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Invited and Plenary talks

Investigation of the Influence of Neutron Irradiation on the Fault Tolerance of CMOS Microcircuits

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The operation of electronic devices is influenced by both the radiation total dose and the effect of single particles (high energy neutrons and heavy charged particles). First effects are neutralized mainly by technological methods in the electronic device manufacturing. The effect of single particles is associated with the injection of additional charge comparable in magnitude to the semiconductor initial doping level. If fast neutrons and heavy charged particles inject a charge, greater than the critical one, a single event upset occurs. A more detailed examination of this effect shows that there exists a threshold effect on neutron energy.

Keywords: Fault tolerance, single event effects, critical charge, high energy neutrons.

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Surface Channeling for Beams and Radiations Shaping

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As known, electromagnetic fields for beam optics are generated by special devices such as various dipoles, quadrupoles, solenoids, etc., which are characterised by a rather complex design, while solids are typically used as simple collimators, scatterers, and absorbers. However, strong electromagnetic interactions take also place in solids or in the immediate vicinity of a solid surface, sometimes offering high field gradients far beyond our technical capabilities implemented in specialized scientific instruments. Strong fields in solid samples of a certain geometry allow the beams to be manipulated giving them the required characteristics for use in many fundamental and applied research.

Since recently, capillaries or capillary structures of various configurations have been considered as one of the most promising techniques for the formation either particle beams (electrons, protons, ions, muons) or radiations (soft and hard X-rays, thermal neutrons). Capillary X-ray and neutron optics has grown from a beautiful idea into a widely used control tool, while capillary beam optics till now remains on a stage of intense investigations. The gap in the use of capillary structures for controlling beams and radiations can be explained by the complexity of the phenomena to be evaluated in the case of interaction of charged beams at the interface, in comparison with the phenomena for radiations.

In the early 1980s the use of curved reflecting surfaces as an alternative method to shape ion beams was discussed in several experimental works with theoretical estimates based on the physics of charged particle channeling in crystals. The interaction of an incident ion with a reflecting surface was described in the approximation of a continuous surface atomic potential, confirming very small angles of ion reflection from a smooth surface regardless of the change in the beam charge characteristics. In order to increase the angles of deflection of the beams, to use curved surfaces, in particular, dielectric capillaries, was proposed. This was the origin for the undoubted interest in the development of capillary optics for particle beams that gives rise to a wide range of experimental work devoted to new phenomenon, with disproportionately less activity in theoretical studies mainly based on Monte Carlo simulations.

Our recent detailed analytical analysis has provided insight into the physics of a charged beam motion into capillaries (see in S.B. Dabagov, A.V. Dik, on channeling of charged particles in a single dielectric capillary (2021) arXiv: 2109.03524 [physics.acc-ph]). The effective potential for interaction of a charged particle with the inner surface of a capillary is derived as a sum of the averaged atomic potential of the capillary wall surface and the induced potential defined by collective surface excitations. We have shown that under certain conditions this potential becomes attractive and may hold a particle in a bound state due to the surface excitations that defines a so-called ”surface channeling” regime of motion. For the first time we have evaluated the induced potential revealing two limits to form either a well or a barrier that are delineated by the ratio of the insulator plasmon frequency to the frequency defined by the particle motion in a capillary.

My talk will be dedicated to a newly proposed and developed general theory for capillary guiding of charged beams. This phenomenology, already applied to X-ray and thermal neutron beams, is based on main principles of channeling theory in capillary structure and allows predicting very fine features in both spatial and angular distributions of charged-particle beams.

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Fourth Generation Light Source Project Skif. General Review

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X-ray research methods with using of the synchrotron radiation are the very powerful and popular scientific instruments actively applied in many modern research fields. Most bright fourth generation or diffraction limited light sources provide extraordinary breakthrough in X-ray research applications, thus many projects for such type sources are under development now in the different countries.

At the 2018, the government of the Russian Federation approved the project of the Siberian Circular Photon Source (SKIF). At present, the project is under intensive development. In the case of successful realization of the project, SKIF can became a brightest X-ray source in the world for some period.

The report describes the main parameters of the light source, common configuration of the accelerator complex, the lattice structure of the main ring, and experimental beamlines of the first phase of project.

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Emission of Surface Polaritons by Relativistic Particles

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It is well known that the medium may essentially influence the characteristics of the radiation from a charge particle. The interaction with medium gives rise to new types of radiation phenomena, such as, Cherenkov, transition and diffraction radiations. In a series of papers, started in [1], we have investigated the Cherenkov and synchrotron radiations from a charge moving along circular or helical trajectories around a dielectric cylinder (see references given in [2]) immersed in a homogeneous medium. It has been shown that the under the Cherenkov condition for the material of the cylinder and the velocity of the particle image on the cylinder surface, strong narrow peaks appear in the angular distribution of the radiation intensity in the exterior medium. At those peaks the radiated energy exceeds the corresponding quantity in the case of a homogeneous medium (when the cylinder is absent) by several orders of magnitude. We have also investigated the radiation propagating inside the cylinder (radiation on the guiding modes of dielectric waveguide).

Under certain conditions on the dielectric permittivities of the cylinder and surrounding medium, a charge particle may emit another type of radiation corresponding to surface polaritons, located near the surface of the cylinder. This type of radiation is present in the spectral range where the dielectric permittivities of the cylinder and surrounding medium have opposite signs. We study the spectral distribution of the radiation intensity for two cases of the charge motion [3,4]: charge rotating around a cylinder and charged particle moving outside a cylinder parallel to its axis. For the evaluation of the radiation fields the electromagnetic Green tensor is used. It is shown that the corresponding waves are radiated on the eigenmodes of the dielectric cylinder. The number of radiated quanta for surface polaritons of a given harmonic can be essentially larger than that for guiding modes of the cylinder. The intensities of Cherenkov and synchrotron radiations in the exterior medium are discussed as well.

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Radiation of Twisted Photons by Charged Particles

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Currently, the twisted photons of different spectral ranges are used in fundamental science and technology [1]. In the optical range and below, the detectors are designed allowing to decompose an arbitrary electromagnetic radiation into twisted photons [2]. The hard twisted photons in the MeV range and higher are not directly observable. However, they can be employed to study the properties of nuclear matter by exciting higher multipole transitions in nuclei and hadrons (see the discussion in [3,4]). Rather recently, it was shown that hard twisted photons can be generated in channeling radiation [5] and strong laser pulses [3,6].

In the present report I will review the properties and the ways of generation of twisted photons by charged particles. The direct generation of twisted photons by charged particles provides bright sources of them and is a unique means for generation of hard twisted photons. In particular, the generation of hard twisted photons in undulators [7], in nonlinear Compton process [8], and in transition and Vavilov-Cherenkov radiations in various media [9-11] will be discussed.

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Angular Distribution of High Power Radiation from a Chain of Charged Particles Rotating Around a Dielectric Ball

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We investigate the angular distribution of the radiation from a chain of relativistic charged particles uniformly rotating along an equatorial orbit around a dielectric ball. For a certain frequency of the chain rotation and in case of weak absorption in the ball material, the radiation intensity is essentially higher than the corresponding quantity for a chain rotating in the vacuum or in a transparent medium having the same permittivity as the real part of that for the ball material. The conditions are specified on the parameters of the problem under which the charges in the chain radiate coherently and the radiation intensity on a given harmonic increases as N^2 with increasing number N of the charges in the chain.

The numerical results are presented for balls made of different dielectrics and for the radiation in the gigahertz and terahertz frequency ranges. We show that the high power radiation from a chain propagates in the angular range determined by the Cherenkov condition for the velocity of the chain projection on the ball surface. This indicates that the amplification of the radiation intensity is closely related to the Cherenkov radiation generated by the chain in the ball material.

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Generation and Application of Femtosecond X-ray Pulses on a Terawatt Laser System

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For time-resolved studies of a non-stationary state of matter X-ray pulses of femo- and atto-second duration are requested. Such pulses can be obtained by converting a high-power laser radiation; the part laser radiation can simultaneously create a non-stationary, extreme state of matter. This enables pump-probe X-ray study with fs temporal resolution. Using a 200 TW laser system, we are developing several approaches for femto- and picosecond X-ray studies at the Laser-Synchrotron Complex at the NRC "Kurchatov Institute". The first approach is the generation of laser-plasma induced characteristic X-ray radiation. With high enough intensity of laser radiation, K-alpha photons (6-8 keV depending on the metal) are generated on the metal surface, with a duration of 50-500 fs, determined by the laser pulse and the target thickness. By optimizing the energy and duration of the laser pulse, the focusing geometry, the pressure of the surrounding gas, we obtain sufficient brightness of this type of X-ray radiation for diffractometry. For pump-probe experiments, X-rays are refocused onto the sample with a specialy developed polycapillary lens. However, such X-ray radiation is non-directional and incoherent. The second approach makes it possible to obtain directional and coherent soft X-ray radiation of significantly shorter duration. The approach is based on the generation of a train of high optical harmonics from a laser pulse of relativistic intensity in a gas jet or upon ablation of the target surface. After spectral filtering, such pulses can reach attosecond duration. In this case, the spectrum extends from the visible range to hundreds of Ev. In the third approach the laser oscillator is carefully synchronized to the repetition rate of synchrotron bunches, amplified laser pulses give a giant energy input into the sample under study, the induced changes in the structure are observed by diffraction of synchrotron, bright and collimated probe radiation, with a time resolution of 100 ps. The delay between laser and synchrotron pulses is scanned.

In this work, experimental results on laser-plasma X-rays from giga- and tera-watt femtosecond laser pulses are compared with the prospects of the high harmonics and synchrotron methods being developed. This work was partially supported by the Russian Foundation for Basic Research 20-21-00140 and 18-02-40032

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Session A

e^-/e^+ beams interaction in solids

- Gharibian (X–ray) and optical transition radiations, Cherenkov radiation, parametric X–ray radiation in media in presence of various origin external fields.

- Electron–positron pair creation in crystals in the presence the acoustic fields.

- Diffraction radiation and Smith–Purcell effect under the external influences.

- Bremsstrahlung, coherent bremsstrahlung and channeling radiation in periodic superlattice media.

- Orientational effects in crystals.

Half-Wavelength-Crystal Channeling of Relativistic Ions and Its Possible Application

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In a half-wavelength crystal (HWC) a channeling particle experiences "mirroring" (HWC channeling) due to only one collision with a crystallographic plane. The HWC channeling was observed for 400 GeV protons at CERN-SPS [1] and for 255-MeV electrons at the SAGA-LS Facility [2, 3]. Compared to protons and electrons, in the case of Relativistic Heavy Ions (RHI), there appear two additional parameters: ion charge Ze and mass number A. The channeling critical angle becomes sensitive to $(Z/A)^{1/2}$. The computer simulations of HWC channeling of low-Z isotopes [4] revealed the remarkable isotopic effect. Here, we present the results of computer simulations of HWC channeling of high-Z RHI (^{129}Xe, ^{208}Pb, ^{238}U) with almost the same values of $(Z/A)^{1/2}$ in Si, Ge and W crystals, using the computer code BCM-2.0 [5]. The assembly of N sequentially placed and rotated by the critical channeling angle HWC increases almost N times the deflection angle. The similar system of several bent and straight (but not HWC) crystals for deflection of a 1.3 GeV proton beam was recently studied in [6].

The applications of HWC channeling for RHI beam deflection and focusing on the downstream target are discussed, in view of atomic physics experiments with RHIbeams planned for Super-FRS Experiment Collaboration [7].

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Transition Radiation from a Dirac Particle Wave Packet

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Transition radiation from beams of charged particles is well studied theoretically and experimentally [1,2]. The quantum theory of transition radiation was also studied [1]. However, the effects caused by non-trivial wave packet profile usually were not taken into account or were considered in the framework classical theory of radiation with classical currents [3,4].

To focus on the main peculiarities of transition radiation from wave packets, we investigated the simplest model of transition radiation, when the wave packet traverses an ideally conducting plate. This model is applicable for good conductors in the infrared and optic spectrum range [2]. We obtained the explicit formula for the inclusive probability of transition radiation from the wave packet of a Dirac particle with anomalous magnetic moment.

We found that in contrast to the classical formula for transition radiation there are radiated photons possessing a linear polarization orthogonal to the reaction plane. This feature facilitates the observation of such an effect in experiments.

In case the when particle's wave packet has the form of N Gaussians, the coherent amplification of probability of transition radiation can be achieved when these Gaussians constitute a regular lattice. As opposed to the classical coherent radiation, there are not harmonics in energy of radiated photons [5].

Inasmuch as transition radiation from twisted particles was already discussed in the literature, e.g., in [3,4], we compared in detail the method developed in the present paper with the method used in [3,4]. The results of our study confirm the viewpoint existing in the literature [5-7] that the inclusive probability of radiation from a one-particle wave packet with nontrivial structure cannot be obtained with the aid of the classical approach even in the case of negligible quantum recoil.

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Parametric X-ray Radiation of Relativistic Electrons in Nanopowder Targets

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In this article presents the continuation of research of parametric X-ray radiation (PXR) of relativistic electrons in powder targets. For the first time PXR in powder targets has been studied in works [1,2], but for this studie was chosen a tungsten powder constituted by crystallites which average size is approximately 1 micrometer. In this work presents the continuation of research of parametric X-ray radiation (PXR) that generated in the powder targets constituted by crystallites which size is less than a 100 nm.

The 7 MeV microtron was used as a source of relativistic electrons. Targets were made of platinum powder, powder of magnesium oxide, and nickel. PXR spectra were obtained under observation angels 150 and 180 regarding the velocity of electrons. The target surface was oriented perpendicular to the beam axis. PXR in energy region between 2 and 8 keV was obtained during this experiment. The results were compared whis the PXR kinematical theory.

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Turning of 10 keV energy electron beam at 360 ° by means of PVC tubes

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Time dependence of the passage of an electron beam with an energy of 10 keV and a beam current of about 1.8 μA through PVC tubes bent into rings at 360 ° was measured.

Tubes with the following parameters were investigated: first — inner tube diameter 2.8 mm, the ring diameter 75 mm; the second is an inner tube diameter of 4 mm, the ring diameter of 150 mm. In both cases, the current of the transmitted electrons was recorded, amounting to about 15% of the current value of the beam incident into the tube. Measurement of the electron spectrum for the ring with a smaller diameter showed that all electrons passed through lose their initial energy.

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Transition Radiation on Acoustic Superlattices

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The transition radiation is among the most interesting types of electromagnetic radiation emitted by a relativistic charged particle interacting with an inhomogeneous medium. Because of its remarkable properties, the transition radiation has found a number of important applications. In particular, optical and extreme ultraviolet backward transition radiation was used for the measurement of transverse size, divergence, and energy of electron and proton beams. It is well known that the interference effects in periodic structures considerably increase the transition radiation intensity. In this talk we present the results of investigations of the transition radiation on an ultrasonic superlattice, excited in a plate of finite thickness. First we consider the radiation from a point charge and then the coherent effects in the radiation from a bunch of particles are described. It is shown that the acoustic waves generate new resonance peaks in the spectral and angular distributions. The heights and the location of the peaks can be controlled by choosing the parameters of the acoustic wave. The numerical examples are given for a plate of fused quartz. We also discuss the features of the transition radiation on a superlattice generated by two acoustic waves.

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Orbital Angular Momentum of Radiation from Relativistic Planar Channeled in Si Crystal Electrons

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The study of the orbital angular momentum (OAM) of electromagnetic radiation is an active field of research both theoretical and experimental. Various schemes of production of the photons carrying OAM (i.e., twisted photons) in undulators [1-4] and free electron lasers [5] have been proposed. High energy twisted photons can also be produced by channeled particles [6, 7].

Channeling radiation of plane-wave photons is well studied and finds various applications. This radiation allows generating the photons in MeV spectral range. There are many theoretical and experimental works devoted to the problem of obtaining the maximum yield of this radiation in thick crystals. Planar channeling radiation has several advantages over other types of radiation such as the narrow spectrum and focus. In our previous the work [6] we calculated OAM per one photon generated by planar and axial channeled electrons depending on the angle of incidence of the electrons on the crystal. The goal of this work is to describe planar chanelling radiation from electrons in terms of twisted photons and to find their energy spectrum, the dependence on the projection of the total angular momentum *m* and on the radiation angle.

