



# **IX International Conference on Electron, Positron, Neutron and X-ray Scattering under the External Influences**

**19 – 26 October 2025**

**Yerevan – Meghri, Armenia**

**Book of Abstracts**



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# Abstracts

# Coherent Optical Transition Radiation from Short Electron Bunches with Non–Gaussian Charge Distribution

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Modern accelerated technology, such as laser driven plasma acceleration, allows us to obtain electron bunches with femtosecond duration. Traditional beam diagnostics based on the optical transition radiation are not applicable for such beams. However, optical diagnostics methods have evident advantages such as reliability, reproducibility, and low noise level.

To apply this technique to femtosecond bunches exhibiting coherent optical transition radiation (COTR), suitable theoretical models must be developed.

Authors of the papers [1–3] considered a possibility to determine bunch length measuring image of the beam via COTR under the assumption that the charge distribution in the bunch is described by a gaussian law.

In addition to the widely used Gaussian charge distribution, this report examines several other forms of charge distributions that are defined on a finite interval, specifically the rectangular, triangular, and cosine quadratic profiles. These alternative distributions are relevant for describing the structure of electron bunches in certain experimental scenarios.

It is demonstrated that, at radiation frequencies significantly exceeding the fundamental frequency—where the fundamental frequency is determined by the duration of the electron bunch—the COTR spectrum exhibits a series of distinct maxima. The occurrence of these maxima is a characteristic feature associated with the specific charge distribution of the bunch.

The spectral position of these maxima can provide a practical means for the bunch length determining analysing the COTR spectra.

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# Features of Particles Scattering in Aligned Optical Lattices

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Channeling motion in solids are well established within the phenomenology of crystal channeling. Indeed, both classical and quantum theories of crystal channeling are well known, most of the features were experimentally proved.

As known, the interaction of two laser fields can create in the intersection area a standing wave picture (optical lattice), which can be used to deflect charged particles due to the diffraction by a periodic grating (Kapitza–Dirac phenomenon). However, at well–defined angular orientations, the optical lattices can guide the charged beams along the standing wave channels (channeling in optical lattices).

In this report I am going to present our results on motion of a charged particle in optical lattices. For a wide spectrum of the particle energies, we have derived the effective interaction potential for a scalar quantum particle in arbitrary nonuniform laser field that enabled us the dynamics of charged particles considering a space charge problem of the guided beam and successfully the limits of applicability of the perturbation theory to be analysed. A zone structure of channeled motion for a particle in optical lattice formed by superposition of electromagnetic fields has been also examined revealing an essential difference in the energy spectra for a channeled particle in optical lattices in comparison with those in crystals crystals. A special case for channeling of a quantum particle as well as accompanying channeling radiation in a field formed by two crossed plane laser waves is considered. It is shown that relativistic particles moving near the laser channel bottom should be evaluated as quantum ones at arbitrarily large longitudinal energies as well as laser fields of accessible intensities.

The results of this report are obtained in tight collaboration with Alexey Dik and Eugeny Frolov (RAS PN Lebedev Physical Institute, Moscow), and I am pleased to acknowledge their attentive work.

---

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# Radiation from Annular Beams

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Annular beams have many applications, including accelerating and collimating charged particles, generating X-rays, manipulating nanoparticles, treating surfaces, depositing materials, and operating free electron lasers. Here, we discuss the radiation of annular beams interacting with media. The simplest example is Cherenkov radiation in a homogeneous medium. Another example is an annular beam coaxially enclosing a cylindrical waveguide surrounded by a homogeneous medium. We find the electromagnetic fields using the Green function. These fields are used to evaluate energy losses in the form of various types of radiation, including Cherenkov radiation, radiation on the cylindrical waveguide's guiding modes, and radiation of surface polaritons. We also discuss the radiation on a dielectric ball.

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# **Peculiarities of Radiation from Relativistic Electron Bunches Passing through a Dispersive Dielectric Ball**

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We present the results of theoretical studies of the spectral and angular distributions of the radiation generated by bunches of charged particles crossing a dielectric ball embedded in vacuum. For non-dispersive dielectric ball, it has previously been demonstrated that, for specific values of the problem parameters, the radiation exhibits a resonant character in narrow frequency ranges. In the present presentation we show that, the presence of dispersion can not only significantly change the spectral-angular distribution of radiation, but also significantly increase the total energy emitted in a fairly wide frequency range.

The work was partially supported by the Science Committee of RA, in the frames of the research projects № 25RG-1C157.

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# Temperature Influence on Interband and Intraband Optical Transitions in Pyramidal Quantum Dot

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In this paper, a study of intraband and interband optical transitions in a pyramidal QD is presented. The energy spectrum and wave functions of the problem are calculated analytically within the framework of the adiabatic approximation. Based on the obtained results, the interband absorption is investigated, taking into account the temperature dependence of the band gap and the spectral broadening of the absorption lines. Then, the linear and nonlinear intraband absorption within the matrix density approach is calculated. The temperature and geometric dependencies of the generations of the second (for a three–level system) and third (for a four–level system) harmonics in the system under study are studied.

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# Geant4 Model for Simulating Storage Ring Based Inverse Compton Scattering Radiation Sources

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Inverse Compton scattering (ICS) [1, 2] is a promising mechanism for engineering of a bright, compact and versatile X- or Gamma-ray source: with dimensions being significantly smaller, the brightness of this source is comparable with that of synchrotron radiation. The intensity of existing ICS sources is unfortunately far from what is desired due to different factors. ICS sources based on storage rings with high repetition rate can help to overcome this limitation. The ring structure of the source, however, introduces several new problems, one of which is the recoil effect. This effect is commonly considered in terms of its influence on characteristics of the generated radiation [3], whereas its impact on characteristics of an electron beam after interaction with a laser beam is usually neglected. This is due to the fact that in most existing ring accelerators, the short beam lifetime prevents electrons from interacting with the laser pulse multiple times. Nowadays ICS radiation sources are being designed with the electron beam lifetimes expected to be long enough to collide with laser pulses multiple times. This repeated interaction leads to a considerable changes of the electron beams' characteristics.

In this work, we present our enhanced Geant4 code [4] for ICS radiation sources simulation. Based on the theoretical model we developed in [5], we have implemented new features to be able to simulate a storage ring based ICS source with arbitrary collision and beams' tilting angles and possibility to track the electron beams' evolution and radiation spectra changes over multiple collisions. We demonstrate that beam evolution must be taken into account, as it critically affects the properties of the resulting radiation. These capabilities make our code a valuable tool for designing the next generation of ultra-bright ICS sources.

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# Application of The SERS Method for Obtaining and Growing New Single Crystals of Some Amino Acid Salts

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The crystalline salts of amino acids and their derivatives possess a number of valuable properties, like nonlinear optical, electro–optical, electrical, dielectric, piezoelectric, pyroelectric and ferroelectric. Amino acid salts that have found wide application in various fields include the nonlinear optical L–arginine phosphate monohydrate (LAP) crystal, the ferroelectric betaine phosphite (BPI) crystal, as well as the pyroelectric triglycine sulfate (TGS) crystal. Our recently developed optical–quality L–Arg·2HBr·H<sub>2</sub>O (LADB) crystal grown by the SERS (Sonic–Enhanced Reaction and Synthesis) method will be applicable as a sensitive element of a receiver sensor over a wider temperature range (up to 345 K) than the TGS crystal (up to 322 K) due to the temperature dependence of its pyroelectric coefficient.

This work refers to the synthesis and growth of amino acids salts using SERS method.

The essence of the SERS method is that it includes a complex of microscopic and macroscopic research of crystal synthesis and growth carried out under the influence of acoustic waves (20÷20000Hz). For each crystal, an acoustic wave of a suitable frequency was selected. The impact of low–frequency waves inside the solution is sufficient to form weak intermolecular bonds that promote microcrystallization. Therefore, the nucleation number is significantly reduced, and the solution becomes non–viscous. Thanks to this method, the conditions of growing crystals are effectively optimized, and it becomes possible to reduce the solubility of crystals and grow crystals of optical quality and large size. The crystals were studied by single–crystal X–ray diffraction, IR and UV–Vis spectroscopy, second–harmonic generation methods, and DFT calculations of optical and physical properties were performed.

This work is supported by the Ministry of Science and Education RA, project No. 24WS–1C022.

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# Effects of Temperature Gradients on Atomic Plane Deformation in Quartz Crystals Studied by X-ray Diffraction

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The peculiarities of X-ray diffraction from atomic planes of the same family in different cuts of quartz single crystals under the temperature gradient are investigated. Quartz single crystals have the form of rectangular parallelepiped plates with X- and Z-cuts, one edge of which (heated) was oriented parallel to the reflecting planes ( $10\bar{1}0$ ). The experiments were carried out using collimated polychromatic X-rays in symmetric Laue geometry. For different values of the temperature gradient applied to the crystal, both sectional topograms at different distances from the crystal and spectra of the reflected beam were obtained. The research results showed that the parameters of the deformation field formed at the same temperature gradient applied perpendicular to the reflecting planes ( $10\bar{1}0$ ) of the crystal with different cuts are significantly different: For the same values of the temperature gradient applied to the single crystal, the bending radius in the X-cut sample is always significantly smaller than the bending radius of the Z-cut sample.

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# Electro–Optical Frequency Conversion in the Compensated Light Rangefinder

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The research results reveal that the use of light modulation–demodulation in a linear section of the light modulation characteristic of the rangefinders can dramatically reduce the amount of microwave power and increase the steepness of the relative light intensity curve from a distance by about 15 times. In addition, the operation of the light rangefinders is approaching continuous operation, the signal–to–noise ratio (SNR) is increased and it becomes possible by simply applying a two–phase light modulation mode.

These results are possible by restoring changes in light intensity detected by photodetectors. In high–precision light rangefinders, it is more appropriate to use photodetectors such as a photoelectron multiplier ((PMTs) than other photodetectors. However, when the light rangefinders is operating in the mid–range linear portion of the light modulation characteristic in the microwave range, photodetectors such as photo electronic multipliers do not restore changes in the distance–dependent demodulated signal due to the fact that the frequency of light modulation is several times greater than the bandwidth of the PMTs type.

