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Section

APPLICATIONS OF NANOSYSTEMS

INVESTIGATION OF THE ELECTRON-PHONON INTERACTION IN STRUCTURES InAs/AlSb IN QUANTIZATION MAGNETIC FIELDS REGIME

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Study of transverse magnetoresistance oscillations $\rho_{xx}(B)$ were performed for InAs/AlSb samples with different doping level at temperatures $T = (4 \div 28)K$. Based on test of magnetic field dependence amplitude $\rho_{xx}(B)$ the formation dynamic of Landau quantization destruction was established. The components of the electron-electron and the electron-phonon interactions were marked out and the relaxation time $\tau_q(\tau_{ee}, \tau_{ph})$ evaluated. On the base of physical model of electron interaction the role of electron-phonon relaxation was revealed as a factor, which stabilize the process of Landau quantization destruction. Experimental nonlinear dependence $\tau_q(T)$ is explained by electron scattering on piezoelectric and deformation potential of acoustic phonons and channels competition inter-(intra-) subband scattering. Parametric dependence of quantum relaxation time from magnetic field $\tau_q \propto B^{-0.6}$ was established.

HIGH-TEMPERATURE PHASE TRANSITIONS IN THERMALIZED ATOM-LIGHT SYSTEM UNDER THE OPTICAL COLLISSIONS

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Nowadays the investigation of phase transitions in atomic gases represents a huge area of experimental and theoretical research where condensed matter and statistical physics are closely connected to the application problems of quantum and atom optics, for example, in the field of quantum information science. Although Bose-Einstein condensation (BEC) of the atoms has been observed in many labs, the requirement to use extremely low (up to micro-Kelvins) temperatures strictly limits the utilization of such an effect for practical purposes. It provides an important reason for studying relatively high-temperature phase transitions. Usually such transitions take place in coupled matter-field systems; polaritons introduced many years ago for describing the interaction of quantized field with quantum excitations in the medium.

We consider a phase transition problem in a two-level atomic ensemble strongly interacting with an optical field. The main features of such a phase transition are connected with a coupled atom-light state thermalization occurring due to the OCs process with buffer gas particles. Such a thermalization can be achieved experimentally for a large value of negative atom-field detuning [1]. Using a thermodynamic approach, we established a gap equation under a mean-field approximation for order parameter, normalized average optical field amplitude. In the paper we present simple arguments confirming that the obtained thermalization of coupled atom-light states leads to the photonic phase transition to the superradiant (coherent) state and is characterized by some ordering (equilibrium state) for two-level atomic system. Such a transition can be connected with superfluid (coherent) properties of photon-like low branch polaritons. We discuss the application of special metallic micro-waveguides for observing predicted effects. We also discuss the problem of high temperature true BEC formation for atomic polaritons in such waveguide cavity.

References:

[1] I.Yu. Chestnov, A. P.Alodjants, S.M.Arakelian, J. Nipper, U. Vogl, F. Vewinger, M. Weitz. *Thermalization of coupled atom-light states in the presence of optical collisions.* Phys. Rev. A, **Vol. 81**, p. 053843 (2010).

[2] A. P.Alodjants, I..Yu. Chestnov, S.M.Arakelian, *High-temperature phase transition in the coupled atom-light system in the presence of optical collisions*. Phys. Rev. A. **Vol. 83**, p. 053802 (2011).

STRUCTURAL INVESTIGATIONS OF BIOGENIC FERRIHYDRITE NANOPARTICLES USING ATSAS PROGRAM MODEL CALCULATIONS

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A promising new dimension in the field of nanotechnology is the use of microorganisms for the production of inorganic nanoscale particles.

In the present paper new structural investigations of biogenic ferrihydrite nanoparticles using ATSAS Program model calculations are developed.

Earlier, it was established that bacterium *Klebsiella oxytoca* produces ferrihydrite nanoparticles, which were investigated by means of Mossbauer spectroscopy, static magnetic measurements analysis, scanning electron microscopy and small-angle X-ray scattering (SAXS) technique [1,2]. In order to take full advantage of the obtained nanoparticles in establishing new technologies one needs to investigate more precisely structural characteristics of the afore mentioned particles. Hereby, we present a structural investigation of water dispersed biogenic ferrihydrite nanoparticles using SAXS. A program package ATSAS [3] for small-angle scattering data treatment and interpretation was used. The package performs major analysis steps of the scattering data reduction to automated 3D modeling. Primary data processing and the computation of the *pair distribution function* of the scattering objects in the solution, followed by the *ab initio* three-dimensional modeling of the particles revealed scattering objects of an elongated shape with 6.73±0.16 nm radius of gyration. **References:**

[1] S.V. Stolyar, et.al. *Iron-containing nanoparticles from microbial metabolism.* Inorganic Material, **42**(7), 763-768 (2006).

[2] Yu.L. Raikher, et.al. *Magnetic properties of biomineral particles produced by bacteria klebsiella Oxytoca.* Physics of the Solid State, **52**(2), 298-305 (2010).

[3] M. Balasoiu, et.al. *Hierarhical structure investigation of biogenic ferrihydrite sample.* Romanian Journal of Physics **55**(7-8), 782(2010).

[4] P.V. Konarev, et.al. ATSAS 2.1, a program package for small-angle scattering data analysis. Journal of Applied Crystallography Part 2, 39, 277-286 (2006).

