National Research Saratov State University



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 **MICRO- & NANOTECHNOLOGY: RESEARCH & APPLICATIONS. THE SCIENCE FESTIVAL FOR YOUNG SCHOLARS**

 April 25, 2022

Saratov

***Convenor:* Angelina I. Matyashevskaya** (Ph.D. in Linguistics, Associate Professor, Department of English and Intercultural Communication, SSU)

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**Aleksandr G. Rokakh** (Doctor of Physics and Mathematics, Professor, Department of Solid State Physics, SSU)

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**PART 1**

**1) Research of Electrophysical Properties of Liquids by the Electroacoustic Method**

**Shamsutdinova Elizaveta, Anisimkin Vladimir, Fionov Alexander, Kolesov Vladimir, Kuznetsova Iren — Kotelnikov Institute of Radioengeneering & Electronics of RAS**

In view of the need to control the electrophysical properties of polar and non-polar liquids, we studied their parameters using standard and electroacoustic methods. Liquids such as liquid paraffin, silicone oil and glycerine have been investigated. At the first stage, the electrical properties of such liquids were investigated by means a measuring cell consisting of an Eppendorf and two coaxial nickel cylindrical electrodes representing a capacitor and by an Agilent E4980A LCR meter. Then, a fluoroplastic bath was placed on the quartz delay line. First, the phase and amplitude of the acoustic signal were measured in the absence of liquid. At the next stage, the test liquid was poured into the bath, the characteristics of the acoustic wave changed, and the values of the liquid viscosity were determined from the calibration curves. At the final stage, microparticles of activated carbon and sorbitan monooleate were added to the test liquid; the properties of the resulting mixtures and solutions were determined by the electroacoustic method described above. The results obtained will be useful in the development of acoustic sensors for the properties of polar and non-polar liquids.

**2) In Silico Study of the Influence of Various Substrates on the Electronic Properties and Electrical Conductivity of Monolayer Films of Armchair Single-Walled Carbon Nanotubes**

**Petrunin Aleksandr — Institute of Physics, SSU**

 As is known, CNT-based thin films with a thickness in the range of 1–100 nm have high electrical conductivity, transmittance, flexibility and stretchability. In addition to these properties, CNT-based films are easier and cheaper in production, and therefore more competitive in comparison with other materials used to fabricate flexible and transparent electronics devices. In this report in silico methods are used to study the electronic properties of monolayer films of armchair SWCNTs located on a SiO2 substrate. This type of substrate was chosen because silicon dioxide SiO2 is widely used in the manufacture of electronic devices and, in particular, carbon nanodevices. We considered SWCNTs of the type (m, m) for m = 4, 5, 6 and 7 with a diameter from 5 Å to 10 Å, that is, nanotubes of sub- and nanometer diameters. The choice of armchair nanotubes is due, first, to the metallic type of conductivity and, second, to the absence of chirality. Achiral nanotube allows matching the translation vector of the nanotube with the translation vector of the substrate, which is not realized for chiral nanotubes.

*Scientific advisor — Glukhova O.E.*

**3) The Behavior of K@C60 Endohedral Complex Inside the Carbon Nanocomposite**

**Levitckii Semion — Institute of Physics, SSU**

The movement of K@C60 complex inside the carbon nanocomposite can be controlled by application of external electric field in THz frequency range. In this study we investigate the optimal parameters of electric field by varying frequency and strength.

*Scientific advisor — Shunaev V.V.*

**4) Plasmon-enhanced Fluorescence Spectroscopy for Human Platelet Spectroscopic Investigation**

**Demishkevich Elizaveta — Institute of Physics, SSU, Baltic Federal University**

The development of science and the need to work with many biological compounds that have absorption bands in the ultraviolet region indicate the importance of studying not only the visible and infrared, but also the UV – range. This report is devoted to the study of spectral photoprocesses in human platelets and their complexes with platinum (Pt) nanoparticles (Nps). Fluorescence spectroscopy analysis of main fluorescent amino acids and their residues (tyrosine (Tyr), tryptophan (Trp), and phenylalanine (Phe)) belonging to the platelet membrane have been performed. The possibility of energy transfer between Pt NPs and the platelet membrane has been revealed.

*Scientific advisors — Kochubei V.I., Ziubin A. Iu.*

**5) Desynchronization of the Circadian Rhythm and the Sleep-wake Cycle Due to Fluctuations in External Influences**

**Merkulova Ksenia — Institute of Physics, SSU**

The circadian rhythm demonstrates the adaptation of the body to the cycle of day and night, that is, it is regulated by illumination. Normally, the sleep / wake cycle is synchronized with the circadian rhythm, but sometimes, for various reasons, the phenomenon of desynchronization occurs, which can take a different form. In study, the model presents this phenomenon by introducing random forcing on the neuronal nuclei responsible for sleep and wakefulness. The results of the study confirmed made it possible to predict that the effect on the homeostatic process associated with the sleep / wake cycle may lead to desynchronization.