In order to resolve this problem, it is proposed to implement optical frequency conversion by passing demodulated light through a second identical modulator at the second frequency  $f_g$ , which differs from the modulation frequency  $f_m$  by an amount slightly less than the bandwidth of a photodetector of the photomultiplier (PMTs) type. A functional scheme for constructing a high–precision compensation light rangefinders is also considered.

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# Experimental Investigation of Gold Nanoparticle–Induced Modifications in Silicon Optical Properties

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The indirect band gap of silicon fundamentally restricts its infrared optoelectronic efficiency. We demonstrate that coating thin silicon wafers with sub–nanometrical gold nanoparticles ( $\approx 0.4$  nm) generates a new absorption edge near 950 nm and intense near–infrared luminescence around 855 nm. These effects originate from photon confinement at the nanoparticle–silicon interface, facilitating momentum–assisted transitions that eliminate phonon involvement. The observed quantum–size dependence confirms the nanoscale origin of this behavior, revealing a practical and scalable route to silicon–based NIR emitters and detectors for integrated photonic and sensing technologies.

The research was supported by the Higher Education and Science Committee of MESCS RA (Research project № 24LCG–1C015).

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# **Features of Dynamic X–ray Diffraction in Double–Slit Geometry on Silicon Crystals**

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To observe the interference pattern from two slits in the X–ray range, special conditions are required (synchrotron radiation, large observation distance). For example, in Young's double–slit experiment with hard X–rays was performed, in which the interference pattern was observed at a distance of  $\approx 30$  m from the radiation source. This distance can be reduced by placing an ideal crystal after the slits, which combines the two beams passing through the slits inside the crystal, and an interference pattern can be observed on the exit surface of the crystal.

In this paper, we experimentally investigated the double–slit dynamic X–ray diffraction in silicon crystals. As a result, Young's interference fringes are observed in the cross section of the diffracted beam. The dependence of the number of interference fringes on the crystal thickness is investigated. It is shown that an increase in the crystal thickness leads to an increase in the number of interference fringes. The experimental results obtained are in qualitative agreement with the theoretical ones.

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# Features of Fraunhofer Diffraction on a Slit under Oblique Incidence of an Electromagnetic Wave in the Presence of an External Magnetic Field

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This work presents the results of a theoretical investigation of Fraunhofer diffraction of an electromagnetic wave on a single slit located between two isotropic media, under oblique incidence and exposed to an external static magnetic field.

It is shown that under the influence of the magnetic field, the dielectric permittivity tensor of the medium becomes anisotropic and gyrotropic, leading to the separation of wave modes by polarization and accompanied by the splitting and mixing of diffraction maxima.

The possibility of controlling diffraction characteristics by varying the magnitude and orientation of the magnetic field is established, which makes it possible to enhance or suppress certain diffraction orders depending on the polarization of the wave relative to the magnetic field. Each polarization, as expected, forms its own system of diffraction maxima and minima.

It is revealed that the magnetic anisotropy of the medium leads to local phase shifts and modification of amplitude distribution, as well as changes in polarization, phase, and propagation direction of the waves, since the magnetic permeability of the medium ( $\mu$ ) becomes a function of the magnetic field  $H$ .

$$\mu = \mu_0 + \Delta\mu(H)$$

An analytical expression has also been obtained, and the condition for the diffraction minima in the Fraunhofer far-field region, taking into account oblique incidence and the presence of the magnetic field, has been analyzed.

The obtained results can be applied in the development of new optical systems and components.

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# Fundamental Principles and Physical Foundations of the Theory of Acousto–Optic Interaction in Crystals

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Acousto–optic (AO) interaction in crystals is based on the diffraction of electromagnetic radiation by a periodic modulation of the refractive index induced by elastic waves. The effect is fundamentally governed by photoelasticity, which describes the change in dielectric permittivity under deformation.

In the present paper, the fundamental principles and physical foundations of the theory of AO interaction in crystals are considered theoretically.

The theoretical description of the process is based on Maxwell’s wave equation, taking into account the modulation of the refractive index and the tensor photoelastic coefficients.

The Raman–Nath regime (thin grating, multi–order diffraction) and the Bragg regime (thick grating, single–order diffraction), as well as the diffraction efficiency, are also analyzed. The efficiency of the interaction is determined by the acousto–optic figure of merit of the material, which depends on the refractive index, sound velocity, density, and photoelastic parameters of the crystal.

It is revealed that the anisotropy of the medium leads to a variety of interaction geometries and specific features of polarization effects.

Theoretical investigations of acousto–optic phenomena in crystals show that the amplitude, phase, frequency, and spatial distribution of coherently scattered light are determined by the corresponding characteristics of the acoustic waves.

The theoretical foundations of the AO effect have found broad application in the development of modulators, deflectors, spectral filters, and optical processors, which makes acousto–optics an important direction in modern quantum electronics and photonics.

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# **Investigation of Deformation Fields Induced by Thermal Gradients in Single Crystals Using X–ray Diffraction**

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As is known, the correct choice of the deviation function is very important in order to obtain a certain intensity, spectral and spatial distribution in the diffracted beams formed as a result of X–ray diffraction in deformed crystals. To describe the deviation function, it is sufficient to provide the dependence of the bending radius and interplanar distances of the reflecting atomic planes on the coordinate. In this paper, the deviation function of the deformation field in a crystal caused by an external temperature gradient was investigated using the narrow collimated polychromatic beam X–ray diffraction method.

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# **Multi-Frequency Asymmetric Air Oscillation System for Artificial Lung Ventilation Devices**

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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 air is developed. To this end a system of harmonic or non-harmonic air oscillations has been developed and created (a laboratory simple).

Experimental studies have shown that non-harmonic air vibrations can create aerodynamic forces, that can improve the efficiency of removing mucus and foreign bodies with exhaled air.

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# Experimental and DFT Study of Crystals of Some Amino Acid's Salts

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The subjects of the present study are L–arginine sulfates (LAS·2H<sub>2</sub>O & LAS), L–nitroarginine sulfosalicylate (L–NNA·SSA) and L–Lysine sulfosalicylate trihydrate (L–Lys·2SSA·3H<sub>2</sub>O) crystals. The thermal properties, vibrational spectra, UV–Vis transmittance spectrum and second harmonic generation activity were studied experimentally. The crystal and molecular structure of crystals were determined by the single–crystal X–ray diffraction method. The optimized unit cell volume was reduced by 6.24% for L–NNA·SSA, 6.65% for L–Lys·2SSA·3H<sub>2</sub>O, 9.9% for LAS·2H<sub>2</sub>O and 5.02% for LAS crystal. The theoretically obtained optical properties agree well with the experimental data. In particular, the absorption spectrum of LAS·2H<sub>2</sub>O decreases rapidly at low energy regions, which agrees well with the transmittance spectrum of LAS, suggesting a dielectric nature of both materials. Moreover, the bands originating from the orbital electrons of oxygen (O), nitrogen (N) and carbon (C) are responsible for the formation of energy gaps of about 3 eV for L–NNA·SSA, 2.9 for L–Lys·2SSA·3H<sub>2</sub>O 4.2 eV for LAS·2H<sub>2</sub>O and 4.6 eV for LAS crystals, highlighting their dielectric properties.

This work is supported by the Ministry of science and education RA, projects No. 24WS–1C022 and NAS RA within the framework of the ‘‘Young Scientists’ Support Program’’ No. 24–YSIP–030.

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# Photon Confinement in Sub–Nanometer Gold Clusters for Enhanced Silicon Raman Scattering

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This research investigates the mechanism of Raman signal enhancement for silicon substrates using sub–nanometric gold clusters. The findings indicate that the primary enhancement mechanism is a photon confinement effect intrinsic to the cluster size, contrasting with the Localized Surface Plasmon Resonance (LSPR) effect dominant in larger nanoparticles. Raman spectroscopy and mapping verified that silicon substrates functionalized with Gold Nanoparticles (GNPs) exhibited a marked increase in peak intensity compared to uncoated substrates.

The research was supported by the Higher Education and Science Committee of MESCS RA (Research project № 24LCG–1C015).

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# Photo–Thermal Reconnaissance

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Thermal imaging technologies have become essential components of modern military operations, providing armed forces with the capability to detect, monitor, and engage targets in complete darkness, adverse weather, and visually obscured environments. These systems operate by detecting infrared (IR) radiation naturally emitted by all objects above absolute zero, converting temperature variations into visible images. Human bodies, for instance, emit IR radiation in the 4–5  $\mu\text{m}$  wavelength range, making them easily detectable by thermal sensors even through smoke, fog, or camouflage. This gives thermal imagers a unique advantage, often earning them the name "night eyes" of the soldier.

Modern thermal imaging devices—such as scopes, monoculars, binoculars, and clip–on attachments—utilize uncooled or cooled microbolometer arrays to capture thermal data and generate high–contrast images of the environment. Lenses made from germanium, which is transparent to IR radiation, focus the heat signatures onto the sensors, while onboard processors convert these signals into visual displays. This allows for the detection of hidden or camouflaged objects, improving target acquisition and situational awareness. Advanced systems can detect human–sized targets at distances of 2 to 3 kilometers, significantly enhancing operational effectiveness.

Despite their many advantages, thermal imaging devices also present challenges. Their cost remains high due to expensive materials and precision engineering, and they tend to consume significant energy, requiring frequent battery replacements or external power sources. Additionally, image resolution is generally lower than that of conventional optical systems, and the devices can be bulky, especially in older models. However, advances in miniaturization, sensor sensitivity, and energy efficiency increasingly mitigate these drawbacks.

For Armenia, where terrain and visibility can complicate operations, integrating advanced thermal optics into infantry, drone, and surveillance units can significantly enhance national defense capabilities.