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On the Features of Radiation from a Charge Rotating Around a Dielectric Ball

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Due to the unique properties such as the high intensity, wide spectral range and high degree of collimation, synchrotron radiation (SR) serves as an extraordinary research tool for advanced studies in both the fundamental and applied sciences. The wide applications of SR motivate the investigations of various mechanisms for the control of the spectral and angular characteristics. By taking into account that the characteristics of high-energy electromagnetic processes can be essentially changed in the presence of matter, it is of interest to study the influence of media on the properties of SR. Already in the case of a homogeneous medium the interplay of SR and Cherenkov radiation leads to remarkable effects. Additional possibilities for the control of SR parameters appear in inhomogeneous media. In particular, the interfaces separating two media with different electromagnetic properties can be used to control the radiation flow.

In the present talk we study the angular distribution of the radiation from a relativistic charged particle uniformly rotating along an equatorial orbit around a dielectric ball. Under the Cherenkov condition for the material of ball and for the velocity of particle, the number of the radiated quanta may exceed the corresponding value for the radiation in a homogeneous and transparent medium by several dozens of times. For some values of the problem parameters and in the case of weak absorption in the ball material, the radiation intensity on a given harmonic can be essentially larger than that for the same charge rotating in the vacuum or in a homogeneous transparent medium having the same real part of dielectric permittivity as the ball material. The generation of such high power radiation is a consequence of the constructive superposition of electromagnetic oscillations of Cherenkov radiation induced near the trajectory of the particle and partially locked inside the ball. The angular distribution of the number of the emitted quanta is investigated for such high power radiation. It is shown that the radiation is mainly located in the angular range near the rotation plane determined by the Cherenkov condition for the velocity of the charge projection on the ball surface. The numerical results are presented for the radiation in the gigahertz and terahertz frequency ranges.

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Transmission of the Non-Coherent Radiation through an Arbitrary One Dimensional Layered Structure

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In this work consider the wave radiation transmission through the one dimensional structure consisting on a finite number of arbitrary layers. For determination of the transmission and reflection coefficients T_N and R_N one should the following set of finite equations:

$$T_N = \frac{T_{N-1}t_N}{1-R_{N-1}r_N},\ R_N = R_{N-1} + \frac{T_{N-1}^2 r_N}{1-R_{N-1}r_N}, \tag{1}$$

where t_N and r_N are the transmission and reflection coefficients of the n-th layer of the structure. This set of equations should be considered in accordance with the following initial conditions:

$$T_0 = 1,\ R_0 = 0. \tag{2}$$

The in general case the problem (1), (2) can be solved numerically only. However in the case of an ideal structure, when all the layers are identical, i.e. for an arbitrary $j\,(j = 1,2,\cdots,N)$

$$t_j = t \text{ and } r_j = r. \tag{3}$$

It is easy to check that when $t_N + r_N = 1$ and $T_{N-1} + R_{N-1} = 1$, then

$$T_N + R_N = 1. \tag{4}$$

This equation corresponds to the flax conversation low.

By introducing the quantities

$$Q_N = 1/T_N,\ P_N = R_N/T_N\ \ (Q_N - P_N = 1) \tag{5}$$

the set of Eqs. (1) can be presents in the linear form:

$$Q_N = \frac{1}{t_N}Q_{N-1} - \frac{r_N}{t_N}P_{N-1},\ \ P_N = \frac{r_N}{t_N} + P_{N-1}, \tag{6}$$

wish intitial condition $R_0 = 1,\ Q_0 = 0$. For an ideal structure (see (3)) one can get:

$$T_N = \frac{t}{t+Nr},\ R_N = \frac{Nr}{t+Nr}. \tag{7}$$

As it seen from the last result when $N \to \infty$, then $T_N \to 0$ and $R_N \to 1$.

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Multi-frequency Asymmetric System of Artificial Lung Ventilation

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We investigated the possibility of developing a new method of ventilation of the lungs, the main features of which are: a) control of the duration of the processes of inhalation and exhalation in a wide range and b) combination of the natural frequency of the respiratory process with high-frequency vibrations of the inhaled and exhaled air.

Experimental studies have shown that high-frequency harmonic, or nonharmonic air vibrations can significantly increase the likelihood of granulation and sputum separation from the walls of the airways and alveoli, as well as create additional aerodynamic forces that can increase the efficiency of removing sputum and foreign bodies with exhaled air.

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Numerical Investigation of Flow Field about Various Bodies in Supersonic Flight

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The characteristics of the flow field around various bodies moving at supersonic speed was investigated by numerical simulation. Preliminary results show, that the characteristics of shock waves and vortex generated by the motion of a supersonic object depend on the speed and acceleration of the object and the characteristics of media. In particular, at certain values of the above parameters, vortex streams with different characteristic frequencies arise simultaneously. The obtained results compared with known experimental data. A similar results are observed during the propagation of shock waves by anti-hail acoustic guns.

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Features of Electromagnetic Field, Generated by Charged Particle, Passing Through the Center of a Conductive or Dielectric Ball

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The features of electromagnetic field generated from a rectilinearly and uniformly moving charged particle is investigated assuming that the particle crosses a conductive or dielectric ball passing through its center. The obtained numerical results are based on the corresponding exact solutions of Maxwell equations. The properties of electromagnetic field in various distances from the ball is studied. A visual explanation of obtained results is given.

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Session B

e^-/e^+ beams interaction in strong external electromagnetic fields

- Advanced accelerator and coherent radiation sources (FEL, XFEL, novel accelerator concepts)
- Quantum radiation es champen qonna
- under the external influences
- Interaction of particle beams with artificial structures (acoustic superlattices, metamaterials, etc.)
- Time–spatial control of working parameters of plasma by acoustic fields
- Ion implantation under the acoustic influences

High-Harmonic Generation as a Probe for Electron Dynamics in Strong-Field Laser -- Solid-Plasma Interactions

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Progress in the creation of ultra-high-power laser systems capable of generating optical pulses of tera- and petawat power made it possible to use them to accelerate electrons to relativistic velocities, and opened the possibility of transferring approaches and research, previously achievable only with the help of large accelerators and synchrotrons, to a laboratory of a more modest size. We present the results of a study of the relativistic dynamics of plasma electrons near the surface of a solid target formed by focusing high-power femtosecond pulses in the mid-IR range using nonlinear optical methods. A comprehensive study of the supercontinuum generated under the given conditions, its spatial and temporal properties, development of methods for controlling the parameters of ultrashort pulses has been carried out. Various modes of generation of high optical harmonics are investigated, physical factors that increase the efficiency of nonlinear optical processes in this wavelength range are studied. It is shown that the relativistic nonlinear electrodynamics of a laser plasma is described by a coupled state of light and matter, in which attosecond relativistic electron bunches ejected from a plasma mirror under the action of laser radiation are tied to attosecond oscillations of the optical field emitted as part of the relativistic laser-plasma interaction. The experimental study was carried out on a unique source of ultrashort mid-IR pulses based on multi-stage optical parametric amplification. The peak power values achieved so far are record highs for mid-IR femtosecond pulses. It is planned to continue an experimental study of the generation of high harmonics in the field of laser pulses in the near-IR range at the subpetawate laser-synchrotron complex of the Kurchatov Institute.

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Soft X-ray Metrology Synchrotron Radiation Station "Cosmos". Current Status and Development Prospects

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Metrology SR station "Cosmos" is functioning in the Siberian Centre of Synchrotron Radiation and uses radiation from the bend magnet of the VEPP-4 storage ring. The station is intended for a wide range of experiments in the VUV and soft X-ray region (10 eV - 8000 eV). To provide such a wide spectral range, we use several different monochromatization systems using planar gratings, multi-layer mirrors and Bragg crystals. The station implements not only metrological measurements, but also testing of various kinds of X-ray equipment, soft X-ray XAFS experiments and other works. It is expected that this year the capabilities of the Cosmos station will be supplemented by a soft X-ray fluorescence spectrometer. The station's basic parameters are presented, description of its configuration and systems of monochromatization and reference detectors are given. The prospects of applying the accumulated work experience for the development of new stations for the 4th generation SR source SKIF will also be considered.

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The Synchrotron Radiation Technological Station as a Base for Training of Scientific Staff for New Synchrotron Radiation Sources

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A unique project is under way in Novosibirsk state to create a scientific facility. The so-called "SKIF" (4+ generation Syberian Ring Photon Source) will be a shared-use mega-science centre. A major challenge for this project represents to develop the human resources that will realize the investigative capacity from a ultra-small emmitance source of synchrotron radiation. There is an opportunity to establish up to 30 experimental stations on storage ring of "SKIF" thanks to its magnetic structure. That is why we have to form highly professional groups with wide competence in the creation and operation of the facility. Practical training of specialists is already under way using experimental stations of VEPP-3 and VEPP-4 storage rings located in the Budker Institute of Nuclear Physics Siberian Branch of the Russian Academy of Sciences. It should be stressed that the two facilities operate in different modes and synchrotron radiation experiments represent only 25 percent of the facility's total operating time. As a result, we have limited capacity to educate people.

A special synchrotron radiation technological station was established at the first beamline of VEPP-4 storage ring. Its purpose is to train university students in synchrotron research techniques and equipment testing. Novosibirsk universitys students participate in the establishment and development of this station and its techniques. The modular concept of the station allows its gradual introduction and implementation of various methods. This article describes the design, radiation properties, automatic control system and first experiments in X-ray fluorescence analysis.

The work was done at the shared research center SSTRC on the basis of the VEPP-4 - VEPP-2000 complex at BINP SB RAS.

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The Wave Field of a System of Point Sources in the Fraunhofer Picture

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In the present paper we consider the conditions, when the wave field of a system of point sources which generate spherical waves can be consider in the Fraunhofer picture;

$$U(\vec{R},t)=\sum_{j=1}^{N}\frac{A_0}{R_j}\cos\left(\omega t-kR_j\right), \tag{1}$$

where $R_j=\left|\vec{R}-\vec{d}_j\right|$ and $\vec{R}\equiv(x,y,R_0+\Delta z)$ is the radius vector of the observation point and $\vec{d}_j\equiv(d_x^j,d_y^j,d_z^j)$ corresponds to the position of j-th source. Note that $L=\left|R_0\right|$ is the average observation distance. The quantities ω and k are the frequency and the wave vector of the superposition field.

When the following conditions take place;

$$|x|,|y|,|\Delta z|<<L\,,\quad \left|d_x^j\right|,\left|d_y^j\right|,\left|d_z^j\right|<<L$$

and

$$\sqrt{\frac{k}{2\pi L}}|x|,\ \sqrt{\frac{k}{2\pi L}}|y|,\ \sqrt{\frac{k}{2\pi L}}\left|d_x^j\right|,\sqrt{\frac{k}{2\pi L}}\left|d_y^j\right|<<1,$$

then in the Fraunhofer picture in (1) one can use:

$$\frac{A_0}{R_j}=\frac{A_0}{L}\ ,\quad R_j=L+\frac{1}{2}\frac{x^2+y^2+(d_x^j)^2+(d_y^j)^2-2(xd_x^j+yd_y^j)}{L}\ . \tag{2}$$

The obtained result allows an easily reproduction of many well-known results of diffraction theory and conduct the wave field consideration for any configuration of disposition of the sources.

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Aeroionizers for Prevention of Viral Diseases

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The use of air ionizers with negative air ions for the prevention of viral infections is considered. Several types of air ionizers have been manufactured for offices and individual use. Their technical characteristics are given. Methods and testing equipment are described that differ from the generally accepted ones. Air ionizers give at the output 10^{10}-10^{11} negative air ions / sec, which ensures a normal air ion environment in the office when the ionizer is operating for several hours a day. The speed of propagation of the ionization wave in the room was measured.

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Generation of Radiation on Forbidden Transitions in Laboratory Acoustoplasma

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Usually, radiation on forbidden lines of hydrogen, oxygen and nitrogen is observed only in cosmic plasma in nebulae; it is believed that it is impossible to obtain emission radiation on forbidden transitions under laboratory conditions. The experimentally obtained generation of a strong nitrogen line at the forbidden transitions at 654.81 nm and 658.36 nm is presented. The results were obtained both in pure nitrogen low-pressure acoustoplasma and in a CO_2: N_2: He = 1: 1: 8 mixture. The results obtained are explained by the acoustoplasma state of the discharge, which removes some of the quantum-mechanical prohibitions.

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Radiation of Twisted Photons in Cholesterics

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Transition radiation of relativistic particles in periodic dispersive media is a well studied subject both theoretically and experimentally [1,2]. It was proved in the recent paper [3] that the media possessing a helical symmetry can be used for generation of twisted photons [4,5]. Namely, the radiation of charged particles traversing such media along the axis of the helical symmetry is a pure source of twisted photons. In the present paper, we investigate a particular case of such a medum – a cholesteric liquid crystal (CLC) – and show by explicit calculations that the charged particle crossing the CLC layer creates the photons with definite projection of the angular momentum at a given harmonic. The radiation of twisted photons by charged particles traversing a cholesteric plate is studied in the framework of quantum electrodynamics in an anisotropic inhomogeneous dispersive medium. The complete set of solutions to the Maxwell equations in the cholesteric plate is constructed in the paraxial and small anisotropy approximations. The explicit expressions for the average numbers of plane-wave and twisted photons created by a charged point particle crossing the cholesteric plate are derived. The selection rules for the twisted photons radiated at the harmonic $n \in Z$ are established. In the paraxial regime, the projection of the orbital angular momentum of radiated twisted photon obeys the selection rule $l = \pm(2n + 1)$. In the approximation of small anisotropy of the permittivity tensor, the selection rule becomes $m = \pm 2n$, where m is the projection of the total angular momentum of a radiated twisted photon. The radiation of optical twisted photons by electrons with the Lorentz factors $\gamma = 235$ and $\gamma = 500$ and by uranium nuclei with $\gamma = 2$ are considered. It is shown that charged particles traversing normally a cholesteric plate can be used as a pure source of twisted photons. *The work is supported by the RFBR grant 20-32-70023.*

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Lines of Electrical Field of a Charge Moving in Linearly Polarized Wave

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The paper presents solutions of the equations of electric field lines for a charge moving in a flat monochromatic linearly polarized wave. It is shown that the equations of electric field lines in this case are reduced to homogeneous, linear differential equations with constant coefficients. Corresponding illustrations both in the orbital plane and outside it is presented.

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Research, Development and Creation of A High-Precision Laser Rangefinder

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The capabilities of modern high-precision linear measurements allow them to be used in different areas of science and technology, including when observing the movements of the Earth's crust, thereby also for the study of earthquakes. The sizes of these displacements of the earth's crust, which should be measured to study the precursors of earthquakes, as is known, are very small, and as different studies show, can amount to only a few units of the seventh decimal place per year from the magnitude of the measured distance.

Basically, interferometers are used in high-precision linear measurements in order to study the movements of the earth's crust to assess its deformations. Recently precision optical rangefinders, such as Mekometer ME-5000 and ME-3000, with an accuracy range of 0,3-0,5 mm, are successfully used in such works. For example, in the seismically active region Zollernalb of the western Germany, the staff of the University Karlsruhe carried out monitoring to study the deformations of the earth's crust by using of specified optical rangefinders. In the Russian Federation the ME-5000 was also used to study deformations on the Lappish break. These works specify the wide opportunity of application of high-precision optical range finders in monitoring in seismically active regions for an estimation of deformations of an earth's crust, as well as the need and urgency to increase the accuracy of these linear measurements.

Currently, the Institute of Applied Problems of Physics of the National Academy of Sciences of the Republic of Armenia (IAPP NAS RA) is conducting research on the creation of high-precision laser rangefinders, the phase error of which is determined by hundredths of a millimeter.

In order to improve the accuracy of measurements of laser rangefinders, we have made the transition to the two-phase method of the modulation, which is the main one for high-precision linear measurements. We formed biphasic signals by an optical path, by introducing a phase plate at $\lambda/2$, by rotating of which two signals shifted in the receiving path of the rangefinder relative to each other by 180°, and the position of the equality of the amplitudes of these signals is fixed during the measurements. The error in determining the phase of the upgraded high-precision rangefinder is in the range of m_φ = 0.03-0.05 mm.