GROWTH OF TI DOPED HALF-METALLIC FE_3O_4 THIN FILMS DIPOSITED ON $SRTIO_3$, AL_2O_3, SI, AND FLOAT GLASS SUBSTRATES

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We investigate the effects of Ti doping on the structural and transport properties of half metallic Fe_3O_4 films grow on varying substrates [$SrTiO_3$ (100), Al_2O_3 (0001), Si (111), and Float Glass (FG)] by pulsed-laser deposition technique (PLD). The structural properties of Ti doped Fe_3O_4 are investigated through X-ray diffraction (XRD) pattern, which infers that parent and Ti doped magnetites are grown in single phase with (111) orientation for all the substrates. The doped films not exhibit a metal–insulator Verwey transition as compared to that of undoped Fe_3O_4 films. The Verwey transition temperature for Fe_3O_4 thin films are 121 K (Float Glass), 123 K ($SrTiO_3$), 123 K (Al_2O_3) and 120 K (Si). The transport properties of the doped films are markedly sensitive to the Ti doping concentration. Raman spectra infer the formation of magnetite phase through out all samples $Fe_{3-x}Ti_xO_4$ (x = 0 and 0.0206). Magnetoresistance (MR) curves show linear magnetic field dependence for the undoped films, while an increase in MR and departure from linear field dependence is observed for Ti-doped films. The Magnetoresistance (MR) curves show highest change in MR for doped and undoped films are in Al_2O_3 (0001) substrate. For parent Fe_3O_4 films MR is of -0.48% at room temperature which increases below the Verwey transition up to -1.12% at 100 K, while in Ti doped films MR is of -1.56% at room temperature which increases up to -3 %.

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References

[1] Deepak Venkateshvaran, Matthias Althammer, Andrea Nielsen, Stephan Geprägs, M. S. Ramachandra Rao, Sebastian T. B. Goennenwein, Matthias Opel, and Rudolf Gross, *Phys. Rev. B* **79** 134405 (2009).

[2] S. B. Ogale, K. Ghosh, R. P. Sharma, R. L. Greene, R. Ramesh, and T.Venkatesan, *Phys. Rev. B* **57** 7823 (1998).

MAGNETIC NANOPARTICLE STRUCTURE DETERMINATION FROM A CONTRAST VARIATION SMALL ANGLE SCATTERING OF NON POLARIZED NEUTRONS EXPERIMENT

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By means of contrast variation small angle scattering of non polarized neutrons on ferrocolloidal suspensions a new experimental method for separate determination of nuclear and magnetic scattering contributions was obtained [1-5]. The present paper presents new developments of this method for the case of taking into account of the incoherent scattering.

References

[1] B.Grabcev, M.Balasoiu, D.Bica, A.I.Kuklin, *Determination of the structure of magnetite particles in a ferrofluid by small angle neutron scattering method*, Magnetohydrodynamics **10**(2), 156-162 (1994).
[2] M.Balasoiu, A.I.Kuklin, B.Grabcev, D.Bica, *The Study of Particle Structure, Particles Interactions and Dynamics in Ferrofluids by Small Angle Neutron Scattering of Neutrons,* Romanian Reports in Physics **49**(9-10), 379-384 (1998).
[3] B.Grabcev, M.Balasoiu, A.Tarziu, A.I.Kuklin and D.Bica, *Application of contrast variation method in SANS experiments with ferrofluids*, Journal.of Magnetism and Magnetic Materials, **201,** 140-143 (1999).
[4] M V.Avdeev, *Contrast variation in small-angle scattering experiments on polydisperse and superparamagnetic systems:basic function approach*, Journal of Applied Crystallography **40,** 56 (2007).
[5] M.Balasoiu and A.I.Kuklin, *SANS contrast variation method applied in experiments on ferrofluids at MURN instrument of IBR-2 reactor*, Journal of Physics:Conference Series **351**(2012).

STUDIES OF ELASTOMER MATRIX STRUCTURE MODIFICATIONS INDUCED BY MAGNETIC NANOPARTICLE INCLUSIONS

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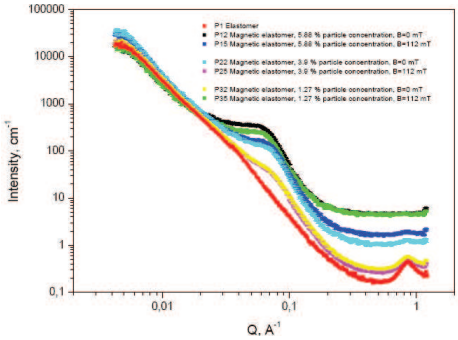
Magnetic elastomers (ME's) represent a specific class of smart materials responding in a complicated way to the changes of external conditions. ME's are composed of magnetic nanoparticles and a low magnetic permeability polymer matrix. These composites are quite new, and the work on understanding their pro-perties in dependence on the synthesis pro-cesssses, composition, mechanical and magnetic fields, etc. is nowadays extensively progressing with regard to nano- or microtechnology.



P15, P22, P25, P32, P35 (with particle concentration and applied magnetic field during the polymerisation process variation) and elastomer matrix P1, obtained at Rigaku spectrometer at IMC, Prague.

Many studies of the observed reinforcing effect of magnetic fillers have approached the problem from a magneto-mechanical point of view, and investigated the microscopic properties through study of the magneto-elastic responses of the composity. Less well understood, however, are the effects of the interactions between the filler and the surrounding polymer on submicroscopic length scales. Such length scales are ideally suited for small angle scattering investigations. In the present paper the microstructure properties of a rubber elastomer matrix polymerized with ferrofluid are investigated and modeled with particle volume concentration variation by means of small-angle X-ray scattering experimental data (Fig.1).

