods of pulse compression with phase modulation in frequency-dispersive media (fibers, grids, etc.). In nonlinear media, the effect of self-compression is used for pulse compression [3]. Recently, compression of pulses with a spectral supercontinuum has been performed [4]. A significant compression was obtained at parametric amplification of chirp pulses [2, 5–7]. Hollow gas-filled photon fibers [8] have a very high dispersion, which is necessary for effective compression. The theory of picosecond pulse compression has been developed using the method of slowly varying amplitudes (SVA method) in the second-order approximation of the dispersion theory [2, 9]. However, this method is invalid for extremely short femtosecond pulses, because the spectral width of few-cycle pulses is comparable with the width of spectrum. Therefore, the propagation of extremely short pulses is described using either the SVA method with allowance for the higher order (third, fourth, etc.) dispersion [2] or the method of slowly varying profile (SVP method) of the pulse electric field. In this study, we used the SVP method to analyze the limiting compression of a few-cycle pulse with quadratic phase modulation. Complex numerical simulation of the equation for the optical wave electric field was performed with varying the phase-modulation index and the pulse width. More detailed equations are shown in [10].

A theory of compression of a few-cycle pulse with quadratic phase modulation has been developed within the SVP method. The equation for the electric field was numerically solved varying the phase modulation index, number of oscillations, and input pulse width. The optimal modulation index was found, at which a pulse can be compressed to one oscillation period. When the modulation index exceeds the optimal value, the width at the compression point increases. This study was supported by Grant NSh-671.2008.2 of the President of the Russian Federation for Support of Leading Scientific Schools and the Russian Foundation for Basic Research, project nos. 09-02-01028 and 08-02-00717.

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MEASUREMENT OF PERMITTIVITY OF METAMATERIAL BY INVESTIGATION OF BAND STRUCTURE OF PHOTONIC CRYSTAL

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Last time, there are many measurement methods of permittivity of metamaterials (resonator[1], waveguide[2], microstripline methods[3], etc.). In this work the new method of measurement of dielectric metamaterial permittivity, based on investigation of photonic crystal (PC) band structure, was proposed. The comparision of experimental and theoretical band structures (transmission spectra) of PC (material with known constructive parameters / material with unknown constructive parameters) is the essence of the method. The elementary PC cell consisted of quartz/investigated specimen and teflon/investigated specimen layers. The opal matrix with magnetic inclusions $Ni_{0.5}Zn_{0.5}Fe_2O_4$ as investigated metamaterial was used. The transmission spectra through the PC in waveguide were investigated in the frequency range of 22-40 GHz. The PC band structures were calculated by transfer matrix method. The value of metamaterial permittivity $Ni_{0.5}Zn_{0.5}Fe_2O_4$, obtained by this method, is equal to $\varepsilon' = 3 \pm 5\%$.