Such high-precision optical rangefinders can be used in charged particle accelerators for high-precision linear measurements and determination of deformations, during the installation and adjustment of optical and radio telescopes, when creating of large machines and aggregates, in hydraulic structures for determining deformations of the installation of aggregates, etc. Such rangefinders can also successfully serve as an intermediate link in the transmission of a unit of length from the standard to the working linear measuring instruments.

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Quantum Computation.

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The general formulation of the classical and quantum searching problems is regarded. **Classical searching problem.** There are unsorted database containing N items and of which just one item satisfies a given condition-that one item has to be retrieved. Once an item is examined, it is possible to tell whether it satisfies the condition in one-step. The most efficient classical algorithm is to examine the items in database one by one.

Solution: We need to examine $\frac{N}{2}$ items before finding the desired item.

Quantum mechanical searching problem. QM postulate:The only possible results of a measurement are eigenvalues of the corresponding Hermitian operator.We are looking for an "item" χ - the wave function with a "given properties": We have to define the Hermitian operator **P**, wich measuares that property of the wave functions:

$$\boldsymbol{P}\chi = 1 \cdot \chi$$

$$\boldsymbol{P}\psi = 0 \cdot \psi \qquad \text{for } \psi \neq \chi$$

The quantum mechanical search problem: Identify the state X (using unitary transformations that is time evolution of the system).

Analogy: $|keys\ \rangle$…….. Door

$|wave\ function\rangle$…… Operator $\boldsymbol{P}$

By QM searching the number of iterations needed is $\frac{\pi}{4}\sqrt{N}$

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Plasma Oscillation Frequency

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Plasma oscillations are collective oscillations of the electron charge density. In an electronic system, an important consequence of the electron-electron interaction is the existence of collective plasma oscillations.

To determine the frequency of these oscillations, consider the self-consistency condition

$$U(r,t) = \delta U(r,t) \tag{1}$$

that describes the intrinsic behavior of the electronic system.

Theoretical and experimental estimates show that the plasma frequency is high in relation to frequencies corresponding to electronic energies

$$\hbar\omega \gg E^{(0)}(P+\hbar q) - E^{(0)}(P) \tag{2}$$

Calculations show that the dielectric function takes the form

$$\mathcal{E}(q,\omega) = 1 - \frac{4\pi n e^2}{m^*\omega^2} = 0 \tag{3}$$

Hence, the plasma frequency is equal to

$$\omega_{pl}^2 = \frac{4\pi n e^2}{m^*} \tag{4}$$

where e is the electron charge,
m^* is the effective mass of the electron,
n is the concentration of electrons.

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Shielding Potential by Electron Gas

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In semiconductors donors and acceptors are charged impurities with a Coulomb potential energy equal to

$$W(r) = \frac{e^2}{|r|} \tag{1}$$

The potential energy $W(r)$ plays here the role of an external potential.

In this paper the screening of this potential by an electron gas is considered.

The Fourier component of the impurity Coulomb potential can be obtained by calculating the integral

$$I = \frac{1}{V}\int \frac{1}{|r|} e^{-iqr-\alpha r} d^3r \tag{2}$$

where e is the charge of the electron, α is the absorption coefficient, q is the quasi-wave vector, r is the radius vector, V is the volume.

The Fourier component of the screened Coulomb potential has the form

$$U_q = \frac{W_q}{\mathcal{E}(q,0)} = \frac{1}{V} \cdot \frac{4\pi e^2}{q^2+\lambda^2} \tag{3}$$

The inverse Fourier transform can be used to find the screened Coulomb potential $U(r)$ in the form

$$U(r) = \frac{e^2}{|r|} e^{-\lambda r} \tag{4}$$

From (4) it follows that at $r = 0$ this potential behaves like a Coulomb potential, and at large r along the length $\sim\lambda^{-1}$. The quantity $r = \lambda^{-1}$ is called the screening radius. It is shown that the screening radius decreases with increasing electron concentration.

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Dielectric Permittivity of an Electron Plasma, Interacting with Laser Beat Waves

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In the framework of the kinetic method [1], the process of interaction of the electron plasma with the laser beat waves [2] is investigated taking into account the initial spread of electrons in the plasma. The collisionless kinetic Vlasov equation is used to determine the expressions for the spectral distribution function of particles of a rarefied nonrelativistic electron plasma in the presence of laser beat waves

$$f = f(\vec{p}, \vec{k}, \omega) = f_0 + \vec{A} \cdot \frac{\partial f_0}{\partial \vec{p}} \quad , \quad \vec{A} = \frac{e^2 {E_0}^2 k_p \vec{z}}{4m{\omega_0}^2 (k_p v_0 - \omega_p)} \quad , \qquad (1)$$

where f_0 is the initial distribution function of an electron bunch moving with an average velocity v_0 along the OZ axis, e and m are the charge and mass of electron , E_0 is the electric field strength of the laser wave with a frequency ω_0, and ω_p and k_p are the plasma frequency and plasma wave vector length.

To find the dielectric plasma tensor, we used expressions for the nonequilibrium current density induced by the perturbed field and the material equation connecting the conductivity tensor with the dielectric constant.

Since averaged motion of plasma electrons occurs along the OZ axis, in the intrinsic coordinate system where the plasma is at rest, dielectric tensor is transformed to the form

$$\varepsilon_{ij}(\vec{k}, \omega) = \delta_{ij} - \frac{4\pi e^2}{\omega} \int \frac{\vec{v}_i}{\vec{k} \cdot \vec{v} - \omega} \frac{\partial}{\partial \vec{p}_j} \left(f_0 - A_0 \frac{\partial f_0}{\partial p_z} \right) d\vec{p} \quad , \quad A_0 = \frac{e^2 {E_0}^2}{4m{\omega_0}^2 v_{ph}} \quad , \qquad (2)$$

where δ_{ij} is the Kronecker delta, ω and $\vec{k}$ are the frequency and wave vector of waves propagating in the plasma, $\vec{v}_i$ and $\vec{p}_j$ are the i-th and j-th components of the velocity $\vec{v}$ and momentum $\vec{p}$ of electrons of the plasma in the presence of laser beat waves, $v_{ph} = \omega_p / k_p$.

Assuming that in the equilibrium state the distribution function f_0 has the form of the Maxwell function, the dielectric tensor is diagonalized.

Note that, using the Lorentz transformation in terms of velocities, one can obtain an expression for the dielectric constant of a relativistic electron bunch in the presence of laser beat waves.

Thus, the results obtained make it possible to study the spectra of longitudinal and transverse waves propagating in a plasma interacting with laser beat waves.

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FEL Gain in an Optical Klystron

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Directional photons also exist in the beam of photons formed as a result of the interaction of high energy electron bunch and undulator field.

Replacing the undulator with two separate undulators of the same total length (optical klystron), an increase in the number of directional photons was observed [1]. This effect is due to the interference of radiation fields generated by electron oscillations in undulators [2].

The dependence of the gain of the stimulated radiation by electrons, with the presence of photons generated as a result of spontaneous radiation, on the distance between the undulators is studied. The frequency distribution of photons emitted at zero angle is obtained. The gain coefficient of the stimulated radiation is determined by the derivative of the frequency distribution of spontaneous radiation. In this case, the frequency distribution is a function of two variables: of $x=1+\rho$, where ρ is the distance between two consecutive undulators in units of the length of the undulators, and of z, which is determined by the difference between the frequencies of the photons providing the largest values for the distribution function and its derivative respectively. In the case of the favorable values of these variables, the necessary condition for the partial derivatives of the gain coefficient to be zero is a system of two equations of the second order of partial derivatives, where there are also trigonometric functions.

In the case of $\rho=0$ the favorable value of z is equal to 1.303. Assuming that in the case of $\rho>0$ the favorable value of z is equal to $1.303+\Delta$, and, expanding the functions in the system into the series of Δ, we obtain the condition that the two polynomials are equally zero. It is possible, if the member coefficients of the polynomials, containing the same degree of Δ, are equal. Equating the first three coefficients (members containing (Δ^0, Δ^1 and Δ^2) we get a system of three linear equations for unknown sine and cosine functions. Excluding these unknown functions gives a 7^{th} degree algebraic equation for the unknown z. Finding the favorable value $x=1.79$, one can also find the favorable value $z=0.57$, in which case the value of 0.81 of the gain coefficient is approximately three times greater than its maximum value of 0.27 at $\rho=0$.

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Session C

X–ray and neutron scattering in crystals

- X–ray diffraction under the external influences
- Neutron and proton diffraction under the external influences
- X–ray and neutron small angle scattering

Lateral Deformation in Potassium Hydrophthalate Crystals in an External Electric Field

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The study of dielectrics, in which it is possible to create deformations of the crystal lattice due to the redistribution of the defects, is of considerable interest today from the point of view of straintronic problems. One of these objects is a crystal of potassium biphthalate, which has pronounced piezoelectric properties. This fact and the content of predominantly light atoms in the composition of potassium biphthalate make it possible to study the deformation behavior of the crystal lattice under the external actions not only in the Bragg geometry, but also in the Laue geometry.

Electrophysical measurements carried out at the room temperature demonstrated the dependence of the conductivity on the applied field strength and the nonlinearity of the current-voltage hysteresis loop. Time-resolved X-ray diffractometry [1] was used to obtain the dependences of the peak position of the rocking curves for reflections 400, 070, and 004 when an electric field of 0.5 and 1.0 kV / mm was applied in the direction of the polar axis [001]. A shift of the diffraction peaks and a change in their integral intensity were found, which indicate a deformation of the lattice. A fast piezoelectric deformation and a reversible relaxation deformation were registered. The deformation depends on the polarity and strength of the applied field; it manifests itself most strongly in the [100] direction and is practically absent in the direction [001] of the field application. The X-ray diffraction analysis revealed the disordering of potassium atoms over several positions and the presence of vacancies in these positions. The largest disorder is observed in the *ab* plane. Potassium atoms are characterized by large displacement parameters, especially atoms that populate additional positions. The estimated heights of the potential barriers between the positions suggest the migration of K^+ ions in the *ac* plane and along the *b* axis within the corrugated cation layer. The X-ray structural analysis data confirm the hypothesis that the observed displacements of the diffraction peaks and the change in their integral intensity are caused by the volume migration of charged K^+ ions in an electric field, which leads to anisotropy of the crystal lattice deformation.

Usually, when an external electric field is applied to the crystal, the deformations of the crystal lattice are observed along the direction of the application of the field [2]. The results obtained in this work open up new possibilities for creating controlled deformations in crystals for the problems of straintronics.

The work was perfomed with financial support of the Russian Foundation for Basic Research (project № 19-29-12037).

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New Technique for Fast Registration of Reciprocal Space Maps Using Adaptive X-Ray Optics

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An urgent scientific task is to study the structure of crystalline materials as well as its dynamics under an external influence. An effective tool for such studies is X-ray radiation, while one of the widely used methods of X-ray studies of the structure of crystals is two- and three-crystal X-ray diffractometry. The first makes it possible to measure the diffraction reflection curves (DRC) - the angular dependences of the intensity of the X-ray radiation reflected by the sample in the vicinity of the Bragg angle, which, when compared with theoretical data, makes it possible to estimate the degree of defectiveness of the crystal. The second, by registering reciprocal space maps (RSM), allows us to answer the question about the nature of the observed deviations [1]. Traditionally, goniometric systems are used for registering RC and RSM, the performance of which is very limited, especially when carrying out repetitive studies, which makes it almost impossible to carry out fast measurements, the most important in terms of studying the structure dynamics.

Within the framework of this work, a new technique was proposed for the rapid registration of the reciprocal space maps of the crystals under study, based on the use of two adaptive elements of X-ray optics [2] which were located in the positions of the monochromator and analyzer on a laboratory diffractometer. Such elements were previously successfully used for fast beam variation and RC measurements [3]. During the first experiment registration of a model RSM for silicon crystal (220 reflection, θ_B=10,67˚) were obtained, and it's showed that by using of the proposed method it's possible to achieve both the winning in measurement times (at least 6 times faster) and by the accuracy of the obtained results, which makes it an effective tool for studying structural changes in promising crystalline materials in real time mode.

This work was supported by RFBR, grant #19-29-12037 mk.

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Fast EXAFS Measurement in Piezo-Driven Single-Crystal Monochromatization Scheme

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At the "Langmuir" station of the Kurchatov Synchrotron-Neutron Research Complex, a single-crystal monochromator based on adaptive bending X-ray acoustic element [1] was implemented for X-ray beam energy fast tuning and for rapid recording K-edge absorption spectra (XANES-spectrum) of Bromine in NaBr powder sample.

To control beam parameters and record the absorption spectrum, Si single-crustal monochromator, driven by ultrasonic vibrations excitation in piezo-actuator, and monitoring system were used. Diffracted synchrotron beam was collimated by slits and recorded using a scintillation detector, connected with multi-channel analyzer. X-ray acoustic element was excited via the inverse piezoelectric effect by applying a AC electronic signal with first harmonic resonance frequency f_{rez} = 239 Hz. During the experiments, the beam intensity was recorded in relation to control signal phase, further converted into an absorption spectrum.

After data processing the results it was established that the position of absorption edge and the first coordination sphere radius coincided for X-ray acoustic and traditional mechanical scan. Achieved energy scan range was 13.25–13.65 keV (400 eV). Maximum time resolution available using the x-ray acoustic method is 2.1 ms, and actual time required to record qualitative spectrum, achieved in this experiment, was about 30 seconds and can be reduced by using detector with a higher dynamic range and counting rate, as well as optimizing X-ray optical scheme.

The developed scheme is promising for QEXAFS methods implementation, useful for chemical reactions kinetics study, for example, the Belousov-Zhabotinsky self-oscillation reaction [2], as well as the deformation processes kinetics research under external influences.

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X-Rays Diffraction by Excitation of Orthogonal Acoustic Oscillations in a Quartz Crystal

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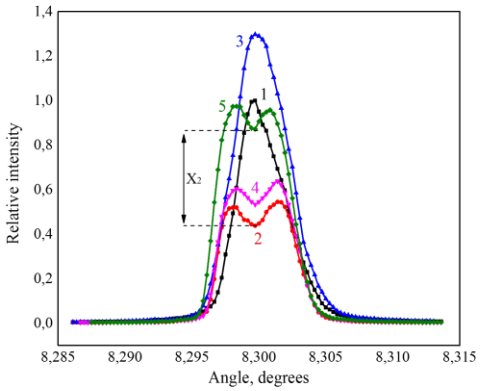
The influence of orthogonal acoustic oscillations in a quartz crystal on the parameters of reflected X-rays has been investigated. The experiments were carried out in the laboratory of x-ray methods and synchrotron radiation at the Federal Research Center "Crystallography and Photonics" of the Russian Academy of Sciences on a modernized laboratory diffractometer TRS-ASSV equipped with an X-ray tube with a molybdenum anode. The investigations were carried out in the double-crystal Bragg-Laue scheme (n,-n) (Pinsker, 1982). The sample under study was a rectangular crystal-resonator made of quartz with a surface $(11\bar{2}0)$ and dimensions 38x10x1 mm, on the side surfaces of which two pairs of electrodes are coated for supplying control acoustic signals. For the experiments, we used symmetric reflections from $(10\bar{1}1)$ atomic planes of a quartz crystal in the Laue geometry. In fig. 3 the RC of the quartz crystal in Laue geometry, from $(10\bar{1}1)$ atomic planes are presented: without any impact (curve 1), when only a low-frequency signal with a voltage of 45 V and a frequency of f_{res} = 132.1 kHz is applied (curve 2), when only a high-frequency signal is applied with a voltage of 35 V and a frequency of f_{res} = 2.7744 MHz (curve 3), with the simultaneous application of both types of signals with the same values of the corresponding voltages and frequencies (curve 4), and with the simultaneous application of both types of signals with an increase in the voltage of the high-frequency signal up to 100 V (curve 5).