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# Remotely Controlled Ball

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In this work we present the design and operation principles of a remotely controlled ball. The device is designed to move across flat and inclined surfaces using electric motors, an integrated microcontroller, and a wireless control system. Control is carried out via Bluetooth or Wi-Fi connection using a mobile application or a remote controller. A control algorithm has been developed to maintain balance and ensure smooth directional changes. Experimental results demonstrate the system's efficiency on various surfaces. The device can be used for educational, research, and entertainment purposes, as well as for the development of small robotic platforms.

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# Resonant Photoelasticity of Crystals in External Static Electric and Magnetic Fields

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In this work, the phenomenon of resonant photoelasticity of crystals is theoretically investigated, arising from the interaction of electromagnetic radiation with the elastic properties of the crystal in the presence of external static electric and magnetic fields.

It is shown that the application of static fields significantly modifies the spectrum of electronic and phonon excitations of the crystal, which leads to enhancement or suppression of the photoelastic effect near the resonant frequencies.

A general expression has been obtained for the resonant part of the dielectric permittivity of the crystal in the quasi-stationary and quasi-homogeneous approximation, under the propagation of a sufficiently strong acoustic wave, which induces a nonlinear modulation of its dielectric permittivity with respect to the sound amplitude  $\Delta\varepsilon_{ik}$ . In the limit of weak external magnetic fields, the main effect on the dielectric permittivity of the crystal is exerted by the electric field, causing the Franz-Keldysh effect and thereby broadening the resonance. It is noted that the application of a sufficiently strong electric field leads to the weakening of the resonant properties of the linear photoelasticity tensor, as well as to the suppression of nonlinearity in the modulation of the dielectric permittivity of the crystal by the acoustic wave. In this case, the dependence  $\Delta\varepsilon_{ik}$ , which is nonlinear with respect to the sound amplitude in the absence of an electric field, becomes an almost linear function of the sound amplitude when a strong electric field is applied.

It has been revealed that in the presence of crossed electric and magnetic fields of comparable amplitudes, a number of strong resonances arise in the behavior of the photoelastic tensor components as a function of light frequency, with the maximum values of the photoelastic tensor components significantly exceeding those in the absence of external fields.

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# Satellite Communication Systems

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Twenty-first century communications have rapidly evolved from early wireless innovations to pervasive satellite-based systems that underpin civilian and military operations worldwide. This paper examines the strategic role of satellite communications (SatCom) for Armenia, tracing the technology’s conceptual origins and practical utility and assessing current national capabilities and constraints.

Satellite links are particularly transformative for unmanned aerial systems (UAS), extending operational range and shrinking control latency (commonly to the order of 20–40 ms) compared with direct radio links, thereby enabling near-real-time video, command–and–control, and rapid tactical decision-making. Militarily, SatCom enhances situational awareness, secure force networking, and resilience to electronic warfare, especially when low-orbit assets and diverse frequency bands are employed.

Armenia’s space capabilities remain nascent. The civilian ArmSat–1, launched in 2022 in cooperation with Satlantis, provides modest spatial resolution (~1.8 m) suitable for mapping and environmental monitoring but falls short of dedicated military reconnaissance requirements. Consequently, Armenian defense forces rely heavily on commercial imagery and services from international providers (e.g., Airbus, Maxar, Planet, Satellogic) and on allied navigational support such as Russia’s GLONASS. Bilateral ties with partners including Russia, France, and India supply complementary technical and intelligence assistance, yet Armenia lacks sovereign, mission–tailored military SatCom and ISR assets.

The report recommends a phased strategy for strengthening Armenia's national security: developing small satellites for specific missions, securely integrating data, strengthening ground infrastructure and cyber defense, and developing local expertise through partnerships.

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# Terahertz Few–particle Magnetoabsorption in Asymmetric Ellipsoidal Ge/Si QD

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In this paper, the behavior of a heavy–hole gas in a strongly oblate, asymmetric ellipsoidal Ge/Si quantum dot under an axial homogeneous magnetic field has been investigated. Due to the specific geometry of the quantum dot, the interaction between holes is considered two–dimensional. The realization of the generalized Kohn theorem in such a system under the influence of the incident long–wave radiation has been shown in the dipole approximation. The exact energy spectrum has been obtained for the case of a strongly oblate ellipsoidal QD with a circular cross–section, using the Johnson and Payne model of a circular two–dimensional parabolic well. A detailed analysis of the energy spectrum is presented.

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# The Path of Development of the Armenian Air Force

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This report examines the historical development, current status, and prospective directions of Armenian military aviation and air force capability. Tracing the conceptual origins of human flight from Leonardo da Vinci's Renaissance designs to the Wright brothers' first powered flight in 1903, the study situates Armenia's aeronautical tradition within broader technological and historical currents. It emphasizes contributions of Armenian-born and Armenian-heritage aircraft designers and engineers—most notably Artem Mikoyan, Hel Margaryan, Rollan Martirosov, and Mikael Poghosyan—whose design leadership and technical innovations substantially influenced Soviet and global military aviation development through platforms such as the MiG and Su families.

Following the Soviet Union's collapse, Armenia inherited limited aviation assets, forming the basis of its small air force. Developed under tight economic and geopolitical constraints, the force relies on aging aircraft and helicopters, with growing emphasis on domestic unmanned aerial systems. Challenges include outdated platforms, limited training capacity, and emerging threats from precision weapons and drones.

To respond, this paper recommends targeted modernization: upgrading key platforms, developing UAV capabilities, enhancing technical training, and improving electronic and cyber warfare capacities. It also stresses the need for diversified international cooperation to support sustainable, mission-focused growth of Armenia's air power.

In conclusion, while Armenian military aviation remains modest in scale, targeted reforms and sustained investment in people, platforms, and integrated systems can significantly improve operational readiness and strategic resilience. The legacy of Armenian aviation pioneers provides both a technical heritage and an aspirational model for contemporary modernization efforts.

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# The State and Prospects of Armenia's Air Defense

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The Air Defense system of Armenia is an integral part of the Armed Forces. Given Armenia's geopolitical challenges and regional instability, the country has continually sought to modernize its air defense capabilities, drawing from both Soviet-era legacy systems and international partnerships.

This report provides a comprehensive overview of the historical evolution, technical characteristics, and current state of Armenia's air defense system.

The limitations of Armenia's inherited Soviet-era air defense system—especially evident during the 2016 April clashes and the 2020 44-day war in countering UAVs, precision-guided munitions, and modern missile threats—served as a wake-up call, prompting a strategic overhaul of the country's air defense doctrine and capabilities.

Today, Armenia is adopting a multi-layered air defense approach, combining legacy Soviet systems (such as the S-300, Osa, Buk, Strela-10) with newer radar technologies (e.g., the French GM200, Indian Swathi) and electronic warfare components. The goal is to build a modern "Air Dome" concept—similar to models employed by Israel, the United States, Germany, and Ukraine—based on a layered network of radars, electronic countermeasures, and missile interceptors covering short, medium, and long ranges.

In conclusion, Armenia's air defense is in a transitional phase—from a legacy Soviet structure to a flexible, modern, multi-tiered system. While challenges such as limited financial resources and geopolitical constraints remain, with strategic planning, international cooperation, and political will, Armenia has the potential to build an effective and resilient air defense system capable of deterring future threats and ensuring national security.

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# Tuning Graphene Interlayer Spacing with Ionic Liquids for CO<sub>2</sub> Absorption

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Graphene, a two-dimensional material with outstanding structural stability and tunable electronic behavior, represents a strong candidate for next-generation environmental technologies. One promising approach involves introducing ionic liquids (ILs) between graphene layers to regulate interlayer spacing and improve selective gas absorption. Recent computational studies [1] have indicated that imidazolium-based ILs, including [Bmim][BF<sub>4</sub>] and [Bmim][PF<sub>6</sub>], can act as molecular spacers, widening the graphene interlayer distance and forming slit pores in the range of 3–6 Å—an optimal scale for CO<sub>2</sub> absorption. In this work, we experimentally investigated several of these IL-graphene systems, identifying clear IL intercalation signatures through Raman and FTIR analysis and confirming absorption trends consistent with theoretical predictions.

The research was supported by the Higher Education and Science Committee of MESCS RA (Research project № 24LCG-1C015, № 23RL-1D001 and № 23LCG-1D019).

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# Visualization of Phase–Contrast Images of Weakly Absorbing Objects Using on X–ray Interferometer

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The paper proposes a new method for visualizing phase–contrast images of polymeric substances using an X–ray interferometer, which makes it possible to determine some of their properties. In particular, based on a three–crystal (two–beam) interferometer, the refractive index and density of polymers were determined by analyzing changes in interference (moiré) patterns. A special device (phase modulator) was prepared and tested to measure the phase change when it is placed in one of the interfering beams. It is shown that the presence of a sample in one of the interfering beams creates shifts in the moiré pattern fringes relative to the fringes obtained in the absence of a sample. The influence of changing the phase relationship of interfering coherent beams on the interference pattern was investigated. The phase shift was determined experimentally and the unit decrement of the refractive index of the sample was calculated. A special device was designed and tested, which allows to change the radius of a cylindrical polymer wire by stretching it. Changing the interference (moiré) patterns and the corresponding diffracted beams in the interferometer leads to the visualization of a phase–contrast image of the polymer cord, which allows its diameter to be determined with great accuracy.