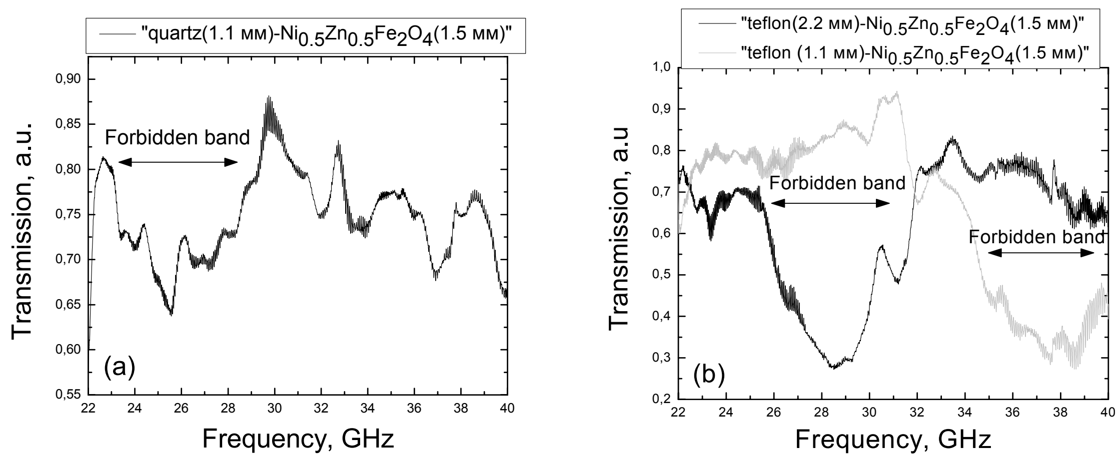

Figure 1 – (a) Experimental transmission spectrum of PC “quartz (1.9 мм)-$Ni_{0.5}Zn_{0.5}Fe_2O_4$(1.5 мм)”; (b) Experimental transmission spectrum of PC “teflon (2.4мм)-$Ni_{0.5}Zn_{0.5}Fe_2O_4$ (1.5мм)” and PC “teflon (1.2мм)-$Ni_{0.5}Zn_{0.5}Fe_2O_4$ (1.5мм)”

This work was partially supported by STCU project (№4912).

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INCREASING OF EHF TRANSPARENCY OF MANGANITE-PEROVSKITE IN NEGATIVE CONSTRUCTIVE PARAMETERS FREQUENCY RANGE

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Last years there is a great interest to investigation of media with left-handed properties – “left-hahded media” (LHM) ($\varepsilon' < 0, \mu' < 0$)[1], in which negative permittivity and permeability is provided by one layer in composite structure [2,3]. In this work it was shown, that one layer of manganite-perovskite can be left-handed medium. The structure of photonic crystal(PC)/manganite-perovskite was investigated. In this structure the surface oscillation, associated with energy concentration on the interface between PC and negative permittivity medium, occurs in the PC forbidden band[4]. The PC consisted of 4 quartz/teflon layers. The manganite-perovskite layer $La_{0.775}Sr_{0.225}MnO_3$ (T_K=370 K) contacted with PC interface quartz layer, Fig.1(a). Transmission spectra through the structure in the waveguide were investigated in EHF range of 22-40 GHz, in magnetic field range of 0-7000 Oe. Increasing of EHF transparency (LHM transmission peak, Fig.1(b)) of manganite-perovskite in negative refraction frequency range was analyzed. The tuning of this frequency range position by magnetic field was shown. The temperature influence on LHM peak intensity, assosiated with manganite magnetization changing, was shown - Fig.1(c). The increasing of surface oscillation peak intensity at coincidence of LHM transmission peak frequency and surface oscillation peak frequency was shown.

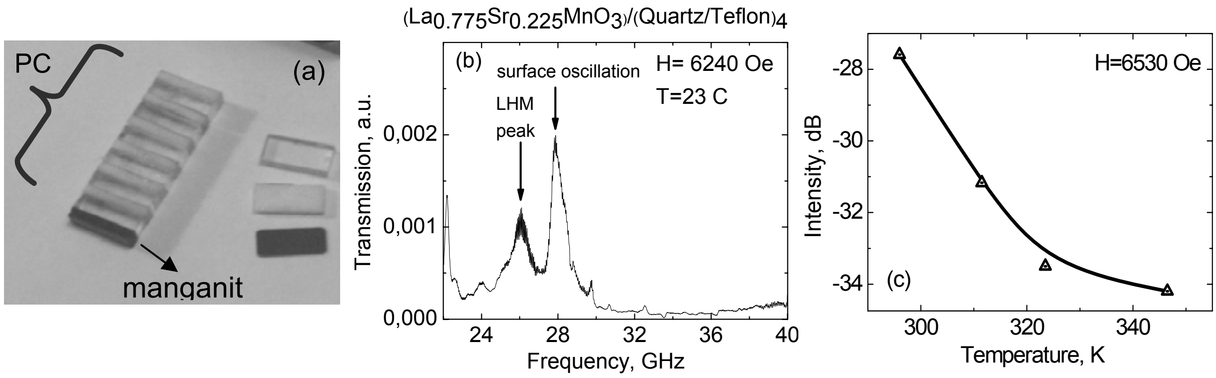

Figure 1 – (a) Photo of investigated structure; (b) Experimental transmission spectrum through the investigated structure at magnetic field H=6240 Oe; (c) Dependence of LHM transmission peak intensity on temperature at H= 6530 Oe