It is shown that under such influence, both effects are observed: one is the X-ray acoustic transfer, which consists in an increase in the intensity of diffracted radiation during oscillations in the direction "through the thickness" of the crystal, and the second is the broadening of the half-width of the rocking curve caused by the formation of a standing wave in the crystal during oscillations "along the length". Thereby, the oscillations «in thickness» make it possible to control the intensity and the oscillations "along the length" - to adjust the angle of the X-ray beam diffracted on the crystal.

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Effect of the Spherical Form of the Front of the Incident Wave for Laue Diffraction in a Weakly Deformed Crystal

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For the first time, the effect of wave front curvature in Bragg diffraction of an initial spherical wave in a crystal lattice was considered in [1]. A further more detailed study of this effect was carried out in [2-4].

In this paper, we consider the problem of dynamic diffraction of a primary spherical wave in a crystal with a quadratic dependence of the displacement vector on coordinates and under the condition of weak deformation. These assumptions allowed us, based on the previously constructed Riemann-Green functions [5], to formulate integral representations of the quasi-amplitudes of the crystal wave field. Integral representations of the quasi-amplitudes of the crystal wave field, in turn, single out the eikonals of two wave modes corresponding to anomalously weakly and anomalously strongly absorbed fields. In the approximation of the stationary phase method, X-ray trajectories are plotted depending on the source-crystal distance, on the modulus and sign of the curvature of atomic planes. Caustic lines and focal spots were revealed and their behavior was investigated in relation to various parameters, such as absorption of radiation in a crystal, parameters of the deformation field, crystal-source distance, etc.

All of the above issues are also considered with the help of numerical calculations using a developed computer program.

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A Method for Solving the Problem of Dynamic Scattering of X-Rays in Crystals Subjected to External Influences

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A method for solving the problem of three-dimensional dynamic scattering of X-rays in crystals is proposed. The method is based on the results of solving the fundamental problem of V.A. Ambartsumyan, known as the Invariance Principle.

It was found that in the presence of ultrasound in a crystal, simultaneously with the Bragg peaks, in all directions of the azimuth, in the plane perpendicular to the direction of propagation of ultrasound, strictly collimated, coherent X-ray radiation with a high degree of polarization occurs.

A sound wave propagating in a medium modulates it along the sound wavelength. This modulation leads to modulation of the electron density, which changes the structure factor of the scattering of the medium in a certain way. A change in the scattering structure factor of the medium leads to significant changes in the scattering spectrum.

New modes can appear in the spectrum, which are forbidden in the absence of sound. In the interference peaks of the scattered spectrum, multiple amplifications are observed, etc. It can be argued that under the influence of ultrasound, the medium becomes a kind of source that generates new spectrum modes in different frequency regions. As is known, a similar phenomenon is observed when, under the influence of an intense laser beam, a sound wave is generated in a medium, due to which the medium becomes a source of directed X-ray radiation.

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X-Ray Interferometric Investigation of the Nanostructure of Surface Layers of Silicon Crystals Subjected to Ionic Implantation

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In works [1,2] X-ray diffraction (not interferometric) methods were used to study the implantation of layers in perfect crystals. It was shown in work [3] that in the case of ion implantation of one of the blocks of an X-ray interferometer, dilation moire fringes can be observed i.e. ions implanted in silicon create transverse deformations. In reference [4] the structural imperfections of silicon crystals caused by boron diffusion were investigated by an X-ray interferometric method, depending on the concentration and penetration depth of the diffusant. An X-ray interferometric method for determining the density of radiation point defects as a function of the dose and penetration depth of electron irradiation using a three-crystal interferometer was experimentally implemented [5]. Thus the X-ray interferometric method is the only precision method that allows to make direct experimental studies of the structure of displacement fields, deformations and stresses of dislocation ensembles arising in blocks of an X-ray interferometer subjected to ion implantation. In this paper the nanostructure of surface layers of silicon crystals subjected to ionic implantation is investigated by the method of X–Ray interferometer. Lateral deformations caused by argon ions with energy 180keV implanted in silicon have been studied. Relative deformations and integral stresses are determined depending on radiation doze. Maximum local stresses are assessed to be $\sigma_{x(max)} = 10{,}2 \cdot 10^7 N/m^2$ and $\sigma_{y(max)} = 8{,}2 \cdot 10^7 N/m^2$ and calculated quantities of the surface elevation of crystal (Δt_{xz}=0.092nm; Δt_{yz} =0.171nm). It is shown that the integral stress in the damaged layer increases linearly with a change in the dose of implanted argon ions (with an energy of 180 keV) from a dose of 10^{13} ions/cm^2 up to 10^{16} ions/cm^2 and with an increase in the irradiation dose, the period of the moiré fringes decreases, and the deformation increases. It is also seen that dislocations arise during implantation. The penetration depth of argon ions with an energy of 180 keV into silicon is valued and $\langle \Delta z \rangle$=0,19mkm is got. The dynamics of changes in moiré patterns depending on the radiation dose is shown.

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Investigation of Structural Changes in the Liquid Crystal System AOT / N-Heptane-Water under the Influence of Vitamin E by the Method of X-ray Analysis

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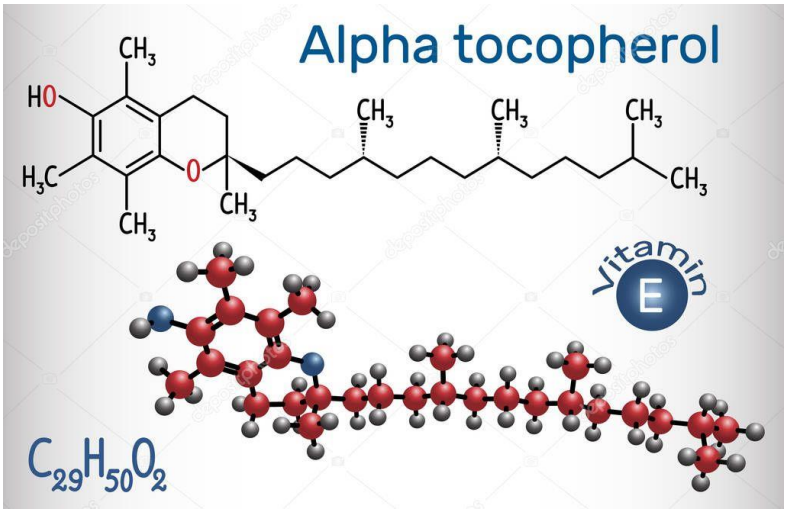
The work investigated the structural rearrangements of the lyotropic liquid crystal system sodium salt of di-/2-ethylhexyl / sulfosuccinic acid / AOT / -n-heptane - water under the influence of vitamin E by the method of X-ray diffraction. The studies were carried out in a concentration range from 50 to 80% AOT + E in an n-heptane / water solution at an n-heptane / water ratio of 1. The studies were carried out with a gradual increase in the coconcentration of vitamin E in the system and with an increase in the concentration of AOT + E in a solution of n- heptane / water.



The mesomorphism of the studied liquid crystal system on the concentration of vitamin E was established.

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X-Ray Study of Structural Changes in the Liquid Crystal System AOT / N-Heptane-Water Depending On the Concentration of Components

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The work investigated the structural changes of the multicomponent liquid crystal system sodium salt of di- / 2-ethylhexyl / sulfosuccinic acid / AOT / -n-heptane - water depending on the concentration of AOT in a mixed solution by X-ray diffraction. The studies were carried out in a wide concentration range from 27 to 92% AOT in a mixed solution with an initial n-heptane / water ratio of 5.8. The studies were carried out with a gradual decrease in the n-heptane / water ratio to the content of bound water in the system and an increase in the concentration of AOT to 92% in the solution.

The mesomorphism of the liquid crystal system on the content of the concentration of the components in the system is established and the region of the compact liquid crystal lamellar "smooth" phase for modeling biological membranes is established.

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Session D

e^-/e^+ X–ray and neutron based applications

- X–ray crystal–based optics and diffractometry
- Development of new principles and methods of fundamental research
- Various applications based on the use of different radiations and charged particle beams
- Novel positron sources
- Creation of new scientific instrumentation and science–based industrial devices.

Modified Composite Thermal Control Coatings Irradiated with High-Energy Particles

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The main trends in modern space instrumentation are an increase in the active life of spacecraft, the tightness of their structure, and the widespread use of new polymer composite materials. Therefore, it is relevant to use physical modeling methods for a comprehensive study of the behavior of materials under the conditions of a forced ground effect of the main factors of outer space - deep vacuum, fluxes of high-energy charged particles, electromagnetic radiation from the Sun, thermal cycling, etc. Composite thermoregulatory coatings are designed to maintain the required thermal regime of objects by establishing a balance between the energy absorbed from the outside and the energy emitted into the environment.

The aim of this work is to study the structure of new composite thermoregulatory materials (coatings) irradiated with high-energy particles - an electron with an energy of 3.5 MeV and a proton with an energy of 18 MeV, using X-ray diffraction analysis, optical photoluminescence doped with cerium, as well as other coatings, a new composition of thermoregulatory coatings was developed by the method of hydrothermal microwave synthesis. Silicate synthesis conditions: microwave frequency - 2.45GHz, microwave power - 600W. According to the results of studies of modified thermal control coatings, it was found that the samples synthesized by the microwave method have a crystalline structure after heat treatment at 1050^0C and 1200^0C. It is shown that the mechanisms of the effect of radiation spectra on the material medium are completely different and are determined by the atomic-molecular structure of matter. Irradiation with highly energetic particles gives rise to color defect centers of two types: - radiation defects caused by the nonstoichiometry of the crystal structure and on intrinsic point defects of the surface; - on defects formed during irradiation in the volume of the crystal cell.

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Controlled Pyroelectric Deflector of Electron Beam

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When two pyroelectric crystals are simultaneously heated in a vacuum, a strong electric field is formed between their oppositely charged surfaces [1]. In such an electric field, it becomes possible to deflect a beam of nonrelativistic electrons with an energy of 30 keV [2].

In this work, we demonstrate the possibility of using a pyroelectric deflector based on a two-crystal scheme for deflecting a relativistic 7 MeV electron beam. The dependences of the strength of the electric field generated in the pyroelectric deflector in vacuum on the temperature of pyroelectric crystals and the residual gas pressure are presented.

The results of the experiments allow us to talk about the prospects for development a controlled pyroelectric deflector applicable in accelerator technology. The work was financially supported by a Program of the Ministry of Education and Science of the Russian Federation for higher education establishments, project No. FZWG-2020-0032 (2019-1569).

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The Role of Nickel in the Composition of Nano- and Microparticles for Immunopathological Conditions of Dental Implantology

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This work investigated the causes of immunopathological conditions in dental implantology associated with clinical manifestations of inflammation. During surgical revisions, soft tissue biopsy samples were taken, and supernatants were made and researched, is obtained from the surface of an orthopedic structure as well as new dental implants of three systems (produced by different manufacturers and used as a control), were examined in patients with previously installed dental implants and orthopedic structures, supported on them, in the presence of inflammatory complications. Nanoscale and microscale metal particles were identified as participants in the inflammatory process in tissues. The components of the oxide layer of products were found using the methods of X-ray microtomography, X-ray fluorescence analysis, as well as the results of the basophilic test and histological studies of peri-implant tissues and supernatants, containing nanoscale metal particles, obtained from the surface of the samples under study.

As a result of these studies, it was found that nano- and microparticles and/or components impregnated the soft tissue biopsy samples that had been part of orthopedic constructions. These components appearing were the direct cause of personalized inflammation in perio-implant tissues of the patients. Notably, significant amounts of nickel were identified as part of the nano- and microscale particles, having been released from the surface of the oxide layer of dental implants, made of "bioinert alloy" on the basis of TiO_2 compound and an orthopedic construct, made of CoCr-based alloy, that could become the reason of personalized immunopathological reactions.

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High-Precision Characterization of Super-Multiperiod AlGaAs/GaAs Superlattices Using X-ray Reflectometry On a Synchrotron Source

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Recently, heterostructures with many strongly coupled quantum wells, such as super-multiperiod (SMP) semiconductor superlattices (SLs), have been of great interest in view of the development of compact IR and THz tunable lasers based on the formation of specific minibands (Wannier–Stark levels) and successive tunneling of carriers through several periods [1]. To decrease scattering of carriers on interfaces, samples with hundreds and thousands of layers should be grown at an atomic layer thickness accuracy, subatomic level of boundary root-mean square roughness & interface diffusivity, and composition accuracy of a few tenths of percent [2]. Synthesis of SMP structures using molecular beam epitaxy (MBE) takes many hours and should be performed taking into account the depletion of sources of deposited materials, which is achieved by *ex situ* analysis of test samples and *in situ* calibration of material fluxes.

High-resolution X-ray reflectometry (XRR) based on analysis of distributions of the scattering intensity in real space and solution of the corresponding inverse problems is a nondestructive and exact tool for studying semiconductor SLs. An independent method for studying such SMP structure parameters is photoluminescence (PL) spectroscopy [3]. Measurements performed on a synchrotron radiation (SR) source and rigorous calculus allow one to investigate thick structures in wide ranges of wavelengths, angles and intensities.

The morphology of SMP $Al_{0.3}Ga_{0.7}As$/GaAs SLs grown by MBE with 100 & 400 periods has been determined using XRR & PL in laboratory and SR studies. The layer thicknesses of SLs correlate with an error of ~ 1%. Reflection peaks, which are not observed in measurements on the diffractometer and are likely related to the technological growth features of SLs, are revealed on the SR source beginning with high (> 4–5) Bragg orders. It is clear from the numerical model that these peaks correspond to modulation in the SLs with a period that is three to five times larger and characterize the layer thickness dispersion over the structure depth of a few percent.

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Peculiarities of Radiation Defects' Generation in Silicon Crystals under Pico-Second Pulse Electron Irradiation

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Investigation of the influence of ultra-short pulse duration ($4 \cdot 10^{-13}$ sec.) electron irradiation with energy of 3.5 MeV on the charge carriers' concentration, mobility and specific conductivity of n-type silicon crystals with different specific resistivity was made. Pico-second electron irradiation at the Advanced Research Electron Accelerator Laboratory (AREAL) in Armenian despite of average electron current low intensity, has a significant effect on the parameters of silicon crystal. The analysis of measurements of dose and temperature dependences of samples' parameters shows that at room temperatures stable radiation defect formation in silicon crystal takes place in stages; at first phase defects are formed as vacancy and interstitial atoms which subsequently gather into clusters, although cluster formation is difficult in Si crystal at 3.5 MeV electron energy. Temperature dependence of charge carriers' mobility shows that after irradiation there are two mechanisms for carrier scattering: scattering on the ionized impurities and on the radiation defects.

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The Study of Morphology, Composition and Structure of Concrements in the Pineal Gland and Choroid Plexus by X-ray Methods

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The epiphysis (pineal gland) is a part of the epithalamus. This is an asymmetric formation with a volume of about 1 cm^3, located in the geometric center of the mammalian brain. One of the functions of the pineal gland (PG) is to synthesize the hormone melatonin, which regulates the circadian rhythms of living organisms. The formation of concretions in the PG and choroid plexuses of the brain is a physiological process and, according to many researchers, is associated with the involution of these structures. In recent decades, a number of publications suggested that calcification of the PG leads to a change in melatonin secretion due to a decrease in the functional activity of pinealocytes (cells of the PG parenchyma) and can cause a deterioration in sleep quality, vascular homeostasis disorder in various neuropathologies and dementia.

In this work, a comparative study of the morphology, microstructure and compositional analysis of concretions in PG and choroid plexus in the human brain were studied by methods of X-ray diffraction (XRD), X-ray microtomography (micro-CT) and X-ray phase contrast tomography (XPCT) with high. Calcospherites in choroid plexus mainly have a regular spherical shape with a concentric lamination structure developed from a single primary centre of their formation. Concrements in PG differs from calcospherites in plexus; they are lobulated and more irregular in shape. In PGs both laminated and nonlaminated calcified concretions were observed. Additionally, we observed micro-granules with irregular shape scattered in PG parenchyma. X-ray diffraction technique showed that separate concrements can reach a dimension of hundred microns. Aggregated a mulberry-like conglomerates have size of up to several mm.