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# A New Dichloridodicopper(II) Tetrakis( $\beta$ -alanine) Dichloride Monohydrate Crystal

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Previously, two amino acid ( $\beta$ -alanine and glycine) salts based on  $\text{CuCl}_2$  were known:  $(\beta\text{-AlaH})_2\text{CuCl}_4$  with dimeric ( $\text{A}^+\cdots\text{A}^+$ ) type ( $\beta\text{-AlaH}\cdots\beta\text{-AlaH}$ ) cation [1] and a salts  $[\text{GlyH}\cdots(\text{GlyH}\cdots\text{Gly})\cdots\text{GlyH}](\text{CuCl}_5)$  with tetrameric  $[\text{A}^+\cdots(\text{A}^+\cdots\text{A})\cdots\text{A}^+]$  type cation [2]. We tried to obtain a similar salt with tetrameric cation of  $\beta$ -alanine. However, we obtained a compound with a  $(\text{CuCl}_2)_2(\beta\text{-Ala})_4\cdot\text{H}_2\text{O}$  (**I**) composition as a first phase and  $(\beta\text{-AlaH})_2\text{CuCl}_4$  as a second phase. Later, the crystal (**I**) also was obtained from a solution, containing stoichiometric composition,  $2\beta$ -alanine +  $\text{CuCl}_2$ . In the present work we describe the structure of the dichloridodicopper(II) tetrakis( $\beta$ -alanine) dichloride monohydrate crystal (**I**)  $\text{Cu}_2[(\text{Cl})_2(\beta\text{-Ala})_4](\text{Cl})_2\cdot\text{H}_2\text{O}$ . In contrast to  $(\beta\text{-AlaH})_2\text{CuCl}_4$  and  $[\text{GlyH}\cdots(\text{GlyH}\cdots\text{Gly})\cdots\text{GlyH}](\text{CuCl}_5)$  salts, in the structure of (**I**)  $\beta$ -alanine is not in cationic, but in zwitterionic state. The compound (**I**) crystallizes in triclinic system with space group  $P\bar{1}$ ,  $Z=2$ . The  $\text{Cu1}-\text{Cl1}$  and  $\text{Cu2}-\text{Cl2}$  distances are of 2.4388(4) Å and 2.4569(4) Å, respectively, and the distances  $\text{Cu1}-\text{Cu1}$  and  $\text{Cu2}-\text{Cu2}$  are of 2.6565(4) Å and 2.6273(4) Å, respectively. The  $\text{Cu}-\text{O}$  distances fall in the 1.97–2.00 Å range. The structure is additionally stabilized due to  $\text{N}-\text{H}\cdots\text{Cl}$ ,  $\text{N}-\text{H}\cdots\text{O}$ ,  $\text{C}-\text{H}\cdots\text{Cl}$ ,  $\text{C}-\text{H}\cdots\text{O}$  and  $\text{O}-\text{H}\cdots\text{Cl}$  type hydrogen bonds. The IR spectrum of (**I**) is interpreted based on its structure.

The work was supported by the Science Committee of RA, in the frame of the research project # 21AG-1D015.

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# **A Unique Pattern of Quasar Distribution**

## **Around the 3C 129 Radio Galaxy**

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Studies of the distribution of extragalactic sources within a region of  $6^\circ$  radius around the 3C 129 radio galaxy show that the number of extragalactic sources in this region does not significantly differ from the number of extragalactic sources in other regions. However, the distribution of quasars in the same region not only differs substantially from the quasar distribution in other regions, but it can also be said that quasars are almost absent there.

Within the  $6^\circ$  radius around the 3C 129 radio galaxy, only two quasars have been detected. This deficit of quasars cannot be explained by the presence of an absorbing medium, since thousands of extragalactic sources have been identified in the same region, of which only two are quasars, and all these extragalactic sources are relatively nearby. This fact allows us to assert that, from the perspective of quasars, a void exists around the 3C 129 radio galaxy.

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# Acoustically Sensitive Inductive Sensor

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Inductive systems, today, are used in all areas of science and technology. The achievements of modern science have led to the fact that such systems can be used in various devices in relatively small sizes. One of the important advantages of inductive acoustic sensors is that the devices are connected to the sensor, which process the signal from the sensor, do not necessarily have to be located directly near the sensor, which allows the sensitive part or the sensor to be used in its entirety even in unfavorable conditions. Inductive sensors also work reliably in difficult conditions, which is why inductive sensors are often used when it is necessary to ensure the safety and reliability of work. Such a requirement is widely used in military, aerospace, railway and heavy industry. Such an approach to inductive sensors is due to the fact that their principle of operation is based on the fundamental laws and principles of physics.

This work presents a sensitive, acoustically wide-range inductive sensor, the peculiarity of which is that due to the inductive system used, the so-called sensitive mechanical, "acoustic" element can have very small geometric dimensions. In particular, its linear dimensions may not exceed the dimensions of the screen of a small spherical transducer.

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# Acoustoplasmic Phenomena

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The results of experimental work obtained by the author over the past 30 years are presented. Acoustoplasma obtained by sinusoidal modulation of discharge current is considered. When plasma interacts with acoustic waves, an acoustoplasmic state arises. If in a conventional plasma, without acoustics, the Coulomb long-range action manifests itself chaotically, i.e., is practically uncontrollable and leads to various, again chaotic, instabilities and oscillations, then in acoustoplasma, standing waves form lattices of parameters and the medium becomes similar to a condensed one, and self-organization occurs in it. Both plasma and acoustoplasma are self-consistent media, i.e. when changing one of the controlling parameters, many controlled parameters can change. In a conventional plasma (without acoustic disturbance), for a given geometry of the discharge tube, a given type of gas and a given pressure, there remains only one control parameter – the discharge current. In the acoustoplasma mode, three new control parameters appear: the frequency, depth of modulation of the discharge current and the shape of its variable component (i.e., the frequency spectrum). Thus, it becomes possible to control almost all parameters of acoustoplasma. This makes it possible to create new types of devices and instruments based on acoustoplasmic interaction.

A table of 40 cells is provided. Each cell corresponds to a group of experiments united to study a single phenomenon. Some cycle of work ended with the creation of corresponding devices that operated in acoustoplasma mode. Because there are many cells, only a small fraction of the experiments has been completed. Most of the cells indicate possible directions for future work. In other words, a control experiment has been conducted demonstrating the existence of this phenomenon. However, further work has been frozen on hold due to a lack of funding.

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# **Astronomical Detectors Operating in the 0.01–100 THz Frequency Range**

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This study addresses the design and application of ultra-high sensitivity detectors operating in the 0.01–100 THz frequency range. The world's leading unique detectors in this spectral domain have been developed specifically for astronomical applications and are deployed across various branches of observational astronomy.

The most sensitive detectors employed in astronomy are engineered to address specific astronomical challenges, each characterized by distinct operational spectral ranges and exceptional sensitivity thresholds, representing the state-of-the-art in detection capabilities.

These unique detectors are designed and manufactured by specialized high-tech companies and research centers in response to specific requirements articulated by the astronomical community. A comparative analysis of these detector systems has been conducted, with particular emphasis on identifying emerging development trends in the field.

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# Cherenkov Diffraction Radiation From 3D-Printed Dielectric Targets

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Cherenkov diffraction radiation (ChDR) arising from the interaction of relativistic electron beams with dielectric interfaces, holds significant potential for non-invasive beam characterization and generation of the intense electromagnetic radiation at THz and sub-THz frequencies. This research addresses the challenge of fabricating complex dielectric geometries by employing fused filament fabrication. The application of 3D-printed dielectric targets for generating ChDR is explored.

A critical prerequisite for this approach is a full assessment of the dielectric characteristics of the resulting 3D-printed samples. The dielectric parameters as refractive index, absorption, reflection of various 3D-printed polymers were measured to identify suitable materials. A selected polymer was used to fabricate a target with a specific geometry.

A target was then printed and tested at the MT-25 microtron (Dubna, Russia) with a 7 MeV electron beam passing parallel to its surface. The generated ChDR was analyzed and its characteristics were compared to those of radiation produced by a standard milled teflon target, validating the 3D printing approach.

This research was supported by TPU development program Priority 2030.

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# Comparative Spectral Analysis of Language Acoustics: Frequency Dominance, Characteristics, Patterns

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This study presents a comparative spectral analysis of Italian, Armenian, English, Russian, Mandarin, Turkish and German languages. The spectral comparative analyses were conducted based on measured results published in international research papers. The AI tools were additionally utilized for data collection. Consistent verification of collected data was applied throughout.

The foundation of this comparative analysis rests on findings from acousto–physical spectral research. Through comparison of Italian, Armenian, German, Russian, Mandarin, Turkish and English, a unique Italian frequency phenomenon has been delineated. However, the verified research data revealed insufficient spectral research coverage for the Armenian language, resulting in partial outputs from comparative analyses.

The gap in acousto–physical spectral investigation of Armenian presents a significant opportunity for scholarly contribution. To address this deficiency, we propose conducting comprehensive acousto–physical spectral research utilizing a representative Armenian language audio corpus. Such investigation would advance our understanding of language–specific frequency phenomena. The research would employ deep, diversified acousto–physics spectral analysis to establish Armenian language acoustic characteristics comparable in depth and rigor to existing studies of other major languages.

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# Detectors Operating in the Terahertz Range

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A review of detectors in the radio–optical range is presented. In this area, the laws of radio engineering and the laws of optics can be applied simultaneously. Optoacoustic, bolometric, and pyro–optic (piezo) detectors, Schottky and metal–oxide–metal (MOM) diodes, microminiaturization of antennas used in the radio range, and other detectors are discussed.

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# Determination of the Refractive Index of Polymer Samples in the Terahertz (THz) Range

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This study demonstrates high-precision refractive index characterization of various solid polymer samples, including 3D-printed materials, using continuous-wave (CW) terahertz spectroscopy based on photomixing. The experimental setup employed frequency-stabilized DFB laser diodes, enabling a non-mechanical imaging scanning methodology based on frequency variation. The results confirm that this technique delivers highly accurate refractive index measurements across a wide terahertz frequency range. Consequently, this work establishes CW terahertz photomixing spectroscopy as a robust and effective method for the nondestructive evaluation and material characterization of polymeric systems.

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# **Diamagnetic Susceptibility and Binding Energy of Hydrogenic Impurity in CdSe Nanoplatelets: Effect of Dielectric Mismatch and Size–Quantization**

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This study examines the binding energy and diamagnetic susceptibility of a hydrogen–like donor impurity in colloidal CdSe nanoplatelets, taking into account polarization effects arising from the dielectric mismatch between the nanoplatelet and its surrounding medium. The adiabatic approximation and numerical methods are employed to solve the Schrödinger equation. The influence of impurity position, number of atomic monolayers, and environmental permittivity on impurity states is analyzed. The results reveal a non–monotonic dependence of the donor binding energy on impurity position and a strong sensitivity of the diamagnetic susceptibility to nanoplatelet thickness and dielectric mismatch. The behavior aligns with recent experimental trends observed for excitonic states in colloidal CdSe nanoplatelets. These insights provide valuable design guidelines for dielectric engineering and impurity control in optoelectronic applications.