*Scientific advisor — Postnov D.E.*

**6) Analysis of the Semiconductor Quantum Dots Electron Spectrum**

**Vetrintcev Maksim — Institute of Physics, SSU**

The results of comparative analysis of quantum dot (QD) electrons energy spectra using the "sphere" and "cube" models are presented. A method for analyzing the semiconductor QDs spectrum using differential current-voltage characteristics (CVC’s) was studied. The quantum well electrons energy spectra were studied using the Comsol Multiphysics software package. Using this model, one can analyze the conduction electron energy levels in a quantum well with a modulated potential. The results presented in this work were obtained for CdSeS/ZnS and CdSe QDs.

*Scientific advisor — Kabanov V.F.*

**PART 2**

**1) The Influence of Defects in a Photonic Crystal on X-Band Reflection Characteristics**

**Andreev Anton — 3 year, Institute of Physics, SSU**

Photonic crystals with a defect in the center of the structure have been studied. The shape of the defect is a superellipse and can be transformed into a rhombus, a circle, and a square. Changes of photonic crystal reflection characteristics related to the changes in the defect shape are demonstrated.

*Scientific advisor — Sergeev S.A.*

**2) Mathematical Modeling of Electronic Processes in High-resistance n-GaAs-based Microstructures at Localized Optical Influence**

**Shchiptsov Roman — 3 year, Institute of Physics, SSU**

A version of the local-field mathematical model has been realized with the Python programming language. This version makes it possible to analyze the dynamics of space charge and current in a semiconductor structure based on high-resistance n-GaAs. The differential equations of the model were solved on a computer using the finite-difference time-domain method. As an output parameter, the current through the sample was calculated and the dependence on the localization of the area of optical influence was investigated.

*Scientific advisor — Mitin A.V.*

**3) The Application of Metamaterials to Determine the Electromagnetic Properties of Various Samples**

**Velikanov Ilia — 2 year, Institute of Physics, SSU**

The manufacture and application of metamaterials for determining the electromagnetic properties of various samples (2D-films, 3D-structures, liquids and powders) were considered in the paper. A classification of metamaterials was given and their applications in various fields were demonstrated. Metamaterials were fabricated for a rectangular waveguide in the X-band and the reflection and transmission coefficients were measured as a function of frequency.

*Scientific advisor — Sergeev S.A.*

**4) Magnetic Field Exposure as a Key Component of Targeted Drug Delivery Systems**

**Kalinova Aleksandra *—* 2 year, Institute of Physics, SSU**

Nowadays much attention is paid to the formation of polyelectrolyte capsules and their properties due to the wide range of their practical applications. The report focuses on the physical component of this treatment method, namely, the influence of the magnetic field and its use in the treatment of cancer. The dependence of the recovery rate on the parameters of the generated magnetic field and the overall effect of the therapy are investigated.

*Scientific advisor — Lomova M.V.*

**5)Raman Spectroscopy to Study Insects**

**Nikelshparg Matvei *—* 1 year, Faculty of Biology, SSU**

In the present study we applied Raman spectroscopy to find out whether the plant Hieracium x robustum is the only source of carotenoids in insect Aulacidea hieracii feeding on that plant. Carotenoid composition in the insect larva was independent of that in the plant tissues. Also we discovered that carotenoid accumulation in the insects is segment-specific and differs in larva and pupa. Thus, the insect Aulacidea hieracii is suggested as a new candidate among animals to have the ability to synthesize and modify carotenoids.

*Scientific advisor — Аnikin V. V.*

**6) Tumor Treating Fields: a New Frontier in Cancer Therapy**

**Semenova Daria, Prokhorova Veronika — 1 year, Institute of Physics, SSU**

Tumor treating fields (TTFields) is a noninvasive, regional antimitotic treatment modality that has been approved for the treatment of recurrent glioblastoma. TTFields therapy delivers low-intensity (1–3 V/cm), intermediate-frequency (100–300 kHz), alternating electric fields to the tumor using transducer arrays placed on the skin around the region of the body containing the tumor. TTFields therapy affects metaphase, by disrupting mitotic spindle formation, and anaphase, by dielectrophoretic dislocation of intracellular constituents, resulting in apoptosis. TTFields therapy is frequency tuned to specific cancer cell types.

**7) Dzhanibekov Effect**

**Shamarina Alina, Dumov Timofei — 1 year, Institute of Physics, SSU**

The asymmetric spinning top is considered to be one of the hardest concepts in Physics. The T-handle is initially spun about the principal axis with intermediate moment of inertia, which is not stable. The result is that the axis reverses repeatedly. This particular behaviour has recently been dubbed the «Dzhanibekov effect» after the Soviet cosmonaut Vladimir Dzhanibekov, who demonstrated it in space in 1985.