We have found that concrements in PG predominantly were composed of hydroxyapatite with trace of other minerals. Concrements in plexus have both organic and inorganic composition with lamination of alternating organic-rich and *mineral*-rich (hydroxyapatite) materials.

The work was supported by the Ministry of Science and Higher Education within the State assignment FSRC "Crystallography and Photonics" RAS in part of "interpretation of tomographic data", Russian Foundation for Basic Research (Projects No. 18-29-26036, 18-52-7819) in part of "absorption, diffraction and phase-contrast X-ray microtomography".

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Geant4 Simulation of Small-Animal Pet Detector Unit with Thick Monolithic Scintillator

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Positron emission tomography (PET) is molecular imaging method for visualization of metabolic and function information of studied organism which based on usage of radioactive tracers. Now PET scanners actively used for preclinical studies of mice and rats especially for radiopharmaceuticals drugs development and testing.

Usually, small animal PET scanner is detection system with stacked rings of units. Each unit consists of scintillator and array of photosensors such as photomultiplier tubes, avalanche photodiodes, silicone photomultiplier (SiPM). In many commercial systems the scintillator is pixelated. It is possible to localize point of interaction in plane parallel to sensors array – XY position. Pixelated scintillator with reflection wrappers provides great energy resolution, but the main limitation is lack of information about the depth of interaction (DOI). On the other hand, now there are examples of systems with monolithic scintillator configuration when array of sensors pixels attached to on scintillator piece. Such detector unit is easier to manufacture, and interaction position can be estimated better.

In this work, the Geant4 simulation of small animal PET with monolithic scintillator was conducted. The main components are LYSO scintillator with thickness equal 24 mm and dense SiPM array 8*16 with size of pixels 6 mm. The total length of unit is 96 mm and width is 48 mm. Also sparse and staggered with fill factor 0.5 were observed.

Firstly, the Compton scattering in scintillator affect on the estimation of point of interaction. If photon scattered before deposition the first point of scattering is “true”. The distribution of maximum distance between “true” point and scattered point was calculated. Results shows that under 1 mm is around 50 % of all events.

Secondly, XY position of photon interaction point was estimated. Generally, all methods could be divided on all methods can be divided into those that use calibration data and those that do not. The Anger classical [1] and squared methods were used as methods without calibration. Classic Anger method shows RMSE equal 2 mm at center fast increase of error up to 16 mm toward to edges. Squared Anger method shows worser RMSE at center (3 mm) but better stability near the edge. The RMSE increased only from 38 mm from center up to 8 mm. Moreover, in work proposed improving of Anger method with calibration data.

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Determining the Depth of a Defect Location in the Circumferential Welding Seam by X-ray Radiography with Time Delay Integration

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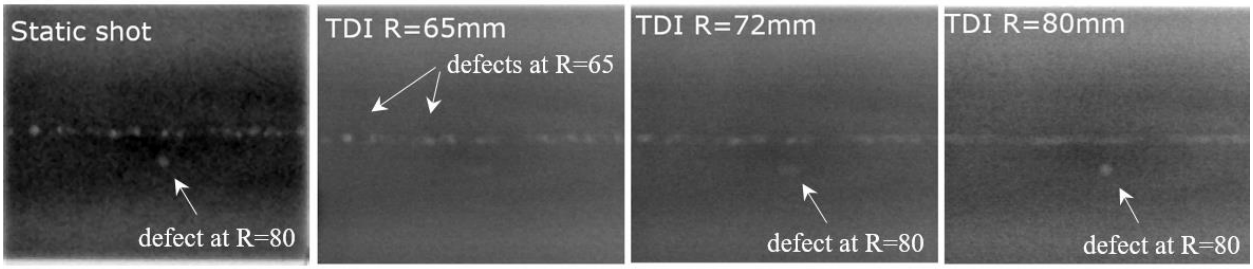
The X-ray radiography is a common application for Non-Destructive Testing (NDT) of welding seams. X-ray films is useful technology for this task [1]. However, in case of the circumferential long seams (tubes, rotors) the problem is field of view and the testing time. One of the way to speed up the process is using digital X-ray detector with Time-Delay Integration (TDI). In this work, we demonstrate that photon counting Timepix detectors [2] with 1 mm thick CdT crystal as sensor and 55 um pixel size is suitable for this task. The test seam rotates around the detector at a constant angular velocity, while the detector captures frames with an integration time less than the time it takes to move the seam along one pixel. Final image of seam are obtained by realizing so called Digital TDI algorithm: one column in result image is integral sum of the frame columns one by one along horizontal direction. The new feature of this approach is that TDI allows determining the depth of a defect in a seam (see pic 1).



Pic. 1 – Static radiography (first shot) and TDI images (next 3 shots) for welding seam. Test object is a steel rotor. Inner radius of the seam R_{inn}=65 mm, outer radius R_{out}=80mm. Static shot: we can see the defects that lies at R_{inn} and at R_{out}. TDI R_{inn}: we can see only inner defects. TDI R_{out}: clearly see only one defect at outer radius. TDI R=72: we can see all defects are blurred.

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Review of Experiments at the Synchrotron Radiation end station «Diagnostics in the High-Energy X-ray Range» On VEPP-4M Storage RING

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The endstation «Diagnostics in the high-energy X-ray range» became the basis for advanced scientific experiments in the materials science, geophysics, archaeology, paleontology, biology and medicine. The endstation has implemented a number of research techniques using high-resolution introscopy, X-ray diffraction and fluorescence.

«Diagnostics in the high-energy X-ray range» has been operating at the Siberian Center for Synchrotron and Terahertz Radiation since 2014 and uses synchrotron radiation from a nine-pole wiggler with a field of 1.9 T. In this presentation, we will describe the equipment and configuration of the endstation, as well as the main experimental results on the use of hard X-ray monochromatic and polychromatic radiation.

We will present the results of the study of archaeological and paleontological samples using X-ray computed tomography. The report will present the results of research in the field of radiation therapy. An X-ray diffraction study of the sequence of melting and crystallization of metal systems will also be presented.

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Ring Artifact Correction Based on Sinogram Integral Interpolation Using Variate Gaussian Width

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In X-ray CT systems where the thickness and density of the scanned objects are high enough to have quite low intensity detector signal compared to image without object, results significantly suffer from different artifacts, including ring artifact. Such type of artifacts appears due to high extent of detector pixel's response heterogeneity even after flat filter is applied, since spectrum conditions for images with object and without it differ greatly. There are lots of methods to correct ring artifacts in sinogram and image domains, but they have their own disadvantages such as high sensitivity to image's edge, insufficient correction of pixels with varying intensity during the scan, high degradation of the structure of the objects or even creating fake samples etc. The purpose of this study is to try to implement an optimal solution for ring artifact reduction, which might be obtained by flexible tuning of the method's parameters.

As a working domain, the sinograms were chosen because of performance issues. The proposed method as many others based on the fact that sinograms' integrals are monotone, so the pixels which are out of trend should be interpolated. However, these integrals have various linearity over the detector's row, so constant interpolation span may cause additional artifacts. In this work, so-called Variate Gaussian Width (VGW) method is proposed to get optimal interpolation span for corresponding sinogram place based on extent of linearity. Furthermore, Gaussian form which is used for interpolation is well suited for this task.

First of all sinograms' integrals are calculated and normalized. After that, the normalized gradient can be calculated and used in further processing. Correction procedure is divided into two parts: linear and Gaussian interpolation. The first step is necessary to remove out liners, so they don't affect the quality of further Gaussian interpolation. Depending on the gradient it is possible to determine the linearity of the place, so decision about whether linear interpolation is necessary as well as which Gaussian's width to use can be made. Since the gradient\width mapping depends on the detector, X-ray spectrum, density, thickness and form of the objects, in order to obtain optimal result it is needed to find out settings for each CT system configuration and objects type. Finally, the pixels with variate intensity during the scan are corrected in the projection domain by linear interpolation.

The method performance is tested for cores of stone with 100 mm thickness. For such type of objects the difference in signal intensity between image with object and without was about 85% which lead to a strong pattern of ring artifact. X-ray tube voltage was 225 keV. As a detector, the flat panel was used with sensitive layer of Gd, thickness 20 um. The comparison with other methods in the same conditions is also presented.

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Simulation of the Passage of Electrons with an Energy of 10 keV through Tapered Dielectric Capillars

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Nowadays, a large number of experiments are being carried out to study the possibility of controlling electron beams with energies of the order of keV using dielectric channels. The results of experiments with conical channels showed that the process of electron beam passing through them can be explained by the formation of a dynamic self-consistent charge distribution on the inner surface of the dielectric channel. The existing models describing the process of the passage of an electron beam through a channel are one-dimensional or two-dimensional, which does not give a complete picture of what the charge distribution looks like in dielectric channels, as well as how the shape and direction of motion of a beam of charged particles changes under the influence of electric fields inside dielectric channels.

In the course of the work we created and implemented a numerical spatial model which describes the process of sliding interaction of a 10 keV electron beam with the surface of a conical channel. This model dynamically describes the motion of the electron beam in the channel, as well as the processes of charging and discharging of the inner walls of the channel. It's assumed that the processes of charging and discharging of the channel occur in a thin surface layer of the material, and the effect of secondary electron emission is neglected.

The results of calculations within created model of the motion of an electron beam through a conical dielectric channel show good qualitative agreement with the data of experiments on the control and focusing of an electron beam with an energy of 10 keV.

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The Multi-Angle Scanning Method Application for X-Ray and Electron Beams Profiles Measurement

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The main requirements for modern methods of radiation beam profile determination are follows: sufficient spatial resolution of the measurement results; short time of data collection and processing; minimization of beam disturbance during measurement. Most of the existing approaches do not meet these cumulative requirements.

In this regard, it is necessary to develop a new method that allows creating devices for beam profile measurement in real time with high spatial resolution and minimal losses of ionizing radiation in the detector working body.

This research is aimed at testing the multi-angle scanning method for radiation beam profile registration. It is proposed to carry out multiple linear scanning at different angles by scanning wire detector in the cross section of the beam. Then the obtained data are reconstructed to the radiation energy distribution in the measurement plane.

This work is supported by the Russian Science Foundation (grant number 21-79-00252).

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Simulation of Multi-Angle Scanning Method for the Medical Electron Beam Transverse Profile Determination

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For ionizing radiation application for medical purposes must conduct a highly accurate control of the beam characteristics. Nowadays, film dosimeters, luminescent screens and matrix detectors are used to measure the medical electron beam profile. These detection methods have significant disadvantages. Time-consuming calibration of each new batch and post-processing of the irradiation results are essential for dosimetry films. The fluorescent screens application requires additional equipment for the digitization results. Matrix detectors have low spatial resolution.

In this work the intensity distributions of a medical electron beam were obtained by the integral transformations method. We used beam profiles obtained with the help of dosimetry planning system for clinical practice cases. The proposed method was applied both for simulated ideal profiles and for experimentally obtained profiles of medical electron beams. Integral transformations were carried out with different numbers of projections.

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Properties Investigation of 3D-Printed Samples with Different Fill Factors

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One of important stages of the radiotherapy sessions is the dose planning, which is usually performed by numerical methods and experimentally verified on medical setup. The verification of radiotherapy plan is performed with dosimetry phantoms. Authors propose to produce dosimetry phantoms using 3D printing approach. For effective implementation of this approach the 3D-printed objects properties should be investigated. One of the important properties of materials used for radiation therapy tasks is tissue equivalence, which is determined by mass density, matter effective atomic number, computed tomography indices or Hounsfield units and electron density. These parameters are keys for the dosimetry planning of radiation therapy sessions based on computed tomography data.

This research presents the results of studies of mass densities, Hounsfield units and 3D electron densities of 3D-printed plastic samples with different fill factors.

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Opportunities for Transforming Fundamental Physics Research into an Innovative Product

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At present, our entire civilization needs long-term forecasts of emergency situations for use in systems of individualized control of the actions of people and robots (AI systems) in the event of an emergency in order to radically reduce human and material losses. This was shown by the events of this year - catastrophic in scale fires, floods, earthquakes, apparently associated with global space phenomena, and man-made disasters, including epidemics, associated with the pace of economic activity - the concentration of the world's population in megacities, globalization of the economy, population mobility, etc. Apparently, the processes on Earth are changing and the old methods of research and predictions are no longer suitable. Therefore, the question arises of using new earlier indicators of future negative events.

Namely, such long-term forecasts are provided by the methods and devices developed by physicists, who for many years have been grouped around outstanding scientists - Academician of the National Academy of Sciences of the RA Mkrtchyan A.R. and Professor of the Physics Department of Moscow State University Bushuev V.A. and regularly speak at traditional conferences. This circumstance is of key importance for the economy of emergencies, as it contributes to the implementation of long-term forecasting systems with large (economically important) predictive potential. Obtaining the same predictions is very important for actively introduced personalized medicine services. The front of these works is rapidly expanding and a lot of funds are required, which can be obtained by transforming the results of scientific research into a demanded innovative product - mass services. An example of the successful practical implementation of such a transformation in our country is the implementation of the project of coordinate-time and navigation support (KVNO) - GLONAS.

FSUE NIIR, IPPU RAS and IPPF NAS RA have experience of participation in the processes of innovative development of KVNO, therefore, in order to go this way in a short time, the participants of our conference initiate the organization of the Association of Researchers of Applied Physics Problems (AIPPF). ...

The possible composition of the AIPPF members: organizations of conference participants, developers of infocommunication and measuring equipment and software, organizations-consumers of products, providers of infocommunication services, developers of infocommunication equipment, operators of communication networks (including operators of mobile and satellite communication systems), etc., for whose participation in the Association will be an opportunity to integrate their products into the emerging mass market for the provision of infocommunication services, as well as consumers and customers, primarily to mass consumers of infocommunication services, subdivisions of state structures (for example, in the Russian Federation - the Ministry of Emergency Situations, Rospotrebnadzor, the Ministry of Natural Resources and Ecology, the Ministry of Health , Ministry of Agriculture, Regional Administrations, etc.).

AIPPF should ensure the coordination of the directions of work carried out by different scientific and production teams, as well as the choice of control systems (service administration systems - ACS, software used, communication infrastructure, including administration systems, measuring equipment, standardization of measurements, etc.) generally accepted standards for the provision of mass information services.

We also believe that the creation of such an association and its launch into operation deserves the category of Megasign and we suggest that the working group prepare the necessary documents and submit an application to the Russian Science Foundation.

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On a Specific Intermolecular Interactions in Nematic Liquid Crystal Systems

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Nematic Liquid Crystal Systems (NLC) that are based on polar liquid crystals, whose molecules have a large dipole moment directed along the long axis of the molecule, have a number of interesting features. Amongst them are the phenomenon of the reentrant polymorphism, the emergence of the incommensurable layered structures in smectic A phase, the formation of an induced smectic phase, the emergence of the antiparallel correlations in the arrangement of the permanent or induced dipoles of the molecules. The changes of the dynamic equilibrium in "monomer-dimer" system influence the delicate balance between the forces of dispersive attraction and steric repulsion in these systems, leading to the above-mentioned features of molecular packing.

The aim of this study was the investigation of the molecular structure of the abovementioned NLC systems, which is both important in terms of understanding the anomalous behavior of elastic modules and other physical parameters, and has a practical importance in the development of the new LC materials for electro-optical systems.

In this work the investigation of a specific intermolecular interaction – the formation of charge transfer complexing (CTC) in LC systems - was carried out by UV and IR spectroscopy. Formation of the CTC of simple and complex compositions was found. The complicated dependence of optical density of the absorption band of the donor and CTC on the initial donor concentration has been obtained. A long-wavelength shift of the CTC absorption band is found. The correlation between the optical density of the absorption bands of the CTC and donor, on the one hand, and the phase diagram, on the other, was demonstrated to occur in the investigated systems. The analytical expressions for equilibrium constants of complexation process were derived, and the concentrations of the complexes were determined based on the absolute rates reaction theory.