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# **Diffraction of an Extended Source Field by a Finite–Dimensional Regular Grating**

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We study the scalar diffraction of a fully coherent extended source by a finite–sized regular amplitude grating, considered both as a periodic diffraction element and as a limiting aperture. It is assumed that all points of the source emit spherical waves with the same initial phase (a phase–matched source). The solution method is based on the proposed approach, which simultaneously imposes constraints on the wave parameters of illumination and observation. We discuss the dimensions of the solid angle encompassing the direction of the source's principal radiation maximum, within which the source field can be approximated as spherical, or, in the limiting case, as planar.

Particular attention is given to situations where the characteristic size of the grating is significantly smaller than the region of "sphericity/flatness" of the source field, so that this approximation is uniformly valid across the entire aperture. It is shown that the resulting diffraction pattern simultaneously exhibits elements of diffraction by a slit and an obstacle (respectively, a single–slit envelope and a finite aperture effect). The results and conclusions are further substantiated by an analytical analysis of a one–dimensional diffraction grating of finite dimensions illuminated by a linear source of limited extent.

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# Fermionic Condensate and the Vacuum Energy–Momentum Tensor for Planar Fermions in Homogeneous Electric and Magnetic Fields

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We consider a massive fermionic quantum field localized on a plane in external constant and homogeneous electric and magnetic fields. The magnetic field is perpendicular to the plane and the electric field is parallel. The complete set of solutions to the Dirac equation is presented. As important physical characteristics of the vacuum state, the fermion condensate and the expectation value of the energy–momentum tensor are investigated. The renormalization is performed using the Hurwitz function. The results are compared with those previously studied in the case of zero electric field. We discuss the behavior of the vacuum expectation values in different regions for the values of the problem parameters. Applications of the results include the electronic subsystem of graphene sheet described by the Dirac model in the long–wavelength approximation [1].

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# Generalization of the Oscillator–Kepler Correspondence

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The Hamiltonian description of the generalized Bolin transform is given, which relates systems with different power potentials. An analogy of this correspondence is proposed on curved surfaces of non-constant curvature, generalizing the sphere and hyperbola. The correspondence between the classical two-dimensional Kepler problem and the two-dimensional isotropic circular oscillator is considered.

In this case, the integrals of the oscillator motion are transformed into the rotational moment and the Runge–Lenz vector of the two-dimensional Kepler problem when moving from the oscillator problem to the Kepler problem. When moving from the oscillator problem to the Kepler problem, the rotational moment of the system doubles, which manifests itself in a double bypass of orbit in the Kepler problem with a single bypass of orbit in the oscillator problem.

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# Halogenobismuthate Salts Containing Different Amino Acids

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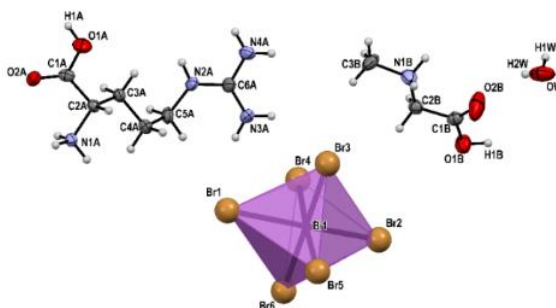
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Recently, the first such salt: (L-ArgH<sub>2</sub>)(SarH)(Bi<sub>2</sub>I<sub>9</sub>)·2H<sub>2</sub>O, containing L-argininium(2+) and sarcosinium cations was discovered [1]. In the present work we report on synthesis and characterization of two new such salts: (L-ArgH<sub>2</sub>)(SarH)(BiBr<sub>6</sub>)·H<sub>2</sub>O and (L-ArgH<sub>2</sub>)(SarH)(BiI<sub>6</sub>)·H<sub>2</sub>O.

The obtained crystals were characterized by crystal and molecular structure determination (Figure 1) and by infrared and Raman spectra. Their electronic structures were calculated based on the crystal arrangement by the DFT method, and the bandgap was experimentally measured using powder diffuse reflectance spectroscopy.



**Fig. 1.** Molecular structure of (L-ArgH<sub>2</sub>)(SarH)(BiBr<sub>6</sub>)·H<sub>2</sub>O.

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# Impact of X–ray Irradiation on the Stability of DNA in the Presence of Anticancer Drugs

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Cisplatin, a widely used anticancer drug, provides therapeutic benefit but causes systemic toxicity and severe side-effects. Porphyrins, another class of compounds used in photodynamic therapy, selectively accumulate in tumour cells and exhibit unique biochemical properties and antitumour activity. Understanding the combined effects of cisplatin, porphyrins, and ionizing radiation on DNA could inform novel therapeutic strategies. To investigate the synergistic effects of cisplatin and porphyrin on DNA stability under X–ray irradiation using thermal denaturation analysis. Cisplatin was dissolved in distilled water (1 mg/ml). Platination of DNA performed in the dark at 37°C during 48 hours in 0.01 M NaCl. Melting curves were obtained using an Agilent Cary 3500 Multizone UV–VIS spectrophotometer at a heating rate of 1C/1 min. The relative concentration of AgTOEPyP4 porphyrin to DNA base pairs is equal  $r=0.02$ .

As observed in the results of melting experiments, the melting temperature of platinated DNA ( $T_m$ ) is lower than that of non-platinated DNA. Melting curves of the irradiated DNA molecule already differ from the melting curve of non-irradiated DNA. Thus, irradiation with an X–ray beam leads to structural changes in DNA, which directly affects the melting curves and, consequently, the melting parameters. Thermal melting experiments of DNA and *cisPt*–DNA complexes at different relative concentrations ( $r=0.01, 0.025, 0.04$ ) were performed at 2 Gy dose of irradiation also. The melting temperature increases for DNA/cisplatin complexes at  $r=0.04$  relative concentration of cisplatin compared to non irradiated complexes. The addition of AgTOEPyP4 porphyrin leads to more stabilization of *cis*–*Pt*/DNA complexes. Upon X–ray irradiation with a dose of 2 Gy, the DNA/*cis*–DDP complex is destabilized at presence porphyrin relative concentration  $r=0.02$ . Our findings reveal dose– and composition–dependent effects on DNA stability. The paradoxical stabilization of irradiated cisplatin–DNA complexes and the destabilizing effect of porphyrin under irradiation warrant further investigation into the underlying mechanisms. These results may have implications for optimizing combined chemoradiotherapy protocols and photodynamic therapy strategies in cancer treatment.

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# **Intermediate Results of Mathematical Analyses of the Distribution of Extragalactic Sources Around Extended Radio Sources**

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Up to now, the distribution of extragalactic sources has been examined in the vicinity of 18 out of the 35 extended radio sources listed in the general catalog. The regions where the distribution of extragalactic sources is consistent with the assumptions of a homogeneous Universe have been grouped together. In contrast, the regions where the distribution indicates cosmic inhomogeneity are discussed separately. For the purpose of statistical analysis, we relied on the large populations of extragalactic sources found in these regions. Particular emphasis has been placed on the distribution of quasars, as we consider them to play a central role in probing the large-scale structure of the distant Universe. In certain cases, it is not possible to draw a definitive conclusion regarding homogeneity or inhomogeneity within a given region. However, there are regions where clear evidence for cosmic inhomogeneity is observed. Among the 18 regions studied, there are some in which it can be stated unambiguously that the Universe is inhomogeneous.

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# Investigation of 3D–Printed Sample Properties for Radiation Physics Applications

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Additive manufacturing technologies have become an indispensable tool in modern accelerator physics and relativistic electron beam research, a status achieved through their unique capability to produce components with complex geometries and tailored material properties. This study presents a systematic investigation into the radiation–related properties of five distinct 3D–printed polymers: SBS (styrene–butadiene–styrene), known for its flexibility and impact resistance; HIPS (high–impact polystyrene), valued for its mechanical durability; pure PLA (polylactic acid), which serves as a biodegradable reference material; and two metal–doped PLA variants containing copper and bronze additives, respectively, which are designed to enhance radiation interaction properties. The investigation encompassed measurements of the refractive index, transmission rate, Hounsfield units, and relative electron density. Particular attention was devoted to establishing correlations between specific 3D printing parameters and the resulting radiation–related properties of the fabricated samples. The complete dataset obtained in this study serves as a valuable reference for designing and optimizing 3D–printed components for various accelerator applications, including beam collimators, energy degraders, and dosimetry phantom design. Furthermore, it provides fundamental insights into the relationships between additive manufacturing processes and the resulting radiation interaction properties in polymer–based materials.

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# Investigation of Channeling Radiation under the Influence of Ultrasonic Waves

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The measurement and verification of the influence of ultrasonic waves generated in a single crystal on planar electron channeling radiation turned out to be an experimental challenge. After a brief explanation of channeling radiation (ChR) as an intense tunable quasi-monochromatic source of X-rays [1], theoretical calculations modelling the influence of ultrasound (US) on ChR [2] as well as experimental requirements are discussed. Measurements on an US superlattice of a quartz single crystal have been performed at the ELBE linac of the HZDR Dresden. Results are presented for discrete ChR lines and defined crystallographic planes of quartz as calculated in the framework of quantum mechanics [3].

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# Leading Application Fields of Equipment and Instruments Operating in the 0.01–100 THz Frequency Range

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This study investigates and presents application fields of the 0.01–100 THz frequency range in developed countries, including: Spectroscopy & Material Characterization, Security & Non-Destructive Testing, Telecommunications & Data Transfer, Astronomy & Atmospheric Science, Biomedical & Pharmaceutical, Industrial Process Control, Research Instrumentation, Synchrotron & Free Electron Laser Facilities, THz Microscopy & Near-field Systems, THz Cameras & Imaging Arrays, Gyrotrons & High-Power Sources, Optical Parametric Systems, Cryogenic Systems for THz, THz Radar & Communications Test, Photomixing & CW THz Systems, Plasma Diagnostics, THz Frequency Combs, Semiconductor Metrology, Metamaterial & Advanced Components, and Key Component Suppliers. Organizations operating in the aforementioned fields and engaged in the design and manufacturing of equipments and instruments have been identified utilizing available open sources.