SURFACE IRREGULAR IMPURITY, BOUND STATE AND CATALYTIC ACTIVITY OF NANOPARTICLE

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Nanocatalysts are the most widely used catalysts in modern chemistry. The main advantage is good surface/volume ratio for nanoparticles. The most important problem is to ensure high catalytic efficiency and to suggest a computational method for determination of characteristics of the corresponding structures. There are different complicated approaches to the problem, but simple model is preferable if it allows one to predict the corresponding properties of the system. Nanoparticle can be con sidered as a crystal of finite (nano) size. One can mention an interesting phenomenon: the catalytic activity of nanocatalyst increases considerably if there are irregular in clusions at the nanoparticle surface. The rise of the surface area is not sufficient to explain this increase. But it is possible to declare additional reasons. Particularly, it is known that other things being equal the catalytic activity increases when the electron density increases at the nanoparticle surface. In the present paper we show that this effect can be related with the surface irregular inclusion. We suggest a simple model to explain the growth of surface electron density. Namely, a nanoparticle is considered as a one-dimensional semi-infinite crystal with zero-range potentials. The Schrodinger operator for an electron in this system has purely continuous spectrum. The presence of irregular perturbation (additional center) at the surface of the crystal can give rise to point spectrum, more precisely, the bound states localized near the boundary appears. It means that one can observe an additional electron density near the surface corresponding to this bound state. As a result, the catalytic activity increases. We investigate the problem of the discrete spectrum existence and find the corresponding sufficient conditions in the framework of this model. The analogues situation is observed, for example, when one deals with low-energy electron-induced reactions in thin films of glucose and N-acetyl-glucosamine the influence of the surface state onto the distance distribution of single molecules and small molecular clusters, the role of sub-surface oxygen in Cu(100) oxidation and the role of nanocavities at nearly ideal (2x1)Si(100) inner

surfaces as nanoreactor, etc. We deal with heterogeneous redox catalysis which is related with the electron transfer. That is why the surface electro state is important for this type of catalysis. The catalytic efficiency depends also on the electron interaction between reactants and the surface of the nanocatalysts and other factors. In the present paper we consider only electron density influence. The obtained result is one of important reasons explaining extremely high catalytic activity of the system ZrO2 − Al2O3 in the reaction of hydrogen oxidation. This phenomenon was observed in [1].

References

[1] O.V. Al'myasheva, E.A. Vlasov, V.B. Khabenskii, V.V. Gusarov. *Thermal stability and catalytic properties of the composite amorphous Al*2*O*3*-nanocrystals ZrO*2, Rus. J. Appl. Chem. **82** (2), 217-221 (2009).

ANALYTICAL APPROXIMATION OF THE NANOSCALE DOSE DISTRIBUTION IN IRRADIATED MEDIA WITH EMBEDDED NANOPARTICLES

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Many different types of nanoparticles are currently being studied for applications in nanomedicine. In particular, the use of gold nanoparticles (NPs) in radiotherapy may provide a high dose to the tumor while delivering a reduced dose to surrounding normal tissue. Numerous theoretical studies have investigated dose localization through the introduction of NPs. Most works have focused on the macroscopic dose enhancement averaging effects over volumes much larger than a single NP. This approach is fundamentally flawed, however, as it neglects the significant dose inhomogeneity on the nanoscale which is caused by the introduction of NPs. An alternative view on NP radiosensitisation was presented in [1], where Monte Carlo (MC) simulations were carried out to calculate dose on the nanoscale in the vicinity of individual NPs. The major disadvantage of MC simulations is that there is no analytical expression and one has to use own simulations or table values and graphs.

In this work we propose an analytical approach describing the dose distribution around NPs embedded in media. The approach takes into account three effects: (1) localized absorption of indirectly ionizing radiation (photons or neutrons) by NPs and generation of secondary electrons or heavy charged particles with various energies insight NPs, (2) effective release of the secondary charged particles from NPs with different energies and angles depending on a radius of NPs, and (3) efficient deposition of energy in surrounding media. The combination of these effects allows to derive analytical expressions for the nanoscale dose distribution.

The approach was applied for the calculation of the dose distribution around gold NPs in water. **References**

[1] S.J. McMahon et al. *Biological consequences of nanoscale energy deposition near irradiated heavy atom nanoparticles*. Scientific Reports, **1**, 18 (2011).

DETERMINISTIC FRACTALS: EXTRACTING ADDITIONAL INFORMATION FROM SMALL-ANGLE SCATTERING DATA

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Deterministic fractal models with controllable Hausdorff dimension are suggested for studying the small-angle scattering from the deterministic fractal systems. The included models are single- and multi-scale mass fractals, whose dimensions can be varied from 0 to 3, and surface fractal, whose dimension lies between 2 and 3. All the fractals show, in the fractal region, a superposition of maxima and minima on the power law decay $I(q) \propto q^{-\alpha}$, called generalized power law-decay (GPLD); here α equals to the fractal dimension D for mass fractals and to $6 - D$ for surface fractals. SAS is considered from a set of non-interacting, randomly oriented and uniformly distributed fractals. Polydispersity can be successfully incorporated into the scheme by considering an ensemble of fractals with different total sizes taken at random. The smearing of the scattering curve increases with increasing the width of the distribution function of fractal sizes. By contrast to the standard methods, the present analysis allows us to obtain from the scattering data not only the fractal dimension and the edges of fractal region but a number of additional parameters. In particular, for single- scale mass fractals, one can obtain the fractal iteration number, the scaling factor, and the number of structural units from which the fractal is composed.

References

[1] A.Yu. Cherny, E.M. Anitas, V.A. Osipov and A.I. Kuklin, *Deterministic fractals: Extracting additional information from small-angle scattering data.* Phys. Rev. E, 84, 036203, 2011

[2] A.Yu. Cherny, E.M. Anitas, A.I. Kuklin, M. Balasoiu, V. A. Osipov, *Scattering from generalized Canto sets* J. Appl.Cryst., 84, 790, 2010

[3] A.Yu. Cherny, E.M. Anitas, A.I. Kuklin, M. Balasoiu, V. A. Osipov, *Small-angle scattering from the deterministic fractal systems* J. Surf. Invest., 4(11), 903, 2010

STRUCTURE PROPERTIES OF FORMATION OF ZnO NANOPARTICLES ON THE ZnSe SURFACE

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In the cubic ZnSe:O monocrystals which has been cut out in parallel of plane (311), contains the low-symmetry ZnO impurity phase (reflection 013). The size of inclusions of the ZnO crystalline phase as estimated from the Selyakova-Scherrer formula is ~27 nm [1]. Alloyed ZnSe:O,Zn with impurity of Te up to 0.2% had orientation of matrix lattice (220) with nanocrystals ZnO phase (110) ≈40 nm and amorphous inclusions up to 0.9 nm. The monocrystals of ZnSe(0.5%Te):Zn with crystals orientation (111) have the ZnO crystal phase responsible for diffraction peak (002), the size about ~52 nm. At such orientation and the critical sizes of potential on the interface ZnSe-ZnO are minimal. Detection growth of microhardness sub-surface layer of ZnSe(Te)-ZnO:O,Zn crystals by depth ~50 μm with increase non-stoichiometry and the sizes of ZnO nanocrystallites.