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Possibilities for Monoenergetic Electron Generation via Pyroelectric Effect in Lithium Tantalate Single Crystals

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The pyroelectric effect in lithium tantalate (LiTaO3) single crystals provides a curious possibility to generate fluxes of electrons, with energy up to 100 keV for all of the above. There are numerous shreds of evidence that the electron fluxes can be self-focused and monoenergetic, which opens perspectives of the practical application of this phenomenon. The experiments on registration of voltage-current dependence of the electron fluxes during periodic variation of temperature of a single crystal of tantalate lithium are presented and described. The possibility of the generation of quasi-constant electric potential in space between the pyroelectric current and the metallic grounded target was revealed. The influence of residual gas pressure and geometry of the pyroelectric generator is discussed.

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Rotational Viscosity of Nematic Liquid Crystals

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Focusing on a viscosity is due to both the practical importance of this property, which determines the switching speed of the liquid crystal (LC) device, and the scientific consequences arising in the study of flows and LC reorientation.

In this work, a theoretical review of the rotational viscosity of nematic liquid crystals (NLC) is carried out. The limits of applicability of various methods for describing viscosity's temperature dependence are discussed. The values of the moments of inertia of studied NLC were calculated.

The influence of the molecular structure of NLC on the value of rotational viscosity and on its temperature dependence is analyzed.

In this study, authors presented the data that make it possible to calculate the value of the rotational viscosity at any temperature related to the nematic range with good accuracy for mesogenic substances from various classes of chemical compounds.

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A New Method for Mathematical Reconstruction in X-ray Microtomography for the Study of Changing Objects

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X-ray microtomography allows studying the internal three-dimensional structure of objects using a set of two-dimensional X-ray images. Traditionally, it is assumed that the object's structure does not change during tomography data collection in such studies. If the structure of the object changes, then, when using traditional reconstruction methods, distortions appear in the reconstructed object's structure - artifacts. There is a whole class of things, the change in the structure of which occurs in such a way that the amount of matter (and with it the absorption of X-ray radiation) at each spatial point of the object does not monotonically decrease with time. Examples of such processes are fluid flow in some porous media, crystal growth, 3D printing, etc.

Various approaches are used to achieve temporal resolution:

1. Modeling the dynamics of an object by a sequence of static states with a complete tomography data acquisition at each step.

2. The quasi-static method assumes that the object changes little over the time of a full tomography measurement. In this case, projections from the sample are continuously collected in different directions, and tomographic reconstruction is performed using a set of X-ray projections with a moving window.

3. Creation of a model of the object and inclusion it in the reconstruction algorithm.

In this paper, we describe a new approach to the reconstruction of dynamic objects, the absorption of which at any point can only increase during the tomographic measurement. The main idea of the developed iterative algorithm is trusting only to experimental sinogram in the current moment of the time and obtain additional information about the sample and sinogram structure from the reconstructions in the other time points. The results of the reconstruction of the synthetic data will be presented.

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Study of Nonlinear Optical L-Nitroarginine Perchlorate Crystal

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The crystal salts of L-arginine (*L*-Arg) and L-nitroarginine (L-NNA) possess nonlinear optical, electro-optical, piezoelectric, pyroelectric valuable properties [1-3]. From the system *L*-Arg+$HClO_4$+H_2O previously the orthorhombic (space group $P2_12_12_1$) crystal *L*-Arg·$HClO_4$ was known [4]. In addition to this crystal with singly charged cations, a crystal *L*-Arg·$2HClO_4$ with doubly charged cations was also obtained earlier by our group. They crystallize in triclinic system with space group P1 and Z = 1[1,5,6]. L-nitroarginine is a derivative of L-arginine. L-nitroarginine (L-NNA) and its crystalline salts can show higher NLO properties due to presence of, in addition to electron donor amino groups, also electron acceptor nitro-group. L-Nitroarginine has first been prepared by Kossel and Kennaway [7]. Crystal and molecular structures of L-Nitroarginine monohydrochloride monohydrate (L-NNA·HCl·H_2O) [8] have been determined. L-nitroarginine is manufactured in form of powder (α-form) by many companies. Recently, R. A. Apreyan obtained and developed a new method of reception of new crystal form L-nitroarginine (β-form) [2] and new crystal salt L-nitroargininium bromide monohydrate (α and β forms) [9], which already shows high nonlinear optical activity.

In this work we report the results of vibrational spectroscopic, range of transparency, thermal properties and nonlinear-optical activity of L-nitroarginine perchlorate (L-NNA.$HClO_4$) crystal. On the basis of vibrational (FTIR ATR and FT Raman) spectra the formation mechanism was determined L-NNA^+·ClO_4^-. Nonlinear optical activity of L-NNA.$HClO_4$ was measured by the modified method of a powder and the range of transparency is determined. A systematic investigation has been carried out on the growth of L-nitroarginine perchlorate crystals and were grown bulk single crystals.

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Measurement of Spatial Characteristics of Ionizing Radiation Beams Using the X-ray Fluorescent Wire Scanner

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To measure spatial characteristics of beams of charged and neutral particles, the wire scanner design is proposed [1-2]. The scanner (Fig. 1) contains several V-shaped wires made of various materials that move perpendicular to the beam axis [3]. Spectra of characteristic X-ray radiation generated in the wires by the beam are registered by an energy-dispersive semiconductor detector. Measured dependences of intensity of the characteristic X-rays on the wire impact parameter make it possible to determine the transverse beam profiles. The energy values of characteristic X-rays allow us to determine which wires the obtained profiles correspond to. Transverse dimensions, shape, trajectory, divergence and emittance of the beam can be determined from the data obtained during the scanning process.

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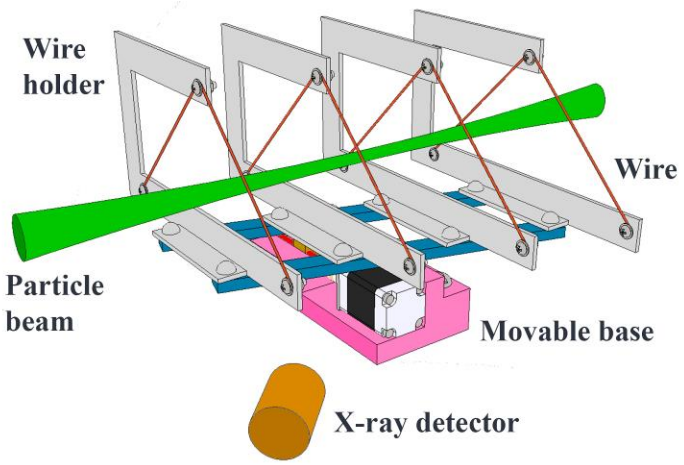

Fig. 1. The proposed wire scanner

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Vibrational Spectra of *L*-Argininium Sulfates

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Crystalline salts of amino acids are known as promising nonlinear optical materials [1]. It's worth noting that being a subject of numerous studies, the crystal triglycine sulfate (TGS) [2] among amino acid salts, has been widely used in various fields as an infrared receiver sensor, particularly in military technology. The crystal L-lysine sulfate ($Lys^{2+}\cdot SO_4^{2-}$, space group $P2_12_12_1$, Z = 4.) was first discovered, and its crystal and molecular structure was determined in 1983 [3]. The same system was later studied by other researchers who claimed to have obtained the $Lys^{2+}\cdot SO_4^{2-}$crystal [4-5]. However, they used different methods to obtain crystals (water-alcohol, acetone-water, etc.). The authors [4,5] received the same IR spectra, and the author [6] received different ones. The authors [6] claim that [4,5] printed the wrong IR spectrum. Since several types of compounds {*L*-$A^{2+}\cdot SO_4^{2-}$, *L*-$A^{2+}\cdot(HSO_4^-)_2$, *L*-$A^+\cdot HSO_4^-$, $(L\text{-}A^+)_2\cdot SO_4^{2-}$, *L*-$A^+\cdot L\text{-}A^{2+}\cdot HSO_4^-\cdot SO_4^{2-}$ (A is amino acid)}, or their modifications, or water types can be obtained from a 1:1 ratio of amino acids and sulfuric acid, it seems that [4,5] may have obtained one of the above.

Due to the above mentioned properties of triglycine sulfate (TGS) crystal, it can be assumed that L-arginine sulfates can have good properties, too. Despite the large number of researchers in the field of amino acid search, no salt has yet been obtained from the *L*-Arg+H_2SO_4+H_2O system. On the contrary, the authors [7] mentioned the formation of a non-crystalline viscous solution. Therefore, in order to obtain new crystalline salts, it is interesting to study the interaction of *L*-arginine and sulfuric acid.

Given these nuances, we investigated in more detail the reaction of L-arginine with sulfuric acid (H_2SO_4) in water and other solvents. We obtained and identified three compounds from the L-Arg+H_2SO_4+aq system by vibrational (IR and Raman) spectroscopy. All three compounds have bands which are very close to characteristics of the free SO_4^{2-} anion: 1105 cm^{-1} (vas), 983 cm^{-1} (vs), 611 cm^{-1} (oas) and 450 cm^{-1} (os) [8]. To understand the discrepancies in the spectra obtained by the researchers [4-5], we compared them with the IR & Raman spectra of the three compounds we obtained. The absorption bands of the spectrum of the resulting crystals are very similar to the absorption bands of the spectrum in [6]. L-$Arg^{2+}\cdot SO_4^{2-}$ can be obtained in the form of bulk single crystal.

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Improvement of Algorithms for Calibration and Identification of Charged Particles during the Flight of the MPD/ NICA Experimental System

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This work isdedicated to improvement of calibration and particle identification algorithms for the time-of-flight system of the MPD / NICA experiment.

The task of the time-of-flight system calibrating is to determine the nonlinearity of the electronics, to calculate the dependence of the time of arrival of the signal from the detector versus the signal amplitude (time-amplitude correction) with taking into account difference in lengths of cables used to read the signal. The best quality calibrations are achieved by individually calibrating each channel of the electronics to avoid interference. For this, a special programmable signal generator is being developed.

Before processing the experimental data for particles identification, an alignment procedure of the TOF system geometry is carried out, which consists in finding all real shifts and rotations of the elements of the system relative to their ideal design position.

Time-of-flight particle identification algorithms in the MPD experiment have been developed and are currently being improved.

The result of this work should be the creation of a set of software and equipment that maximizes the efficiency of particle identification by the time-of-flight method in the MPD experiment in the first heavy ion collisions at the NICA collider.

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Preparation, Study and NLO Activity of L-Nitroarginine Tetrafluoroborate (L-NNA·HBF_4)

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L-nitroarginine (L-NNA) is a derivative of L-arginine (*L*-Arg). Those and there crystalline salts recently have attracted significant attention as nonlinear optical (NLO) materials [1-3].

L-nitroarginine has first been prepared by Kossel [4]. Crystal and molecular structures of L-NNA·HCl·H_2O have been determined [5]. L-nitroarginine is manufactured in form of powder (α-form) by many companies. Recently, R. A. Apreyan developed a new method of reception and synthesized new crystal form L-nitroarginine (β-form) [2,6] and new crystal salts L-NNA·HCl·H_2O (α and β forms) [3,6].

The crystal L-Arg·HBF_4 (space group $P2_12_12_1$) with singly charged cation was previously known from the system L-Arg+HBF_4+H_2O [7] and recently our group also obtained the crystal L-Arg·$2HBF_4$ with double charged cation (space group P1) [8].

In this work we report the results of vibrational spectroscopic (Fourier transform infrared and raman), range of transparency, thermal properties, and nonlinear optical activity of L-nitroarginine tetrafluoroborate crystal. Based on IR and Raman spectra, the presence of functional groups and water in the compound can be confirmed. All study data of crystal L-NNA·HBF_4 were compared with L-arginine tetrafluroborates data. Unlike the crystal L-Arg·$2HBF_4$, the crystal L-NNA·HBF_4 is not hygroscopic and has a high point of damage 183°C and is very easy to grow. NLO activity of L-NNA·HBF_4 was measured by the modified method of a powder (conversion efficiency L-NNA·HBF_4 is two times as high as in the L-Arg·$2HBF_4$) and the range of transparency is determined (339–1100 nm).

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Modulation of The Electron Beams Depths Dose Distribution Via 3D Printed Plastic Samples

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The main aim of the radiotherapy is to provide increasing tumor control probability while reducing normal tissue complication probability. To reach the latter the radiation field should be specifically modulated. The authors propose application of 3D-printed plastic samples to modulate depths dose distribution of electron beams. The rapid prototyping technology application allows producing compensators and boluses with complex form cheaper and faster in comparison with the standard techniques taking into account the tumor shape and location. This will make it possible to create more accurate beam depth doses distributions individually for each patient.

The work investigates the applicability of 3D-printed samples made of ABS and HIPS plastic for clinical electron beams modulation. The samples are designed to estimate simultaneously the efficiency of electron beam modulation via a plastic compensator, collimator and wedge. This research includes an experimental series and numerical simulations using the Monte Carlo method.

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Single Crystals of α–$LiIO_3$ Doped with L-arginine and L-nitroarginine

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One of essential crystals for technology is hexagonal modification of lithium iodate (α-$LiIO_3$), which is endowed with nonlinear optical, pyroelectric, piezoelectric, acousto-optic properties.

In recent years, a number of research groups studied physical and physiochemical properties of several single crystals (KDP, ADP, BTCA, ZTC) that were grown in the presence of some amino acids (L-alanine, L-glycine, L-arginine, L-lysine, etc.) [1,2].

In all these studies a positive effect on growth process and crystal quality is described for the amino acids being used as dopants in solutions.

For the first time, such work for single crystals of α-$LiIO_3$ was carried out in the laboratory of crystal growth of the IAPP. Single crystals of α-LiO_3 were grown from low-temperature aqueous solutions doped with L-alanine, L-lysine, L-histidine, L-glycine, L-valine and potassium permanganate [3,4].

Based on the positive results of these studies, this work presents the effect of mixtures of the amino acids L-arginine and L-nitroarginine on α-$LiIO_3$ single crystals. The crystals were grown by the method described in the work [5]. Studies of IR and Raman spectra, UV-Vis transmittance, thermal properties and nonlinear optical activity have shown that the optical quality and physicochemical properties of the crystal are improved in the presence of amino acids. The obtained experimental data showed that second harmonic generation activity of the crystals of α–$LiIO_3$ grown with L–arginine and L–nitroarginine dopants is 1.0 – 1.5 times higher than that of pure α–$LiIO_3$.

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Clinical Electron Beam Shaping By 3D Printed Plastic Collimators

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The issue of external therapeutic electron beam delivery is very topical for all manufacturers of modern clinical accelerators. Typically, these accelerators are supplied with basic sets of applicators, which provide only circular or rectangular beam with prescribed sizes and uniform dose distribution in a target. To form more complex fields, standard metal blocks or custom individual metal collimators of optional shape can be used.

This work investigates possibility to provide specifically shaped beam using 3D-printed plastic collimator. The dose fields shaped by metal and plastic collimators are compared. The obtained results showed suitability of PLA plastic for absorption of therapeutic electron beam with 6 and 12 MeV nominal energies. Objects made of this plastic by rapid prototyping techniques allow collimated electron beams with the same efficiency than using standard metal devices.

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Salts Containing Different Amino Acids. Four Types of Salts with Hexafluorosilicate Anion

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Reactions of amino acids with inorganic and organic acids lead to formation of salts of various types. The majority belongs to simple salts. Salts with dimeric cations of various types also are known, as well as mixed salts with different anions [1,2]. Salts containing different amino acids were not previously known. Recently we have discovered a whole class of such salts with different amino acids [3,4].

In the present work we report crystal structures of four types salts of glycine (Gly), sarcosine (Sar), dimethylglycine (DMG), betaine (Bet), β-alanine (β-Ala) and L-proline (L-Pro): (β-AlaH)(BetH)$SiF_6 \cdot H_2O$ (s.g. $P2_1/n$) (I), (β-AlaH)(L-ProH)SiF_6 (s.g. $P2_1$) (II), (β-AlaH)(L-ProH···L-Pro)SiF_6 (s.g. $P2_1$) (III), (BetH)(BetH···Sar)$SiF_6.H_2O$ (s.g. $P2_1/n$) (IV) and $(GlyH\cdots DMG)_2SiF_6$ (s.g. *P*bca) (V) and $(DMGH\cdots Sar)_2SiF_6$ (s.g. $P2_1/c$) (VI).