Particular attention has been focused on companies designing and manufacturing equipments and instruments operating within the 0.01–100 THz frequency range to identify future development directions and the expansion of applications in the 0.01–8 THz frequency range.

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# Obtaining Phase Images for the Terahertz Range Using a Tabletop Mach–Zehnder Interferometer

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Phase–contrast projection images from different type of low absorbing phase objects was obtained using a tabletop Mach–Zehnder interferometer for terahertz radiation range, based on a laboratory THz source and a matrix detector provided by TeraSense. These images were used to obtain a pure phase distribution in the projection plane and the refractive index of the objects' materials was measured in the terahertz range. Additionally, a set of test phase–contrast images was obtained for samples of different shapes.

This study was supported by the Science Committee of RA (Research project № 23RL–1C037).

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# On Certain Issues of Intermolecular Interactions in Nematic Liquid–Crystalline Systems that are Based on Polar Liquid Crystals

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Electron donor–acceptor liquid crystals have garnered considerable attention due to their potential applications in optoelectronics and photonics. The creation of such charge transfer complexes is a powerful and flexible instrument for modifying the structures and properties compared to those of the initial components.

In the present work, the investigation of a specific intermolecular interaction – the formation of charge transfer complexing (CTC) in nematic liquid crystal (NLC) systems that are based on polar liquid crystals ( these compounds have a large dipole moment directed along the long axis of the molecule ) was carried out by UV and IR spectroscopy.

In the UV spectra of such NLC systems, a new absorption band appears, the position of the maximum of which, depending on the composition and temperature of the LC system, changes in the range of 300–390 nm. The emergence of a new band can be explained by the formation of the CTC from various compositions. A possible mechanism for the formation of the CTC of  $DA$  or  $D_2A$  type is presented. The analytical expressions for equilibrium constants of the complexation process were derived, and the concentrations of the complexes were determined based on the absolute rate reaction theory. The molecular length of the CTC  $l_{CTC}$  is found to be in the range:  $l_0 < l_{CTC} < 2l_0$ , where  $l_0$  is the length of the donor molecule. Hence, it becomes obvious that the complexation promotes the formation of the smectic phase, builds the induced smectic  $A_d$  phase in NLC systems.

Another feature of the UV spectra: with the increase of the donor concentration the  $\lambda_{max}$  of the absorption band of the  $DA$  type CTC is shifted to longer wavelength by 90 nm, that is, to the decrease in the charge–transfer band energy observed in the UV spectra. The static interaction explains such a shift in molecular crystals. The investigation has a practical importance in the development of the new LC materials for electro–optical systems.

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# **Parametric Amplification of Discharge Current Oscillations in An Acoustoplasma Discharge**

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An increase in oscillations in an acoustoplasmic discharge obtained with sinusoidal modulation of the discharge current is reported. The amplification at the subharmonics of the modulation frequency is obtained if the frequency of the subharmonics coincides with the acoustic modes of the discharge tube. In this case, the mechanism of competition of modes plays a role. Since the amplification occurs at a subharmonic, which is equal to half the modulation frequency, a parametric mechanism for amplifying current oscillations is considered. The experiment was carried out for helium gas at a pressure of 20 torr. The inner diameter of the discharge tube is 15 mm. At current densities less than 5 mA/cm<sup>2</sup>, no acoustoplasmic effects were observed. The parametric amplification effect was observed at an average discharge current of > 6 mA/cm<sup>2</sup>. The modulation depth was  $\approx 0.5$ . An amplification of 5 times was obtained.

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# Positron Channeling Along the Main Axes in Crystals with a Fluorite Structure

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In [1], the features of channeling and the resulting spontaneous radiation during channeling of relativistic electrons in the main planes (100), (110), and (111) in complex crystals of  $\text{CaF}_2$ ,  $\text{SrF}_2$  and  $\text{BaF}_2$  with a fluorite structure were investigated. It was shown that, as in complex crystals of tetrafluoroaluminates (see [2]), a fairly intense short-wavelength spontaneous radiation arises, which depends significantly on the angular dispersions of the electron beams, as well as on temperature factors.

In this paper, the channeled motion of relativistic positrons along the main axes [100], [110], and [111] is studied in these crystals. Calculation of the interaction potentials, for example, with the [110] axes, shows that fairly deep potential wells arise in rectangular regions of the interaxial space. Based on the numerical solution of the Schrödinger equation in Cartesian coordinate systems, the transverse energy levels and the corresponding wave functions for relativistic positrons with different Lorentz-factors are found. Further, using these data and in accordance with the methodology described, for example, in [3], the spontaneous radiation spectra for positron beams with different angular dispersions are investigated in the dipole approximation.

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# Quantum Motion of a Single Photon in an Arbitrary Medium

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Until now, the quantum theory of the photon has not been sufficiently developed; moreover, the wave function of the photon is often considered a controversial. It should be noted that only the quantum theory of electromagnetic radiation is well developed, and, aside from frequency (wavelength), it provides no other information about the photon. The main difficulties are that photons are never non-relativistic and can be freely emitted and absorbed, so there is no law of conservation of the number of photons for them, which makes their description within the framework of the usual paradigm of quantum mechanics, if not impossible, then very problematic. Meanwhile, theoretical attempts to determine the wave functions of the photon have a rich history and date back to the time of the emergence of quantum mechanics itself. It should be noted that quantum physics, which seeks to provide a complete description of various natural phenomena, must be able to describe such a fundamental physical particle as a photon, which is impossible without formulating the concept of the wave function of this particle. Note that the cross sections of all processes involving photons strongly depend on their spacetime structure. The problem is becoming increasingly important due to the rapid growth in the number of experiments on the generation and detection of single photons, related to such important areas as quantum computing and quantum cryptography, quantum measurements, quantum communications and other ultra-sensitive quantum technologies. To solve the problems, we considered the wave function of a single photon within the framework of the gauge symmetry group  $SU(2) \times U(1)$ , using the Yang–Mills (Y–M) equations for Abelian fields. Taking into account the Y–M equations, a system of second-order equations is obtained that describes the three-component vector wave function of a photon. We derived a Klein–Gordon–Fock type equation for the full wave function of the photon, taking into account the helicity of the particle. By considering the propagation of a photon in a nanofiber inside which quantum dots are randomly placed, the mathematical expectation of the photon wave function is obtained. Expressions for the probabilities of transitions of a single photon to various Bell states are constructed.

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# Quasi–Monochromatic Polarization Radiation of Moderately Relativistic Charge Particles

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The report shows investigation of methods for generating monochromatic radiation from moderately relativistic charged particles. The main focus is on polarization radiation mechanisms such as transition radiation and Vavilov–Cherenkov radiation. These mechanisms are considered in the context of developing new radiation sources and methods for diagnosing charged particle beams.

The relevance of the research is due to the development of compact high–frequency electron guns with a photocathode, which allow generating short electron bunches with a high repetition rate. Such bunches find application in free–electron lasers, X–ray sources, and other devices.

The work conducts a theoretical and experimental study of the mechanisms for generating polarization radiation. Particular attention is paid to the development of methods for forming an electron beam consisting of several subpicosecond bunches, as well as creating experimental setups for measuring the spectral and angular characteristics of radiation.

The results of the research can be used to create compact sources of monochromatic radiation in the terahertz frequency range, as well as to develop methods for diagnosing and accelerating charged particles.

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# Radiation Resistance of Concrete

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Radiation materials science in the construction industry is a process of exposure to radiation (gamma radiation, ionizing radiation, etc.) on building materials, which subsequently causes changes in the structure of materials, i.e., radiation affects the basic properties of building materials: ionizing radiation initiates changes in the crystal structure of building materials, leading to degradation (decomposition) and changes in the mechanical, thermal, and other properties of materials.

Materials containing hydrogen, such as water, paraffin, polyethylene, graphite, boron, and cadmium, are ideal for protecting buildings and structures, as well as the people inside them, from neutron radiation. Among all building materials, concrete is considered the most preferred nowadays, i.e. artificial stone, which is formed as a result of solidification of a mixture of cement, aggregates (sand, gravel or crushed stone, water). It is precisely because of the presence of water in its composition that concrete is regarded as a retarder and absorber of high-speed neutrons, since hydrogen in water affects the process of weakening neutrons. The slowdown occurs due to the collisions of neutrons with the nuclei of hydrogen atoms, resulting in the loss of energy by the neutrons and their transition to the state of thermal neutrons. Heavy-duty high-strength concrete is based on high-density heavy aggregates made of barite, iron ore, limonite, magnetite, scrap metal, etc. It protects the structure of buildings and structures from  $\gamma$ -radiation and neutron fluxes. Research results have shown that such concretes have acceptable radiation resistance, and they can withstand long-term exposure to radiation with a neutron flux of up to  $5 \cdot 10^{24}$  n/m<sup>2</sup> at a temperature of 500°C without significantly affecting their basic properties. These concretes are also resistant to local overheating up to 1100°C. Thus, the basic building material for protection against  $\gamma$ -radiation is particularly heavy concrete belonging to the B30 and higher strength classes (or the M400 and higher grades), which have a density exceeding 2500 kg/m<sup>3</sup>.

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# Scientific Tourism as a Tool for Science Popularization and Youth Engagement (Case of Institute of Applied Problems of Physics)

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International scientific conferences and scientific tourism organized in the field of physics serve as important platforms for knowledge dissemination, promoting collaboration, and generating public interest. Such events provide opportunities for specialists to exchange the latest scientific results and serve as excellent means for physics popularization, engaging students, teachers, and other stakeholders.