References

[1] D.B. Elmurotova, E.M. Ibragimova, M.U. Kalanov, N.A. Tursunov, *Radiation-Induced Formation of ZnO Nanoparticles on the ZnSe Single-Crystal Surface* // ISSN 1063-7834, Physics of the Solids State, © Pleiades Publishing, Ltd - St. Petersburg, V.**51**, №3, 456-464 (2009).

NANOCOMPUTING AND OTHER APPLICATIONS OF NANOTECHNOLOGY

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More than forty years ago, Richard Feynman said, "The principles of physics, as far as I can see, do not speak against the possibility of manouvering things atom by atom." He continued, “There is plenty of room at the bottom.”

Nanotechnology is the projected ability to make things from the bottom up, using techniques and tools that are being developed today to place every atom and molecule in a desired place. If this form of molecular engineering is achieved, which seems probable, it will result in a manufacturing revolution. Presently our handling of the molecular manufacturing process is very crude, we move atoms around in great heaps and pile them together, but we lack the ability to snap them together in a meaningful way. With nanotechnology, we'll be able to snap together the fundamental building blocks of nature easily, inexpensively and in almost any arrangement that we desire.

In this paper the author presents the basic concept of Nanotechnology with a focus on Nanocomputing. Further this paper takes a review of applications of nanotechnology in the fields of transportation, data storage, space exploration, national security, energy and information systems.

POSSIBILITIES OF THE NEUTRON AND SYNCHROTRON RADIATION FOR THE CHARACTERIZATION OF THE LIPID NANOSYSTEMS

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Lipids are important components of biological membranes and essential components of vesicular and liposome drug carriers. Different methods of lipid structural investigations are presented for the solving of modern problems of cryobiology, membrane biophysics, dermapharmacology, and nanodiagnostic of drugs and drug carriers:

- Method of lamellar and lateral synchrotron X-ray diffraction in real time for the cryoprotector characterization
- Method of neutron diffraction for study of model stratum corneum membranes
- Method of separated form factors for characterization of vesicular nanodrugs
- Method of contrast variation of X-ray scattering by disaccharides.

References

[1] M.A. Kiselev, S. Wartewig, M. Janich, P. Lesieur, A.M. Kiselev, M. Ollivon, R. Neubert. *Does sucrose influence the properties of DMPC vesicles?* Chemistry and Physics of Lipids, **123,** 31-44 (2003).

[2] M.A. Kiselev, T. Gutberlet, P. Lesieur, T. Hauss, M. Ollivon, R.H.H. Neubert. *Properties of ternary phospholipid / dimethyl sulfoxide / water systems at low temperatures*. Chemistry and Physics of Lipids, **133,** 181-193 (2005).

[3] M. A. Kiselev, N. Yu. Ryabova, A. M. Balagurov, S. Dante, T. Hauss, J. Zbytovska, S. Wartewig, R. H. H. Neubert. *New insights into structure and hydration of stratum corneum lipid model membrane by neutron diffraction.* European Biophys. J., **34,** 1030–1040 (2005)

[4] M.A. Kiselev, E.V. Zemlyanaya, V.K. Aswal, R.H.H. Neubert. *What can we learn about the lipid vesicle structure from the small angle neutron scattering experiment?* European Biophys. J. 35, 477-493 (2006).

[5] M.A. Kiselev. *Methods for investigation of lipid nanostructures at neutron and synchrotron sources*. Particles&Nuclei, **42,** 578-635 (2011).

RESPONSE OF MAGNETIC NANO-PARTICLE ASSEMBLIES

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Nanostructured magnetic materials on, e.g., ferroliquids, nano-particle self-assemblies and/or arrays, have a variety of promising applications, like, nano-scale electronic devices, sensors, high-density data storage media, systems for a controlled drug delivery and cancer diagnostics and treatment. Such soft magnetic systems provide an opportunity to develop new materials with characteristics far beyond traditional solids.

Resently developed randomly jumping interacting moments (RJIM) model, see [1] and refs. therein, provides useful framewok for studies of magnetic nano-particle assemblies. In particular, it allows to develop analytical tools employed in order to specify, quantify and analyse respective magnetic structure. Such tools explore correlations of magnetic noise amplitudes and demonstrate an application for quantitative definition, description and study origin of superferromagnetism, as well as self-organized criticality.

In this contribution we continue on such an analysis of nanostructure magnetic reactivity in external fields, on examples of (i) spatially uniform field changing slowly in time and (ii) magnetic moment of single particle, i.e., a mode of sensor for detection of magnetic particles. The Monte Carlo simulation technique, cf., [1], was used to describe the system dynamics. Optimized serial algorithms and parallel CUDA programming on graphic processing units (GPU) were developed to provide acceptable level of calculation rates. Arrays of nano-particles with multiple magnetic response anomalies are demonstrated to display strong dependence on system disorder. Possible implications of peculiarities in magnetic planar array response as sensors are considered. The surface and boundary effects are discussed.

References

[1] V. N. Kondratyev. *Dynamics of magnetic nano-particle assembly*. J. Phys.: Conf. Ser., **248**, 012027 (2010).