The O···O distances in dimeric cations (L-ProH···L-Pro) of (III), (BetH···Sar) of (IV), (GlyH···DMG) of (V) and (DMGH···Sar) of (VI) are equal to 2.438(2) Å (III), 2.5310(12) Å (IV), 2.4980(9) Å (V) and 2.4610(19) Å (VI).

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Analysis of the Oscillation Generation Process in a Nonlinear Parametric System Using Differential Equations of Amplitude and Phase

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A logical simple method is given that allows the most complete disclosure of the physical essence of the processes occurring in the system and presents their overall picture. For the first time this method was used in [1], it was shown more fully in [2], and in her review, received from the Physics Department of the Moscow State University after M.V. Lomonosov, the desire was expressed to see an even more complete author's interpretation of the method. This is what is being done. The inhomogeneous nonlinear differential equation of the second order compiled for the system was solved by a powerful asymptotic method. It gives the best approximation of the first terms of the solution to the exact one. Together with the solution, we obtain shortened differential equations describing the rates of change of the amplitude and phase, which are not separated with respect to amplitude and phase. They are solved by numerical integration for each specific initial values of the amplitude and phase and cannot reveal all the regularities. The author simply constructed curves of the rates of change of the amplitude and phase depending on the phase. They explain everything. The role of quadrature components and their action are revealed. A possible decrease in the amplitude at the initial stage is explained. The zones of attraction of the phase, bi furcation parameters, the position of the separatrix and their changes in the generation process are determined. The role of the detuning mechanism is explained. A phase portrait is displayed. The possibility and conditions of a "phase jump" are established, which led to malfunctions of communication systems with phase manipulation using such generators. It is indicated how to avoid this. It is shown how receivers with phase manipulation signals can be used as radiometers, and for detecting drones [3], and how to ensure their maximum sensitivity. The method is also convenient for expression analysis when you need to quickly determine some parameters. It is also suitable for the analysis of vibrations in other, for example, mechanical, systems, wherever shortened amplitude and phase equations are obtained.

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Salts Containing Different Amino Acids. Three Types of Salts with Sulfate Anion

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Crystalline salts of amino acids are promising source of ferroelectric, pyroelectric, piezoelectric and nonlinear optical materials [1]. Triglycine sulfate (TGS) (GlyH)(GlyH···Gly)SO_4 (space group $P2_1$) is one of the ferroelectric crystals widely used today. In the frames of works amino acids salts containing different amino acids [2,3] we obtain three types of salts with sulfate anion. Two crystals of them are analogs of triglycine sulfate.

In the present work we report crystal structures of four types salts of dimethylglycine (DMG), betaine (Bet), β-alanine (β-Ala) and L-proline (L-Pro): (β-AlaH)(DMGH)$SO_4 \cdot 2H_2O$ (I) (s.g. $P2_1/c$) (I), (β-AlaH)(BetH)SO_4 (s.g. *P*nma) (II), (β-AlaH)(L-ProH)SO_4 (s.g. $P2_12_12_1$) (III), (BetH)(L-ProH)SO_4 (s.g. $P2_1$) (IV), (β-AlaH)(L-ProH···L-Pro)SO_4 (s.g. $P2_1$) (V), (β-AlaH)(β-AlaH···DMG)SO_4 (s.g. $P2_1/c$) (VI).

The O···O distances in dimeric cations (L-ProH···L-Pro) (V) and (β-AlaH···DMG) (VI) are equal to 2.4501(18) Å (V) and 2.5295(12) Å (VI).

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Diffraction of Fraongofera on Cells at the Border between Vacuum and Anisotropic Medium

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Although the principles of diffraction in optics have been established long ago consideration of situations where diffracted radiation does not penetrate into vacuum, as usual, but into a material medium, is of interest in view of the fact that the medium in which diffracted radiation propagates leaves its imprint on diffraction pattern. In this paper, we consider Fraunhofer diffraction of light on a slit-transparent screen located between a vacuum and a homogeneous anisotropic medium, in the absence and in the presence of absorption, and at various orientations of the optical axis of the medium relative to the slit. The well-known formula for diffraction in vacuum is generalized, which also includes the case of diffraction into a uniaxial anisotropic medium, in the absence of absorption. A formula has been obtained that makes it possible to determine the directions of the diffraction minima and maxima with allowance for absorption.

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Methanesulfonates of Glycine, Sarcosine, Dimethylglycine and Betaine

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Salts of amino acids are known as a source of nonlinear optical, piezoelectric, pyroelectric and ferroelectric materials [1]. Various types of compounds of glycine (Gly) and its *N*-methyl-derivatives, sarcosine (mono-methyl-glycine) (Sar) and betaine (tri-methyl-glycine) (Bet) are known as ferroelectrics. Recently we discovered two salts of dimethylglycine (DMG) with dimeric cation, (DMGH···DMG)Cl and (DMGH···DMG)Br displaying ferroelectric properties [2]. Also, we investigated sulfamates and methanesulfonates of L-arginine and L-histidine [3]. In this regard we decided to reinvestigate more systematically sulfamates and methanesulfonates of glycine, sarcosine, dimethylglycine and betaine. Previously, glycinium methanesulfonate (GlyH)(CH_3SO_3) [4] and sarcosinium sarcosine methanesulfonate (SarH···Sar)(CH_3SO_3) [5] were known. Both crystallize in centrosymmetric structures with $P2_1/n$ and $C2/c$ space groups, respectively.

In this work the simple salts of sarcosine (SarH)(CH_3SO_3) (space group $P2_12_12_1$), dimethylglycine (DMGH)CH_3SO_3 (space group $P2_1/c$) and betaine (BetH)CH_3SO_3 (space group $P2_1/c$) were obtained. Additionally, we obtained salts with dimeric cation of glycine (GlyH···Gly)CH_3SO_3 (space group $P2_1$), dimethylglycine (DMG-1/2H···1/2H-DMG)CH_3SO_3 (space group $P2_1/n$) and betaine (BetH···Bet)CH_3SO_3 (space group $P2_1/c$). All of them were characterized structurally and by vibrational spectroscopy. The salt with dimeric cation (GlyH···Gly)(CH_3SO_3) with polar symmetry deserves further investigation as possible pyroelectric or ferroelectric crystal.

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The DNA Damage Induced by X-Ray Irradiation in the Presence of Porphyrins

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The study and understanding of the mechanisms of radiation causing DNA damage are one of the actual problems for the development of new cancer therapies and effective radiosensitizers. In this work, we study the dependence of DNA damage on X-ray radiation dose in presence of unique molecules – porphyrins. Porphyrins constitute a big class of photosensitive molecules, used in different areas of medicine, such as diagnostics and treatment of malignant tumors. The samples (calf thymus DNA and TOEPyP4 porphyrins complexes) with different relative concentrations of porphyrins per base pair were irradiated by the electron beam. After samples irradiation, the melting curves (the dependence of denatured DNA percentage on temperature) of investigated complexes have been obtained. It is known that the melting parameters of DNA (T_m and ΔT) are sensitive to the structure of the double helix. Therefore, it can be used as an indicator of the cleavage of strands of DNA molecules after irradiation.

The conclusion about the changes in the DNA can be deduced from the melting parameters of non-irradiated and irradiated DNA. The result obtained from the melting curves of non-irradiated DNA and irradiated DNA shows that the X-ray irradiation caused the DNA structural changes (double-strand breaks or local melting), as expected.At the same radiation dose, the presence of porphyrins causes a stronger radiation effect on the DNA structure. In vitro investigations of DNA damage for various porphyrin concentrations, DNA sequences, and radiation dose levels are planned.

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Sulfamates with Dimeric Cation of Glycine, Sarcosine and Dimethylglycine

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Amino acid salts having the formula (AH···A)X and formed by (AH···A) type dimeric cation (where AH is protonated state of an amino acid A) are known for various amino acids and several anions [1]. Those are interesting from various point of views, as crystals with strong O-H···O hydrogen bonds and potential crystals with nonlinear optical, piezoelectric, pyroelectric and ferroelectric properties. Recently we reported two more salts of dimethylglycine (DMGH···DMG)Cl and (DMGH···DMG)Br, displaying ferroelectric properties at room and higher temperatures [2]. With sulfamate anion ($NH_2SO_3^-$) only one simple salt of betaine (BetH)(NH_2SO_3) [3] and one salt (Bet···H···Bet)(NH_2SO_3) [4] of the (AH···A)X type are known. Both crystals are centrosymmetric with space group $P2_1/c$.

The main goal of the present work was to investigate the possibility of obtaining (AH···A)X type salts for glycine, sarcosine and dimethylglycine, with hope to get new salts with polar symmetry. Herein, we report our results on synthesis, crystal structure and vibrational spectroscopic characterization of new crystals (GlyH···Gly)NH_2SO_3 (I), (SarH···Sar)NH_2SO_3 (II) and (DMGH···DMG)$NH_2SO_3 \cdot H_2O$ (III). The salt (III) and known salt of betaine are centrosymmetric (space groups $P2_1/n$ and $P2_1/c$ respectively), while the crystals (I) and (II) crystallize in polar space groups, Pn and $Pna2_1$, respectively, and deserve for further investigation as possible pyro- and ferroelectrics.

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The Probability of Correct Registration of Weak Signals at Their Super-Regenerative Parametron Reception

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This work is a continuation and development of [1]. Here, the theory of reception by means of parametron is built in the relationship between the parameters of the received signal and the dynamics of the processes occurring in the parametron, taking into account the possible statistical relationship between the samples and for various methods of forming radio pulses of subharmonics / superization/. It is shown that with an increase in the frequency of excitations of the parametron: on the one hand, the reception approaches continuous, which increases the probability of correct reception (P); on the other hand, the input signal-to-noise ratio decreases and the threshold increases, which leads to a decrease the (P). The optimal sampling frequency depends on the relationships between the spectrum width /duration of the signal/, Q-factor /bandwidth /of the parametron, and the duration of transients. The optimal modes of the parametron providing a maximum of (P) were determined. Its evaluation showed that with the same probabilities (P), the required increases in the ratio of the signal energy to the noise power spectral density compared to the corresponding ratio for optimal reception are: with a probability of 0.9 and modulation of the pump phase -1.026, Q-factor modulation -1.13, modulation of the pump amplitude -1.4; with a probability of 0.98 and a pump phase modulation of -1.016, a Q factor of -1.07.

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Benefits of Mapping the Uv-Uv-Exclusion's Intensity on the Earth (Armenian Case)

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As it is known, the intensity of the UV-range of the Sun rays affects humans, animals and vegetation. The UV radiation above a certain level of intensity has a negative effect, even dangerous. However, the UV rays are also important, particularly for the synthesis of vitamin D in the body.

Therefore, it is not necessary to try to exclude the UV rays, but to know magnitude of their intensity isimportantso tofollowthat the intensity of these rays does not exceed the level of danger [1].

Thus, the UV intensity mapping can help to quickly find areas on the Earth's surface where the UV intensity is favorable in certain extents. In the field of medicine, in particular, it is very important to map the areas of intensity, where vitamin D is best synthesized and will not have a detrimental effect.

Our work presents data on the intensity radiated by the Sun in the UV range, and its impact on the quality of human life. By marking the coordinates of such areas, where the level of UV intensity is favorable for humans, we will significantly help people to make the best use of the opportunity for the synthesis of vitamin D in the body.

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Some Features of Corundum-Based Crystals and Creation of UV Detectors with Their Usage.

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We have performed series of spectral studies of corundum various crystals with different mixtures and isolated a number of crystals whose luminescence has the highest integral intensity [1-4].

Based on the above-mentioned crystals, we are going to design and create two types of the luminescenceregistration detectors for certain studies of ultraviolet rays:

- Radiation matrix converter made of corundum fiber crystals, the spatial clearance of which will depend on the size of the matrix element (probably 0.2 mm);
- Integrated radiation converter.
- To this end, through a series of spectrometric studies of rectangular crystals, we have isolated those crystals which direct ultraviolet rays with very small losses to the vertical plane. As a result, these rays are added to the rays passing through that plane and provide some amplification, due to which the detectors obtained with such crystals become more sensitive.

Our goal is to create spatial-sensitive detectors based on our studies of corundum (with different activation centers) temporal, spectral, energy characteristics by different methods.

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About Hidden Energy (part 2)
Testing the evolution of the absolute magnitude of type Ia supernovae and cosmological parameters.

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As is known, the ΛCDM model of the universe prevails in modern cosmology, which makes it possible to best explain the observed data, in particular, the apparent magnitudes of type Ia supernovae (SNeIa). The main parameters of this model are Ω_M and Ω_Λ related to the density of matter and the density of the hidden energy of the universe, respectively. The main criterion for the acceptance of a theory is the best correspondence of this theory to the observed data.

In our previous report [1], we estimated the cosmological parameters Ω_M and Ω_Λ for a flat ΛCDM universe under the assumption that the absolute magnitude of the stars SNeIa is constant from z. It was found that, for different samples, the best fit according to the chi-square criterion of fit gives for Ω_Λ a value of no more than 0.5. In this paper, we discuss the case when the absolute magnitude of a supernova evolves with time. We studied the SNeIa Union2 sample [2]. It is assumed that the absolute magnitude of a supernova changes linearly with z. Computer simulations show that, with this assumption, the observational data are in better agreement with theory than with a constant absolute value. In addition, at the same time, the best approximation gives zero value for the hidden energy density. In this case, it is required that the absolute magnitude of the supernova at a distance at z = 1 change by only 0.3^m. This value of the evolution of the absolute magnitudes of supernovae is consistent with many observational results (for example, [3]). Note also that the values of the parameters Ω_M and Ω_Λ are very sensitive to the accepted value of the absolute luminosity of stars. In particular, it was shown that at a constant absolute value of supernovae, a change in this value by only 0.4^m leads to a change in the parameters from Ω_Λ = 0.7 and Ω_M = 0.3 to Ω_Λ = 0 and Ω_M = 1. On the other hand, according to numerous studies, this parameter fluctuates in a very wide range from -18 to -19.5. This means that a correct estimate of the absolute magnitude M of type Ia supernovae is extremely important for estimating cosmological parameters.

Thus, it was found that the assumption of the evolution of the absolute magnitudes of SNeIa supernovae improves the agreement between the theory and observational data. In this case, a zero value of the hidden energy is obtained, i.e. the universe consists only of gravitational matter.

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Proparties of Space and Time. The Rol of Universal Constants in Physics

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In the work, from a large number of physical constants, those constants that were of fundamental importance in physics were singled out. Also presented are the units of measurement of physical quantities developed by Planck.

Key words: Time, space, causation, fundamental physical constants

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Electromechanical Devices with Internal Adhesive Joints

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In the last decade, a new class of electronic mechanical devices (EMD) has been developed, which include various mechanical elements and are designed to work as sensors of angular accelerations, angular displacements, accelerometers, pressure sensors, etc. elastic elements and resonators of various types.

The use of glue greatly simplifies the production technology and reduces the cost of production[1]. The glue allows you to reliably connect parts made of dissimilar materials, eliminating the risk of mechanical or thermal damage, and ensures a uniform distribution of mechanical stresses in the gluing area. Investigation of gas release from the adhesive into the vacuum environment of an EMD is a topical issue in the operation of an EMD [2].

The aim of the work is to study the evolution of gases in the vacuum environment of EMD, using their activation energies, and also to calculate the sensitivity of EMDs when the vacuum in them deteriorates. Calculations and estimates have shown that these changes can be approximately ~5 $^{0}/_{0}$.

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Phenomena of Absorption of Soft and Hard Components of Space Rays in the Atmosphere in Yerevan Conditions

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Primary cosmic rays from space (such as a proton or an alpha particle), which have a relatively large mass - a high energy reserve (on the order of 10^{15} eV), at an altitude of 15-20 km above sea level, collide with the nuclei of atoms of air molecules, causing a large number of predominantly active particles - Mesons: positive, negative և neutral (pions).