Through scientific tourism, the public gains access to specialized laboratories, research centers, and historically significant sites, which stimulates interest in science and contributes to scientific advancement. This combination of the academic rigor of scientific conferences coupled with the engagement of scientific tourism promotes the popularization of scientific thought and deepens scientific–cultural connections. This type of tourism serves as a bridge between the younger generation and science, stimulating interest in physics and creating unique added value.

Based on the experience of the Institute of Applied Problems of Physics and studies conducted among target audiences, preliminary results have been documented.

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# Signatures of Galactic Expansion in Gaia DR3: Implications for the JWST Early–Galaxy Puzzle

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Recent James Webb Space Telescope (JWST) observations of massive galaxies at redshifts  $z > 6$  challenge standard models of galaxy formation, which predict slower assembly timescales. One possible explanation is that active galactic nuclei (AGN) drive large-scale outflows that accelerate galaxy growth. To test this scenario in the local Universe, we analyzed Gaia DR3 data for stars within 5 kpc of the Galactic center, computing galactocentric radial velocities ( $v_{\text{radialgc}}$ ) in 27 spatial sectors covering the entire Galaxy, with radial binning of 0.25 kpc. We find that 21 of 26 sectors exhibit statistically significant outward motions of 10–25 km s<sup>-1</sup>, while one quadrant shows negative velocities consistent with Galactic rotation geometry. Both disk and halo populations also display small but significant mean expansion of 2–5 km s<sup>-1</sup> ( $p < 0.01$ ). These results are consistent with our previous studies, where globular clusters showed outward velocities of 17–31 km s<sup>-1</sup> up to 12 kpc, and axisymmetric analyses of Gaia DR3 stars indicated expansion of  $\sim 19$  km s<sup>-1</sup> to 5 kpc. Taken together, the evidence suggests that the Milky Way exhibits measurable central expansion, potentially reflecting AGN-driven feedback. This interpretation departs from standard theory and should be regarded as preliminary, requiring further study. However, if confirmed, such expansion could provide a natural explanation for the rapid appearance of massive galaxies observed by JWST.

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# **Studies of the Characteristics of the Quasar 0736+01 and the Distribution of Extragalactic Sources Around it**

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The spectrum of the 0736+01 quasar is quite flat in the radio range. Starting from the infrared range up to the X-ray range, the spectrum decreases slowly. This means that the quasar remains quite active also at shorter wavelengths. The 0736+01 quasar is very compact, despite the presence of an extended radio source around it.

Just like in the case of the 0422+00 quasar, there are rather few quasars around 0736+01. This number is not sufficient for a separate analysis, but when compared with other regions, we observe that throughout the entire field of this quasar there is a deficit of quasars. This means that, as in the case of the 0422+00 quasar, here as well there may exist an absorbing medium, or indeed a clear manifestation of a void.

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# Study of the Influence of the Stress–Deformed State of the Interferometer Block on its X–ray Diffraction Pattern

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This work examines the effect of mechanical damage to the X–ray interferometer block on its X–ray diffraction pattern. An explanation is given for the origin of the contrast caused by imperfections in the crystal structure of the interferometer block that arise when it is mechanically damaged.

It has been proven both theoretically and experimentally that the curvature of interference fringes in a moiré topogram is the result of scratches applied to the surface of the crystal block of the X–ray interferometer. The dependence of the period of moiré patterns on the density of dislocation and their movement has been determined. The average value of the dislocation density near the scratch center is calculated. It is shown that the period of the moiré pattern is inversely proportional to the dislocation density.

It has been experimentally proven that a change in the moiré pattern also occurs when the crystal contains dislocations generated as a result of a scratch applied to the surface of the X–ray interferometer crystalline block. The geometric parameters of the scratch applied to the surface of the interferometer crystal block are determined. Determination of dislocation density, length of free paths of dislocation the magnitude of the shift in a crystal when all dislocations move in the slip plane. The scratch depth and the length of the dislocation group are calculated.

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# Surface Potential of Titanium Dioxide

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In new generations of modern solar cells (photovoltaic converters of solar energy into electrical energy), organic materials are being used for the optical–absorbing layer. Titanium dioxide is often used as the electron–transport layer. A key factor in optimizing solar cell performance is the matching of the surface potentials of adjacent layers.

Different methods for producing a titanium dioxide layer can also result in different structures. Nanotubes, nanopillars, and nanowires can be produced. The surface potentials of these structures can vary. Research in this area allows for the optimization of technologies for creating various devices: solar cells, nanoelectronic structures, including those based on quantum dots, and various sensors.

This paper examines the surface potential of titanium dioxide nanotubes. Gaussian software was used for the calculations.

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# **The Possibility of Using Corundum to Create Sensitive VUV, UV and IR Detectors**

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Research was conducted on the energy, spectral, and temporal characteristics of corundum ( $\alpha$ -Al<sub>2</sub>O<sub>3</sub>) with various activators across different optical ranges. Elements that can be incorporated into optically active crystals were identified, as well as elements capable of enabling new exciton–photon interactions, leading to novel transitions and energy transformations. The impurity concentrations in these crystals were determined, along with the specific mixture ratios at which maximum optical emission conversion occurs. Absorption and luminescence spectra were obtained. Luminescence measurements were performed at several fixed excitation frequencies and under different crystal orientations. These studies demonstrated that corundum can not only serve as a photoconverter in the UV and VUV ranges, but also as a basis for highly sensitive detectors in the IR wavelength range, taking into account the material's high thermal stability. To modify the electrophysical properties of the single crystal, corundum was irradiated with accelerated ions of different elements, thereby creating active centers with precisely defined dimensions. In addition, new activators were introduced into corundum that exhibit strong absorption in the IR and VUV spectral regions.

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# The Use of Additive Manufacturing Materials for Creating Tissue–Equivalent Dosimetric Phantoms

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Additive manufacturing methods, particularly fused filament fabrication (FFF) technology, are being widely adopted in medical physics for the production of specialised equipment and tissue–equivalent phantoms [1].

This work presents the results of an experimental study investigating the physical characteristics of materials used in additive manufacturing: BFCopper, PETG, PLA, AEROTEX, ABS and CERAMO–TEX. The obtained data form the basis for selecting suitable composite materials for producing tissue–equivalent dosimetric anthropomorphic phantoms through the fused filament fabrication.

Test samples in the form of rectangular prisms (50×50×10 mm) were created using additive manufacturing with fill factors of 70, 80, 90, and 100%, representing the percentage of material filling the interior. These samples were quantitatively assessed for physical density by gravimetric method and examined by computed tomography to analyze Hounsfield units and relative electron density.

Based on the data, a human head phantom was produced, and dosimetric tests showed ionization chamber (FC65–P) readings matching the treatment plan dose within 1%, confirming the materials' suitability for tissue–equivalent dosimetric phantoms.

This research was supported by TPU development program Priority 2030.

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# Two-dimensional Focusing of an X-ray Beam

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It is known that during the diffraction of a spherical X-ray wave by a single crystal in Laue geometry, focusing of the weakly absorbed mode of the diffracted wave field occurs both inside the crystal and behind it – in vacuum.

From a practical standpoint, it is most convenient to record the focal image immediately behind the crystal, i.e., to obtain a focus on the crystal's exit surface. This can be achieved by using a temperature gradient directed perpendicular to the crystal's entrance surface. In fact, a small gradient (on the order of  $10^2 \text{ Kcm}^{-1}$ ) allows for complete control of the focal depth in the crystal plate [1]. Note that all of the above applies only to focusing in the scattering plane, i.e., a linear focus will be achieved.

To achieve a two-dimensional focus, it is proposed to use a crystal with a low-angle twist boundary perpendicular to the crystal surface. In this case, a dislocation wall perpendicular to the scattering plane forms in the crystal, which limits the vertical divergence of the diffracted radiation so much that the focal image in this direction is on the order of submicrons [2].

Interestingly, in this geometry, the focusing conditions in the vertical direction are satisfied both before and after the focus. However, since the width of the image before and after focus is of the order of submicrons, then to regulate the magnitude of the temperature gradient for precise focus on the exit surface of the crystal, it is sufficient to monitor the focusing in the scattering plane.

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# **Using Theory of Catastrophe when Working with an Experimental Database**

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The literature on Theory of Catastrophe (TC) presents results that are already well known from other fields of knowledge. This is sufficient to confirm the applicability of TC. However, we cannot provide a single reference that directly describes the methodology for using TC in real experiments. However, there are some examples of TC application. This work is devoted to the development of a methodology for applying TC to databases that are obtained in new experiments, where there is still no good theoretical basis. It also applies to experiments where random parameter fluctuations play a significant role. The field of acoustoplasma research is chosen as an example, but this methodology can be applied in various fields.

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# Quantum–Mechanical Estimation of Negative Values for the Dielectric Constant of a Dielectric Material in a Special State

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The accumulated significant experimental material on the detection of special (anomalous) states with negative values of dielectric constant in ferroelectric ceramics and metacomposites is of great importance for obtaining new materials with promising applications. However, the theoretical study of this problem has not been adequately presented in the literature. Therefore, the proposal of possible new approaches as an attempt to study the task is relevant.

This paper proposes a quantum–mechanical consideration of the behavior of a material in an anomalous region. In the presented approach, the assumption of the formation of dipole–domain cells (DDCs) in the substance is of key importance. The state of matter is characterized by the parameter  $E_s$  of the degree of orientational ordering of the DDCs and in this consideration this parameter is identified with the order parameter in perturbation theory. Within the framework of the proposed approach, the material under study is considered as a continuous homogeneous medium of identical and weakly interacting DDC particles with the same values of the parameter  $E_s$ . The frequency dependence of the dielectric constant  $\varepsilon(\omega)$  in the anomalous incommensurate phase in a certain temperature range is considered. At the same time the macro state of a substance is defined as a superposition of microstates DDCs with a corresponding set of natural frequencies. The theory of small perturbations is applied, assuming that the interaction of DDCs with an external field is sufficiently weak. In the dipole approximation, the Schrödinger equation is solved to find the wave function of DDC. The transition of matter into anomalous states during the resonant interaction of DDCs with an external field is discussed from a new perspective, as a result of certain contributions to the measured value  $\varepsilon(\omega)$  by the components of the dipole moment  $d_{0j}$  for the DDC in a superposition of microstates determined by resonant (natural) frequencies. The external field oscillates different values of  $d_{0j}$  in the studied macro state in different ways, with a certain contribution  $|d_{0j}|^2$  from a specific microstate. However, the obtained result with the  $\varepsilon(\omega)$  estimate does not require adjustment to take into account nonlinear effects.