NARROW OPTICAL BAND-PASS FILTERS AND NANOPLASMONICS

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Narrow optical band-pass filters are widely used in the systems with optical processing of information, color displays development and optical computers. Existing optical band-pass filters are based on the interference of optical modes from multiple thin dielectric layers which are manufactured by different types of expensive layer deposition techniques. The cost of such optical filters can be greatly reduced if one can apply simple non-vacuum technology for their manufacturing. The advent of nanotechnology gives impetus to the field of plasmonics [1] which enables one to operate with light at the nanoscale, well below the scale accessible for the classical techniques. Nanoplasmonics offers to employ various remarkable optical properties of nanoparticles for design of novel narrow band pass filters.

Recently the structural tunability of plasmon resonances in metal-based nanoshells was demonstrated [2]. Nanoshell is a nanoparticle consisting of a dielectric core which is covered by a thin metallic shell. It can be shown that such particles may have a few plasmonic resonances, depending on the number of layers in the complex nanonostructure. In particular, the interaction of the plasmons on the inner and outer surfaces of the shell gives rise to two hybridized plasmon modes which energies can be varied widely with the variation of the inner to outer shell radius ratio. In addition, there is an energy (optical) window between two resonances, where the scattering by such nanoparticles can be drastically decreased [3]. To enhance the transparency in the optical band-pass we suggest to choose nanoshell material permittivity in such a way that a nanoshell dipole polarizability equals to zero in the center of the optical band-pass.

We propose to use the narrow localization in the energy of the nanoshell plasmonic resonances for construction of novel narrow optical band-pass filters. Thin polymer film containing a proper amount of nanoshells can act as such a filter. The main band-pass frequency can be controlled by the permittivity variation of the inner dielectric material and the geometry parameters of the nanoshell.

References

[1] V. Klimov, Nanoplasmonics (Pan Stanford Publishing, Singapore, 2011).
[2] E. Prodan, C. Radloff, H. J. Halas, and P. Nordlander, Science, Vol. **302**, 419 (2003).
[3] Y. B. Martynov, R. G. Nazmitdinov, I. A. Tanachev and P. P. Gladyshev, Pis'ma v ZhETF, Vol. **95**, 138 (2012).

QUADRUPOLE EXCITATION IN TUNNEL SPLITTING OSCILLATION IN NANO-PARTICLES Fe_8 AND Mn_{12}

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Spin tunneling effects in nano-particles Fe_8 and Mn_{12} are studied by instanton calculation technique using SU(3) generalized spin coherent states as a trial function. Energy level splitting is calculated by use of the spin coherent states path integrals and their dependence on the excitation of quadrupole dynamics is shown. For the both nano-particles, it arises due to the presence of a Berry like phase in action, which causes interference between tunneling trajectories (instantons).

If we consider only dipole excitation in Hamiltonian H related to nano-particle Fe_8, the number of quenching point in the interval h (proportional to magnetic field) from 0 up 0.25 are three. By experimentally, and by numerical diagonalization of the appropriate model Hamiltonian, only four quenching point are seen. For this nano-particle, it is established that the quadrupole excitation change only the location of the quenching points and the four point is very nearly to input to interval 0 up 0.25. Due to the symmetry of spin operators in Hamiltonian, for being more accurate, we have to consider other multipole excitation.

Experimental results show a series of steps in the hysteresis loops in Mn_{12} in low temperature. The steps observed in the hysteresis loops at nearly equal intervals of magnetic field are due to enhanced relaxation of the magnetization at the resonant fields when levels on opposite side of the anisotropy barrier coincide in energy. In calculation of spin tunneling amplitude related to this nano-particle, if we consider only dipole excitation, the number of quenching points is five. These numbers of quenching points are not equal to the number of steps in the hysteresis loop. Due to the symmetry of spin operators in related Hamiltonian, for being more accurate, we consider both dipole and quadrupole excitations. In this case number of quenching point's decreases to four that equal's to the steps in the hysteresis loop for this nano-particle.

FORMATION OF NANOSTRUCTURE FRAGMENTS IN PURE SiO2 GLASS UNDER IRRADIATION

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Optical spectroscopy and X-ray diffraction techniques were used for studying nanoscale particles formed in pure SiO_2 glass under irradiation in water in the reactor core with fast neutrons up to the fluency of $5 \cdot 10^{19}$ cm^{-2} and gamma-rays. The neutron irradiation results in destroying of the initial α- β-quartz mesostructure of 1.7 and 1.2 nm sizes and growing of cristobalite and tridymite nanocrystals of 16 and 8 nm sizes in the thermal peaks of displacements. The point defects (E'_s, E'_1, E'_2 and NBONC) induced by the gamma-irradiation are accumulated around the nanocrystals and form a defective envelope of 0.65–0.85 nm thickness. Additional NBONC are generated due to the water radiolysis, with the concentration growing with the fluency up to saturation. Interaction of close point defects at the nanocrystal-glass interface causes the splitting of optical absorption bands into the intensive narrow (D~2-4) resonances, with the width of 10-15 nm being close to the nanocrystals' sizes, and the energy depending on their structure. Having the perfect structure, the nanocrystals have zero optical density in the forbidden gap.