In the work under the conditions of Yerevan, the dependence of the intensity of cosmic rays on the polar angle was studied, for which the FPK-01 space telescope was used to register the rays. The viewing angle during measurements was changed from 0 to 90 degrees with a step of 15 degrees.

Until now, it was assumed that the intensity of cosmic rays changes in direct proportion to the square of the cosine of the polar angle. However, according to the results o bviously it can be occur only in the range of polar angle values from 0 to 30 degrees, and in the range from 30 և 45 degrees to 90 degrees decreases exponentially.

Despite the dependence of the number of soft and hard cosmic rays on the polar angle, their change obeys two different laws, and since the FPK-01 space telescope used in the experiment registers only parallel particle fluxes, measured in the range from 0 to 90 degrees (TABLE), these the data allow determining their absorption coefficient in the atmosphere.

Comparing the absorption of soft and hard components of cosmic rays in atmospheric air with their absorption, we can say:

1. The soft component of cosmic rays is noticeably absorbed by lead and atmospheric air.
2. If the absorption rate of the solid component of cosmic rays is imperceptible in an 18 cm layer of lead, then it is significant in a long thick layer of atmospheric air, because the total intensity of soft and hard components tends to asymptotically tend to zero.

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Diffraction Image of a Point Source of Slow Neutrons in a Weakly Deformed Crystal

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The problem of dynamic diffraction of slow neutrons from a point source on the spatial lattice of a crystal with a weak deformation field is considered. The study is based on the asymptotic representation of the Riemann function for a pair of hyperbolic Hamilton equations describing the propagation of quasi-amplitudes of slow neutrons of diffracted waves in a crystal lattice. The conditions for focusing one of the wave modes inside the crystal and its reflection behind the crystal in vacuum are considered. The main parameters of the focal spots inside and behind the crystal are investigated depending on the distances between the source of slow neutrons and the crystal and the plane of registration. The behavior of focal spots from the parameter of the deformation field is also analyzed in detail.

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Determination of Particle Sizes by Optical Methods

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Determination of particle sizes in the micrometric size range is an urgent task. In this work, we experimentally investigated two optical methods for determining the particle size:

1. Determination of particle sizes by measuring the intensity of a part of the light scattered by a particle (Lorentz-Mie scattering).
2. Determination of the particle size by the diffraction pattern: An experimental technique (using a coordinate detector) has been developed to register an "instantaneous" diffraction pattern from an individual particle during the period of the particle crossing the laser beam.

In the approximation of paraxial beams of incident light, the problem of light scattering by spherical particles (microdroplets) is considered in the approximations of geometric and wave optics. The corresponding formulas for estimating the particle size are obtained. Good agreement between the calculated and experimental results has been established experimentally. Based on the results obtained, an operating optoelectronic unit was developed and manufactured to determine the counting concentration and particle size distribution..

The experiments were carried out on monodisperse droplets and solid particles obtained by the generator of monodisperse particles [1].

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Preparation of Carbyne on the Surface of the Polycrystalline Diamond by the Intense Laser Ablation

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It is well known and widespread in nature are two allotropic manifestations of carbon, diamond, and graphite, which exist in various polymer modifications. Transitional forms of carbon: coal, soot, soot, coke, etc. are similar in structure to graphite. New forms of carbon have recently been discovered. Transitional forms of carbon: coal, soot, soot, coke, etc. are similar in structure to graphite. New forms of carbon have recently been discovered. They are spherical carbon molecules. Carbon may exist in three valence states, SP3-diamond, SP2-graphite, and the third valence state SP1-carbyne is a one-dimensional linear polymer [1,2]. With the help of such irradiation of the diamond ceramic surface, a surface layer with pronounced semiconducting properties is obtained. Based on the experiments performed on the interaction of pulsed laser irradiation from the surface of polycrystalline diamond, it can be concluded that the phase composition is transformed according to the diamond-graphite-carbyne scheme [3-4]. Depending on the temperature, electro-physical measurements unambiguously showed the semiconductor nature of the laser-modified conductive paths on the diamond surface. The band gap is 1-2 eV. X-ray diffraction patterns of this layer confirm the presence of one of the carbon allotropies, carbyne, in this layer. It is supposed to use this property for the development of temperature sensors in nuclear reactors, since the obtained material is resistant to neutron irradiation.

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Multichannel Projection Formation in X-ray Spectral Tomography with a Crystal Analyzer

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We recently demonstrated the ability to implement spectral microtomography on a laboratory set-up [1]. We used CCD camera and Si crystal analyzer with a thickness of 540 μm to separate the $K\alpha$ line and the $K\beta$ line from the polychromatic radiation of the X-ray tube with a Mo anode. The first experiment with a gold grid showed that using a projective transformation is enough to align three images (transmission, $K\alpha$, $K\beta$), and construct a multichannel tomographic projection [2]. However, an experiment with an object containing regions of a circular shape has demonstrated the presence of distortions that cannot be compensated by the projective transformation (Fig.1). We have found that the effect of the crystal thickness (marked by a red line in Fig.1) can be modeled by a convolution operation (own operator for each reflex). Now we present a new three-step algorithm to construct tomographic projection: 1) to apply an affine transformation (best approximating projective transformation [3], but not transfigurating the convolution operators) to align three images, 2) to perform the deconvolution procedure for $K\alpha$ and $K\beta$ images and 3) to compensate the residual misalignment effect by a projective transform.

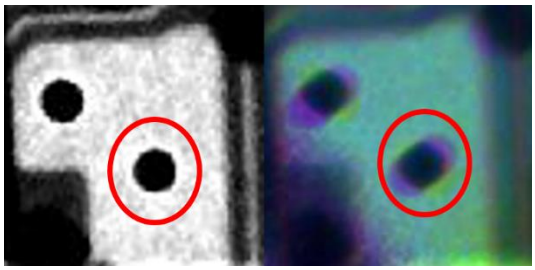

Fig 1. Left: transmission image.
Right: RGB image (red-transmission image, green – $K\beta$ image, blue – $K\alpha$ image) [2].

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Controlling of 10 keV Electron Beam Using Different Dielectric Channels

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Since the 2000s, studies of the possibility of controlling beams of charged particles using dielectric channels have become increasingly popular in view of the potential for creating autonomous and simple devices. The effect of controlling charged particles is due to the formation of a self-consistent charge distribution on the inner walls of the dielectric channel, which ensures the passage of a part of the beam without direct contact with the channel surface. Control efficiency is characterized by the value of transmitted beam current, energy state of the particles passing through a channel, stability of a channel transmission, and spatial-angular characteristics of the transmitted beam. This paper presents the results of an experimental study of the effect of controlling a 10 keV electron beam using various dielectric channels (PET nanocapillary foils, glass tapered capillaries, ceramic macrocapillaries, an array of polysulfone fiber tubes, PVC tubes bent into rings at 360 ° etc.).

Also presented are the results of measuring the time dependence of the passage of an electron beam with an energy of 10 keV and a beam current of about 1.8 μA through PVC tubes bent into rings at 360 °. The data obtained indicate the possibility of effective use of various dielectric channels as autonomous elements of electronic optics.

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Lectures

of the International Scientific School named after Gurgen Askaryan

Exploration of the Moon: The First Modern Stage

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The creation of an inhabited research station on the Moon is a logical step in the further study of space. However, there are a number of technical and financial difficulties. It is mainly due to expensive delivery to the Moon of any cargo and even more expensive delivery back to Earth. The solution of the issue is the use of local resources, soil (regolith) and water. The existence of the latter was recently indicated near the poles of the Moon. The presence of energy resources allows to produce, building materials and various constructions from the regolith.

Previously obtained data on the water content in cold traps of 5 and 30% make it possible to assume its production on an industrial scale, and to use electrolysis to obtain rocket fuel, which is necessary both for further study of the outer space and returning people and research apparatus to Earth.

Keywords: Moon, water, polar areas, electronics fault tolerance, inhabited research station.

Synchrotron Radiation. Introduction to the Theory

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Lection introduces the theory of the radiation relativistic charge particles during their movement by circular trajectories in the magnetic fields. The simple examples explain necessary conditions for breaking out the electromagnetic field from the charged particles and transformation this in the electromagnetic waves. A special attention will be paid to case circular movement of charge particles with velocity near speed of light. Simple conclusion in this case permit denoted angular, spectral and polarization properties of the produced radiation.

Additionally, some qualitative description will be done for cases radiation from multipoles insertion devices like wigglers or undulators and differences between these cases.

Finally, there will be described effects of influence the electron beam size and angular divergence to brightness of the produced radiation. In the end the synchrotron radiation sources will be classifies by generation in according with their emittance.

Positive and Negative Phenomena of Digital Transformation of Primary and Secondary Education. Preliminary Results.

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During the transition of education to new methods, the positive role of digital technologies in education became visible: in the management system of educational institutions, in the logistics of their supply, in solving urgent social problems of rural schools, in new opportunities for "nuggets from the periphery", in access to educational, methodological and scientific literature, etc.

At the same time, the public began to pay attention to the negative effects of digitalization and the results of the implementation of the digital educational environment.

In these conditions, before moving forward, it is necessary to analyze the current situation and determine the causes of the costs associated with digital technologies.

The report examines the achieved results in detail and proposes measures to stop negative phenomena. The report is addressed to both teachers and students.

The controlling of parameters of diffracted X-rays from a single crystal with external influences (acoustic fields and temperature gradient)

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The aim of the lecture is obtaining X-ray beams with controlled space-time parameters using X-ray diffraction from a quartz crystal in the Laue geometry in the presence of acoustic vibrations or a temperature gradient. The lecture presents various X-ray diffraction effects manifested in the diffraction of X-rays from a quartz crystal in the presence of external influences. Basically, we will talk about the effects of X-rays full transferring, focusing, transparency etc., which were obtained at the Institute of Applied Problems of Physics of the National Academy of Sciences of the Republic of Armenia under the leadership of Alpik Rafaelovich Mkrtchyan.

Ionizing radiation effects on biological molecules

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According to the classical view, the effect of ionizing radiation on the biological systems is mainly preconditioned by the effect on the double helix structure of DNA, which in turn activates the signals of DNA damage to cause apoptosis, necrosis and aging [1].

DNA damage in cells occurs either by direct ionization or indirectly, through the generation of free radicals that attack DNA resulting various lesions on DNA molecules (single-strand breaks (SSB) and double strand breaks, or crosslinks), which is the basis of radiation therapy [2]. However, DNA damage can occur both in cancer cells and near located healthy cells, which can lead to many human diseases [3], the so-called side effects of therapy. Therefore, it is important to minimize the side effects that can be achieved by using the possible narrower irradiate beams or lower doses.

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3D printing for medical beams dosimetry

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With this lecture you will know about the main approaches of radiation therapy application for cancer treatment. The dosimetry methods of such procedures will be considered. The difficulties in clinical dosimetry caring out and ways of arise issues solution will be described. You will know about new approach for the implementation of individual dosimetry for radiation therapy sessions being developed based on the rapid prototyping devices application.

Blaze Diffraction Gratings Fabricated On Si(111) Wafers By Anisotropic Wet Etching

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Using direct laser lithography and liquid etching of polished vicinal Si(111) wafers, a technology was developed and diffraction gratings 500 mm^{-1} with blaze angles of 3–4° were fabricated. The manufacturing process of reflective Si-gratings of a triangular profile can be divided into four principal stages: (1) obtaining a pattern of a resistive mask for etching grooves; (2) anisotropic etching of grooves in KOH solution; (3) etching to smooth the grating profile and polish the surface of working facets; (4) coating to increase reflectivity [1]. The obtained samples were characterized using AFM and SEM methods to determine the shape of groove profiles and roughness: the shape turned out to be close to ideal triangular and the RMS roughness was less than 0.3 nm in 1×1 μm^2 scanning area (Fig. 1). Using a PCGrate® code based on the boundary integral equation theory and taking into account the measured groove profile we simulated the diffraction efficiency and scattered light intensities of the same Si-master-grating operating both in classical and conical mounts in EUV and soft-X-ray ranges. The derived efficiency values are close to the record ones for the corresponding mount, spectral range and coating (Fig. 2).

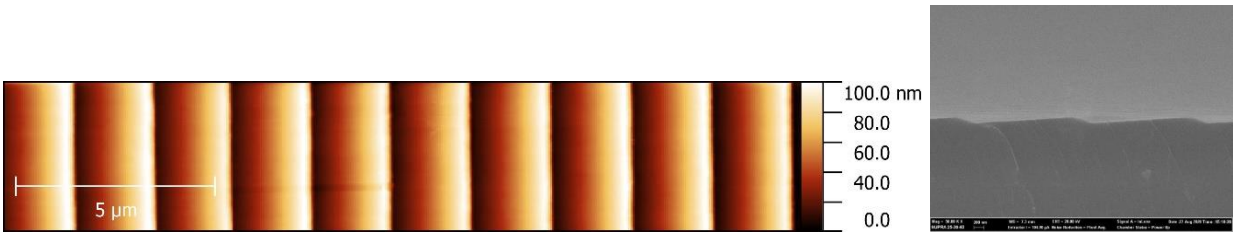

Fig. 1. Surface topography of a sample obtained by: (left) AFM scanning; (right) SEM scanning

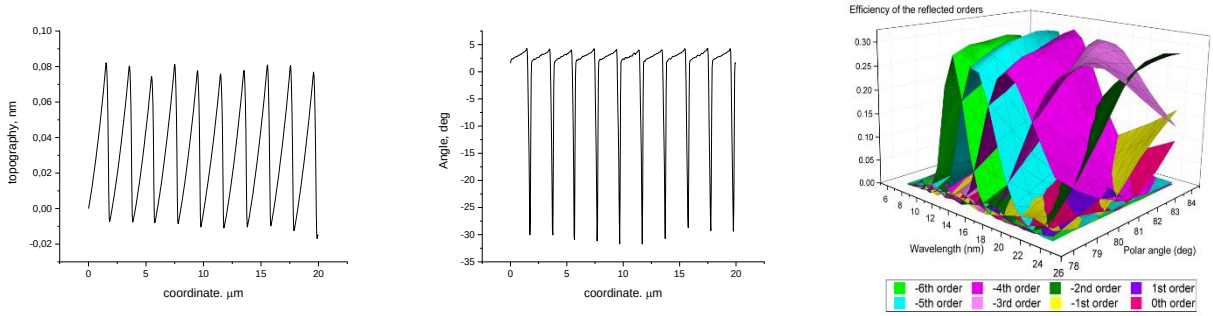

Fig. 2. Profile topography obtained by AFM scanning of a sample of area 10×10 μm^2 and computations based on it: (left) surface; (center) blaze angle of the working facet; (right) 3D efficiencies of diffraction orders of 500 /mm Au-coated blaze grating

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Quantum Field-Theoretical Effects in Graphene

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There has been a growing interest in recent years in models formulated on backgrounds with the number of spatial dimensions less than two. Aside from their role as simplified models in particle physics, field theories in lower dimensions serve as effective theories describing the long-wavelength properties of a number of condensed matter systems. Examples for the latter are high temperature superconductors, d-density-wave states, Weyl semimetals, graphene (and graphene related materials) and topological insulators. For these systems, the long wavelength dynamics of excitations is formulated in terms of the Dirac-like theory living in (2+1)- dimensional spacetime where the role of the velocity of light is played by the Fermi velocity. In topological insulators, 2D massless fermionic excitations appear as edge states on the surface of a 3D topological insulator. (2+1)-dimensional models also appear as high temperature limits of four-dimensional field theories. We discuss quantum field theoretical effects induced by nontrivial spatial topology and by boundaries in two-dimensional fermionic systems. The ground state current densities are considered in cylindrical and toroidal topologies. Applications are given in graphene nanotubes, nanoloops and nanocones.

Theoretical Aspects of Dynamical Diffraction of X-rays in Deformed Crystals

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The main stages in the development of the theory of dynamic X-ray scattering. A brief historical overview.

Basic equations of dynamic diffraction.

Description of various types of deformations, including continuously deformations.

Eikonal approximation of dynamic diffraction and the basic equation of this approximation.

Some analytical solutions of the basic equations, including diffraction in a perfect crystal and in a crystal with a deformation field quadratic in the coordinates.

Multicrystal systems and their applications.