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# Dielectric Measurements of Compounds from the CCTO Family with Ion Substitution in Sublattices

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The study of compounds from the CCTO family remains relevant due to their enormous permittivity, despite the extensive literature on this topic. However, due to their high loss tangent, these materials have not yet found practical application, particularly in capacitor manufacturing.

For our study, we chose the compound  $\text{Bi}_{1/3}\text{Y}_{1/3}\text{Cu}_3\text{Ti}_4\text{O}_{12}$  [1], which has a  $\text{tg}\delta$  of approximately 0.019 at a measurement frequency of 100 kHz and a permittivity of approximately 5000. In this study, by varying the composition of  $\text{Bi}_{1/3}\text{Y}_{1/3}\text{Cu}_3\text{Ti}_4\text{O}_{12}$  in the Ti sublattice, one Ti atom out of four was replaced by a Zr atom in proportions of 0.2, 0.4, 0.6, 0.8, and 1.0. Synthesis was performed by heating at 1050°C for 24 hours, and the pressed pellets were sintered at 1050°C for 12 hours. After contacting the sample  $\epsilon$ ,  $\text{tg}\delta$ ,  $R_{dc}$  and  $G$  were measured as temperature and frequency dependent [2]. Similar experiments were conducted using a  $\text{Ga}_2\text{Nb}_2$  combination instead of Zr. The results showed a decrease in permittivity, while an increase in  $\text{tg}\delta$ .

A change in the sublattice of the large ion replacing Y with La, resulted in a decrease in  $\text{tg}\delta$  to 0.008 and a decrease in permittivity to 200 at a measurement frequency of 100 kHz.

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# Lectures

# Mathematics Is a Universal Language for Communicating with Nature

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Hilbert formulated the sixth problem as follows:

"Research into the foundations of geometry leads us to the problem of how to treat, in the same way, those physical sciences in which mathematics already plays an important role today, using axioms; probability theory and mechanics occupy the forefront."

Mathematics plays a key role in describing physical processes in nature. It often dictates how we understand nature, predicting astonishing physical effects. This became especially evident after the creation of quantum mechanics.

The topic of this talk will be a discussion of some aspects of the relationship between physics and mathematics from a historical retrospective.

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# Quantum Vacuum is a Medium with Unusual Properties

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Recently, within the framework of stochastic Yang–Mills equations for the gauge symmetry group  $SU(2) \times U(1)$ , the possibility of the existence of massless Bose–particle–*hions* with spin–1 was proven. It is shown that the ensemble of *hions* as a result of Bose condensation forms massless scalar and vector fields. The scalar field makes up the bulk of the energy of the ensemble of *hions*, while the vector field is formed by a large number of weakly entangled *hions*, which create small–volume formations with a total spin equal to zero. The main goal of our experiment was to demonstrate the possibility of manipulating the refractive indices of “empty space” (vacuum), i.e., the possibility of implementing spacetime engineering through external influence on the vector field and thereby proving that vacuum is a medium with unusual properties. We modified the well–known Fraunhofer diffraction experiment on a single slit by placing a cylinder with a light guide wound on it behind the slit. When two independent low–power laser sources of visible light are switched on, one of which falls on the slit and the other propagates along the light guide, a redistribution of the light intensity in individual Fraunhofer diffraction zones is observed. The effect turned out to be so strong and macroscopic that it cannot be explained within the framework of classical or quantum electrodynamics. The latter indicates a new, previously unknown mechanism of polarization of the quantum vacuum, mediated by massless particles – *hions*. As shown by a comprehensive analysis and numerical estimates, such a polarization, similar to a spin glass, can arise as a result of the reorientation of the spins of *hions* under the influence of an external electromagnetic field. In other words, the experiment indirectly proves the existence of massless Bose particles – *hions*, which form physical space itself, which allows us to consider “empty space” or vacuum as a medium with unusual properties.

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# **From Physics to Patient Care: The Power of Ionizing Radiation in Modern Medicine**

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The successful application of ionizing radiation in patient care is a direct translation of physical principles – such as energy deposition, dose distribution, and interaction with matter – into clinical methodologies. This translation, facilitated by medical physics, enables the precise conformal delivery of doses to tumors while minimizing damage to healthy tissues, making radiotherapy a cornerstone of modern oncology. The understanding of radiation physics effects allows for the development of safe, effective, and personalized cancer radiotherapy protocols. The technological evolution from 2D to 3D–conformal therapy, and the importance of quality assurance is explored in the report.

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# Quantum Vacuum

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In quantum field theory, the vacuum state is defined as a quantum field state with a zero number of quanta. The particle number and field operators do not commute, so the field in the vacuum state fluctuates. These fluctuations give the vacuum nontrivial properties. These properties manifest in the vacuum state's response to external influences, such as external fields. In this lecture, we will discuss the effects of vacuum fluctuations, such as spontaneous emission by atoms, the Lamb shift, and vacuum polarization by charged particles. We will show that the notion of the vacuum depends on the observer. For example, we will discuss the vacuum states for inertial and uniformly accelerating observers. The Casimir effect, a macroscopic manifestation of the nontrivial properties of the vacuum, will also be discussed. This effect is induced by the boundary conditions imposed on the field operator.

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# Binding Energy of a Homonuclear Diatomic Molecule in the Heitler–London Approximation, Analytical Results

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*Studying the properties of diatomic molecules allows us to better understand the characteristics of each type of chemical bond. Homonuclear molecules are of particular interest in this regard, as they exhibit pure covalent bonding. The hydrogen molecule has been studied in considerable detail, but even in this simple case, the results obtained through numerical calculations play a decisive role. In this paper, we demonstrate that the contribution of numerical calculations can be significantly reduced, which contributes to a better understanding of the nature of covalent bonding.*

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# Small Modular Reactors

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Small modular reactors (SMRs) are an innovative nuclear technology that opens up new possibilities for safer, more flexible, and more cost-effective energy solutions. These reactors perform the same basic function as conventional large-scale reactors – generating heat through nuclear fission to produce electricity – but they differ significantly in design and application. SMRs are built using modular construction techniques, meaning they can be manufactured in a factory setting and transported to a site for installation. This reduces construction time and costs, and improves quality control.

Modular reactors are designed with enhanced safety features. Many of them use passive safety systems that rely on natural processes such as gravity and convection, rather than external power or human intervention, to shut down the reactor safely in case of an emergency. In addition, their smaller size and simplified design make them more adaptable to different locations, including remote areas or regions with limited energy infrastructure.

There are several types of modular reactors currently under development, each with unique technologies and fuel types. Some use water as a coolant, like traditional reactors, while others use gas, liquid metal, or molten salt. These variations reflect the diverse approaches to achieving safer and more efficient nuclear energy production.

In conclusion, modular nuclear reactors represent a significant step forward in the evolution of nuclear energy. By combining advanced safety, flexibility, and the potential for lower costs, they offer a practical solution to meeting the world's growing energy demands while minimizing environmental impact.

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# **X–ray Studies of Armenian Metal Archaeological Artefacts and Prospects for Synchrotron–Based Analysis**

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X–ray analytical methods are widely applied in the study of cultural heritage objects, particularly archaeological artefacts. These investigations are of crucial importance for reconstructing provenance of these objects as well as for conservation and restoration purposes.

This report presents the results of X–ray fluorescence and microtomography studies of metal jewellery uncovered at two archaeological sites in Armenia: the Nerkin Naver burial mound (Middle Bronze Age) and the Teishebaini necropolis (Uartian period). The investigated objects include a gold bead from Nerkin Naver, dated to around 3000 BCE, and a set of bronze ornaments from Teishebaini, dated to the 7th century BCE. The studies were carried out using laboratory–based X–ray sources.

The obtained data made it possible to identify the features of the elemental composition of the materials and to determine the key techniques used in their processing. It should be emphasized, however, that the use of synchrotron radiation sources can significantly increase the accuracy and informativeness of such studies. Moreover, synchrotron facilities open up the possibility of carrying out fundamentally new experiments, including high–resolution elemental mapping, confocal X–ray fluorescence analysis, X–ray ptychography, and other advanced methods.

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# **Radiation–Induced Biological Responses: From Molecular to Organism Level**

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Ionizing radiation causes complex biological responses: from molecular level, like DNA damage to effects on whole organisms. Understanding these mechanisms is essential for developing effective radiotherapy strategies and radiation protection protocols.

One of the main targets for radiation is considered to be the DNA molecule through direct energy deposition and indirect damage via free radical formation. This results in various types of DNA lesions including single–strand breaks, double–strand breaks, and base modifications. Cells respond through DNA repair mechanisms, cell cycle arrest, and programmed cell death pathways.

Modern radiotherapy approaches focus on radiosensitization—combining radiation with agents that enhance treatment efficacy. The combined effects of radiation with cisplatin and porphyrin compounds show particular promise. Cisplatin enhances radiation sensitivity by forming DNA cross–links and inhibiting repair pathways. Porphyrins function as both photosensitizers and potential radiosensitizers, offering opportunities for combined treatment modalities.

As a living organism model for investigating radiation–induced damage was chosen *Escherichia coli* bacteria. Bacterial survival curves, mutation frequency measurements, and DNA damage assessments allow quantitative evaluation of combined radiation and drug treatments.

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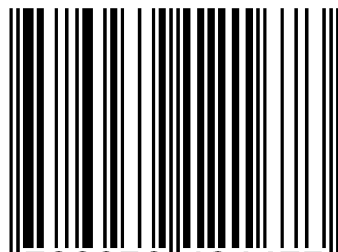
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