PHYSICAL PROPERTIES OF SILICON AND GERMANIUM NANOWIRES

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In the paper some physical properties, especially electrical conductance and thermal conductance, of semiconductor nanowires are discussed. We have analyzed and measured nanowires created of silicon and germanium because of using both Si and Ge for manufacturing of electronic devices. Electrical conductance G_E and thermal conductance G_T of a nanostructure describe the effect of electron transport in nanowires. Electrical conductance quantization in nanowires has been observed in units of $G_0 = 2e^2/h = (12.9\ k\Omega)^{-1}$ up to five quanta of conductance according to the theory proposed by Landauer. In the paper we present our measurements of electrical conductance quantization in Ge, Co (Fig. 1) and Au nanowires at room temperature. Quantized thermal conductance in one-dimensional systems (e.g. nanowires) was predicted theoretically by Rego. The thermal conductance is considered in a similar way like the electrical conductance. In one-dimension systems are formed conductive channels. Each channel contributes to a total thermal conductance with the quantum of thermal conductance G_{T0}. Quantized thermal conductance and its quantum (unit) G_{T0} was confirmed by Schwab. The quantum of

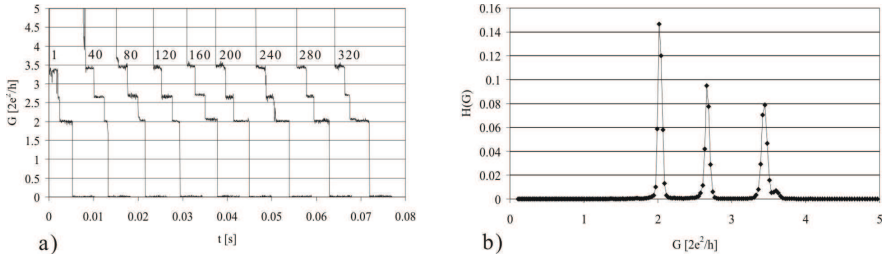

Fig. 1. Room-temperature conductance of nanowires formed between a Co tip and a Ge plate. (a) Electrical conductance curves of nanowires; (b) histogram exhibiting the statistical conductance for Co-Ge.

thermal conductance G_{T0} [W/K] = $(\pi^2 k_B^2/3h)T = 9.5\times10^{-13}T$ depends on the temperature. At $T = 300$ K value of $G_{T0} = 2.8\times10^{-10}$ [W/K]. This value is determined for an ideal ballistic transport in a nanowire, with the transmission coefficient t_{ij} = 100%. It means that in all practical cases (when $t_{ij} < 100\%$) the thermal conductance is below the quantum limit.

A single nanowire should be consider together with its terminals. Electron transport in the nanowire itself is ballistic, it means the transport without scattering of electrons and without energy dissipation. The energy dissipation takes part in terminals. Because of the energy dissipation the local temperature T_{term} in terminals is higher then the temperature T_{wire} of nanowires itself. A heat distribution in terminals of a nanostructe should be analyzed.

In small structures a dissipated energy is quite large. For the first step of conductance quantization, $G_E = G_{E0} = 7.75\times10^{-5}$ [A/V], and at the supply voltage V_{sup} = 1 V the current in the circuit I = 77 μA. The power dissipation in terminals of nanowires is $P = I^2/G_{E0}$ = 76 μW for the first step of conductance quantization. One can notice that the density of electric current in nanowires is extremely high. The diameter of the silicon nanowire on the first step of quantization can be estimated to D = 0.5 nm, so for I = 77 μA the current density $J \approx 4\times10^{10}$ [A/cm^2].

INFLUENCE OF CHANGING OF DEFECT NANOSTRUCTURE, MECHANICAL TREATMENT ON INELASTIC CHARACTERISTICS OF SIO_2 + SI

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The interaction between dislocations and impurities influences on the process of plastic deformation SiO_2 + Si. The depth of dislocation density N_D and the broken layer h_b are determined from internal friction (IF) difference ΔQ^{-1} on the nearby harmonics f_1 and f_2 after mechanical treatments. The dislocation density are measured in limits $N_D = 10^6 \div 10^9$ m^{-2}. The depth of the broken layer h_b = 1000÷3000 nm is on Fig. 1.

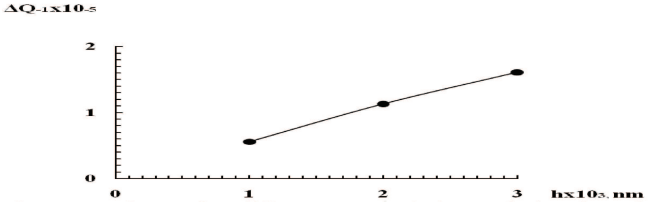


Fig.1.Dependence of IF difference ΔQ^{-1} of SiO_2 + Si plate from the depth of the broken layer h_b.

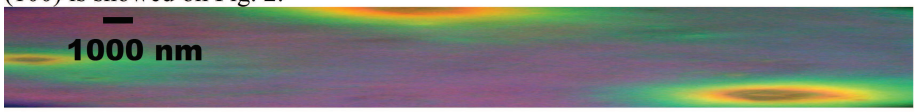
The account of dispersion of elastic mechanical vibrations energy of SiO_2 + Si plate on the structure defects results in expression for frequency of free vibrations of disk:

$$\omega = \sqrt{\frac{D\beta^2}{\rho h R^4} - 2\pi^2\left(\frac{Q^{-1}}{T}\right)^2}, \qquad (1)$$

where cylindrical inflexibility of plate D, determined through the elastic module E, plate thickness h and Puasson's coefficient μ:

$$\mu = \frac{(\frac{1}{2}V_{\updownarrow}^{\,2} - V_{\leftrightarrow}^{\,2})}{(V_{\updownarrow}^{\,2} - V_{\leftrightarrow}^{\,2})}. \qquad (2)$$

The microstructure of SiO_2+TiO_2+ZrO_2 film with thickness h ≈ 200 nm on Si (100) is showed on Fig. 2.