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STUDY SPECTRAL AND ENERGY FEATURES OF THE LAMP OF THE CAPACITIVE DISCHARGE ON VAPOUR OF HEAVY WATER

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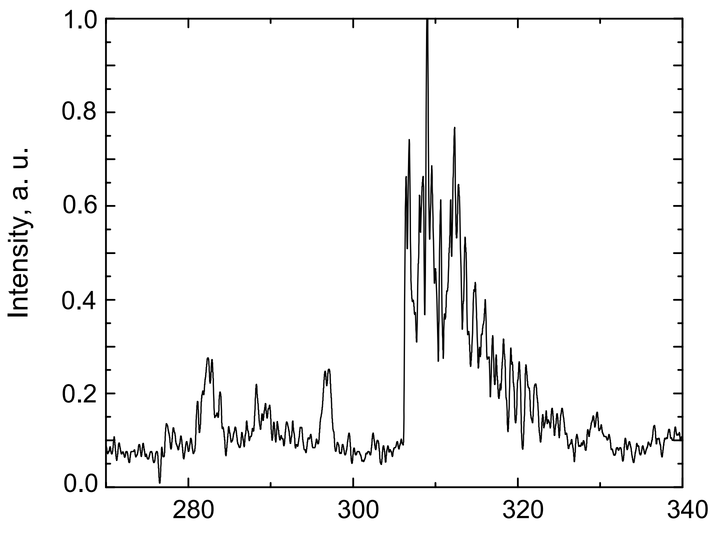
The more intensive study of the sources ultraviolet (UV) of the radiation began in connection with growing of the practical applications. For instance, first ingenious attempts of the using UV radiations of the nitric lazer on wavelength 337.1 nm are undertaken in medicine at treatment varieties of the tubercle bacillus [1]. Bottomed out interest to studies of the sources spontaneous UV radiations on base of the molecules N_2*, *OH** and *OD**, which radiate in given range. To this molecule special interest since worker of the ambience on their base does not contain vapours of the Hg and Cd.

In the result of the experimental study of UV radiation of the spectrum of the lamp on base of the molecules OD^* are presented in this work.

Excitement of the capacitive discharge of the low pressure in lamp - a quartz tube with internal diameter 12 mm, the length 50 cm, distance between cathode and anode 20 cm, was power supplied from a generator with the resonance recharge of a 670 pF capacitor bank switched by a TGI1-2000/35 pulse thyratron, as commutator. Heavy water was found in a offshoot which was in lamp.

For registration of the emission features of the lamp was used monochromator *MS 7504i* of the company *SOLAR TII* with a photomultiplier *PMT R928*. The experiments are made at pressures ~ 1 Torr, frequency of the repetition pulse 5 kHz, a voltage 3 kV, a current 0.09 A, under these condition was a recorded spectrum in the region of 270 – 340 nm (fig.).



For measurement of the average power with point area of the lamp was used meter of the power - IMO-2N.

In UV region of the spectrum of the radiation of the lamp on vapour of the molecules OD^* concentrated mainly in the region of 305 – 325 nm, where radiates a transition $A \rightarrow X$ molecules OD^*, with the mainly by maximum ~ 309 nm, as well as maximum under ~ 306 nm, ~ 312 nm, ~ 297 nm, ~ 282 nm and ~ 288 nm.

Thereby, source spontaneous uf radiations was created on vapour of heavy water with average power of the radiation ~ 43 mW, under enterring power ~ 27 W and efficiency source in UV region of the spectrum ~ 0,16 %. it is created lamp can find using that area, where it is necessary not coherent UV radiation in spectral region 305 – 325 nm, for instance, medicine, photobiology and photochemistry.

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NOTES

The author is responsible for the content of his abstract.