TEMPERATURE DEPENDENCE OF CONDUCTIVITY OF DIELECTRIC HIGH-SILICA ZEOLITE WITH METAL NANOPARTICLES

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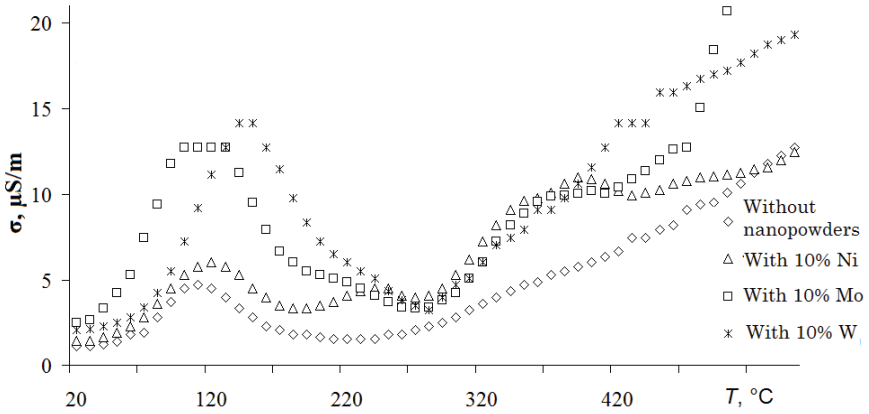
At present a perspective method for improving material properties is the use of metal nanoparticles. This paper analyzes experimental data about conductivity (σ) of the system "nanopowder – polycrystal zeolite". It is found, that conductivity increases with rise in temperature. Sample without nanoparticles (non-modified) has the least σ. Dependences obtained can be attributed to dissociation of water contained in zeolite polycrystals, which causes protons and hydroxyl groups to form. This also leads to increase in mobility of exchange cations, providing electroneutrality, and, therefore, increase in conductivity. At temperature 110-150°C there is a decrease in σ due to zeolite dehydration and increase in framework and cations interaction, which hinders movement of the later. Conductivity rises with further increase in temperature because cation mobility increases. Higher σ values of modified samples could be due to conductor nanoparticles, coated with nanometer oxide semi-conuctor film, on the surface of dielectric zeolite. The highest conductivity is seen for the sample with 10% W. Conductivity values of this sample could be two times as much as those of non-modified sample.



KAPITZA RESISTANCE BETWEEN THE ELECTRON AND PHONON GASES

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It is well known, that boundary thermal resistance, first observed by Kapitza, is one of most important characteristic of heat transfer in nanocomposite materials. Until now, however, most of the reported studies involved only the phonon flow between two bodies. At the same time, the case of most interest, to wit, the metal-dielectric contact, where heat is transferred between the electron gas in a metal and the phonon gas in a dielectric, has not thus far been enjoying adequate attention. This gap appears essential, because electrons are the major carriers of heat in metals, and phonons, those in a dielectric. Thus, for heat transfer to be efficient, such a mechanism should provide a major contribution to heat transfer between a dielectric and a metal.

Here we will consider a one-dimensional problem (Fig. 1) in which the electron and phonon gases interact at one point only. The spectral functions of electrons and phonons in such a system have been derived and analyzed in an analytical form. The results obtained were employed in calculation of the thermal resistance constant at the boundary separating the electron from the phonon systems. It has been demonstrated that thermal resistance decreases with increasing electron-phonon interaction coefficient and/or temperature; at large values of these parameters, thermal resistance at the boundary no longer depends on these quantities. The results obtained correlate well with the available experimental data.

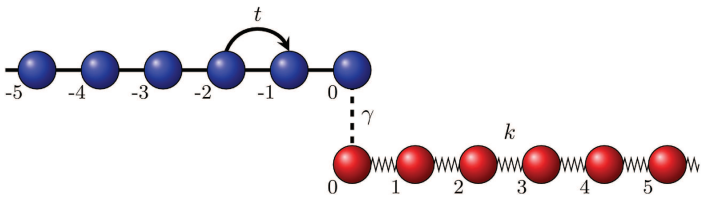

Fig. 1 Schematic visualization of a semi-infinite electron system, in which the overlap integral for neighboring atoms is t, and a semi-infinite phonon system, in which elastic coupling between neighboring atoms is characterized by the elastic constant k. At site *0*, local electron-phonon interaction is operative, and the electron-phonon subsystem coupling energy is γ.

VIBRON SELF-TRAPPED STATES IN BIOLOGICAL MACROMOLECULES: COMPARISON OF DIFFERENT THEORETICAL APPROACHES

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We present the results of the research on applicability of the variational treatment based on the usage of the modified Lang-Firsov unitary transformation (MLF method) [1] to investigating of the vibron self-trapped states in biological macromolecule chains [2, 3, 4, 5, 6]. We compare the values of the ground state energy predicted by MLF method with the values of the ground state energy predicted by the standard small-polaron theory, for various values of the system temperature and for various values of the basic energy parameters of the system. We obtain the regions in system parameter space where MLF approach gives better description of the vibron states.

References

[1] I.J. Lang and Yu.A. Firsov, *Kineticheskaya teoriya poluprovodnikov s maloi podvizhnostyu*, Zh. Eksp. Teor. Fiz., 43, 1843 (1962) [Sov. Phys. JETP, 16, 1301 (1963)].
[2] E.I. Rashba, in E.I. Rashbam, M.Struge (Eds.), Excitons, North-Holland, Amsterdam (1982).
[3] D.M. Alexander and J.A. Krumhansl, *Localized excitations in hydrogen-bonded molecular crystals*, Phys. Rev. B, 33, 7172 (1986).
[4] Y. Toyozawa, *Self-trapping of an electron by the Acoustical Mode of Lattice Vibration I*, Progr. Theor. Phys., 26, 29 (1961).
[5] D. Emin, *On the existence of free and self-trapped carriers in insulators: an abrupt temperature-dependent conductivity transition*, Advan. in Phys., 22, 57 (1973).
[6] D. Cevisović, S. Galović and Zoran Ivić, Nature of the vibron self-trapped states in hydrogen-bonded macromolecular chains, Phys. Rev. E , 84, 011920 (2011).

QUANTUM OPTICS WITH POLARITONS IN A SPATIALLY-PERIODICAL ATOMIC MEDIUM

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Nowadays, photonic band-gap micro- and nanostructures, i.e. photonic crystals, photonic crystal fibres, cavity arrays, etc, are known to be important tools for controlling light propagation properties in media. Strong confinement of the photons and reduction of the group velocity of light due to the band-gap energy spectrum for one-, two- or three-dimensional boson-like systems play an essential role in the solution of modern problems in both material science and information science.

We discuss a new type of spatially periodic structure, i.e. polaritonic crystal (PolC), to observe a 'slow'/'stopped' light phenomenon due to coupled atom–field states (polaritons) in a lattice [1]. Under the tight-binding approximation, such a system realizes an array of weakly coupled trapped two-component atomic ensembles interacting with the optical field in a tunnel-coupled two-dimensional cavity lattice. We have studied two- and three-body polariton-polariton scattering parameters by means of the Holstein-Primakoff approach [2]. We have shown that two-body polariton scattering dominates in the positive atom-field detuning domain that corresponds to atomlike LB polaritons. We consider macroscopic properties of such polaritons as a whole at the bottom of the dispersion curve in the continuous limit of a spatially periodic (lattice) structure. A variational approach is used to study the related widths, chemical potential, and characteristic frequencies of PolC ground state wave functions around the equilibrium points. For a negative scattering length, the wave function collapses in the presence of a small quintic nonlinearity appearing due to a three-body polariton interaction. Nonequilibrium effects of a weak polariton number decaying in the PolC structure are examined as well.

References

[1] A.P.Alodjants, I. O. Barinov, S. M. Arakelian. *Strongly localized polaritons in an array of trapped two-level atoms interacting with a light field*. J. Phys. B: At. Mol. Opt. Phys. **Vol.43**, p.095502 (2010).

[2] E.S. Sedov, A.P. Alodjants, S. M. Arakelian, Y. Y. Lin and R.-K. Lee, *Nonlinear properties and stabilities of polaritonic crystals beyond the low-excitation-density limit.* Phys.Rev.A. **Vol. 84**, p. 013813-1 (2011).

NANOPARTICLES FABRICATION FOR DAIRY WASTE (WHEY) PROCESSING

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Chitosan nanoparticles fabrication with Maleic acid was investigated for Metals, proteins and fats removal in whey. The prepared nanoparticles have a significant contact surface area and better adsorptive properties compare to conventional Chitosan. The concentration of Chitosan nanoparticles and conventional Chitosan at 0.02, 0.03 and 0.05 g in 10 ml of whey, and pH at 4, 5 and 6 were compared for adsorption of protein, fat and metal ions in whey by using spectroscopic method. The results showed that at pH=6 and concentration of 0.05 g/10ml of nanoparticles have the highest removal capacity. Atomic absorption spectroscopy (AAS) techniques were used to determine the removal efficiency of proteins and fats and metals ions, respectively. A removal efficiencies of 100% for Pb, 83% for Fe and 53% for Cu at pH 6 and 0.05 g Chitosan nanoparticles /10 ml whey were obtained. The corresponding removal efficiencies of proteins and fats by Chitosan nanoparticles were found to be 69 and 76%, respectively, at pH 6 and 0.5 g/10ml whey. Removal efficiencies of 30% proteins and 29% fats at pH 6 and 0.5 g/10 ml whey were obtained by Chitosan.

Keywords: whey, Chitosan, nanoparticles, lactose, isolation

THE DIFFUSION OF SURFACTANTS THROUGH TRACK-ETCHED NANOPORES

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The addition of small amount of surfactants to the alkali solution, sodium dodecyl diphenyloxide disulphonate (SDDD), leads the nanopore channels to the highly tapered profile [1].

To understand the nanopore formation mechanism, it's important to know about the diffusion of surfactant molecules. This work presents the data on the diffusion of a surfactant SDDD through TMs with the different pore diameters in compare with the diffusion of potassium chloride KCl. Fig.1 shows the time dependence of number of moles of KCl and SDDD which passed through one pore on the TMs with pore diameter of 260 nm, 100 nm, 62 nm, and 54 nm. It shows, 1) when pore diameter is larger, both of molecules of KCl and SDDD are pass through the pores faster, 2) the diffusion of KCl doesn't have a time lag, 3) the diffusion of SDDD has a time lag and the time lag is very big when the pore diameters are smaller(62 or 54nm). The correlation of the result of diffusion experiment and the pore geometry of TMs controlled with the surfactant is discussed.

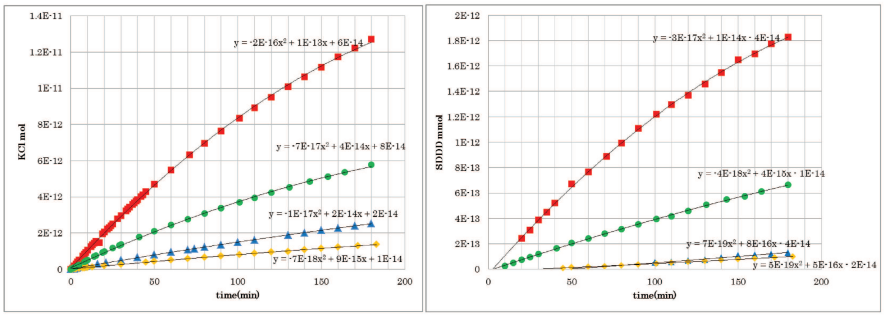

Fig.1 The time dependence of number of moles of KCl (left) and SDDD (right) which passed through one pore. We use the TMs with pore diameter 260 nm (square), 100 nm (circle), 62 nm (triangle), 54 nm (diamond).

References

[1] Colloid Journal, 2009, Vol. 71, No. 5, pp. 634–639, Yu.S. Kovalev, N.V. Levkovich, A.I. Kuklin, P.Yu. Apel, (2009).