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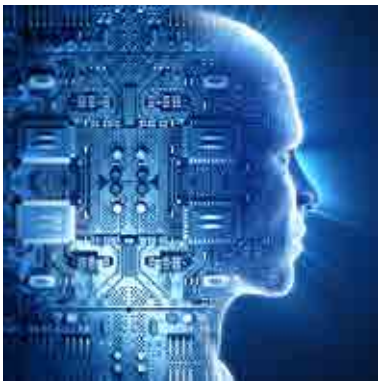
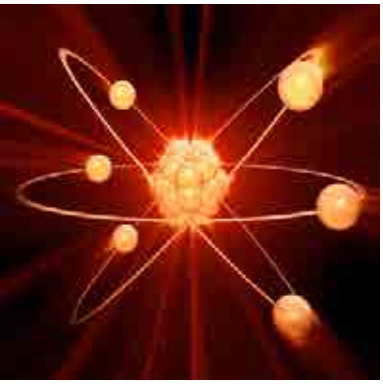
Physics 2018





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Applied Physics

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Low-temperature thermal properties of type-1 thermoelectric clathrates

Kirill Pilipenko

Petrovsky Bryansk State University, Russia

Thermoelectric type-1 clathrates are a special class of substances whose crystal structure features lead to low values of their thermal conductivity and high electrical conductivity ("phonon glass electron crystal"). This contradictory combination of properties is achieved due to quasi-independent vibrations of guest atoms in the cavities of the host matrix and the presence of free electrons from the host atoms. The specific heat (2-300 K) and lattice parameters (5-300 K) of clathrates-1 of different compositions were studied. It was established that the phonon spectra of clathrates are satisfactorily approximated by two Einstein functions accounting for vibrations of guest atoms in cavities of two different types and one Debye function describing vibrations of matrix-host. Second, we show that the possibility of the guest atoms to occupy spatially close but energetically non-equivalent states in the host cavities leads to the formation of two-level systems and, consequently, to a specific low-temperature contribution to the thermal characteristics of clathrates-1, which can be described by the Schottky function. Finally, we have found that the presence of vacancies in the host matrix and the disorder of the arrangement of constituent atoms of different types lead to a glass-like contribution to the heat capacity and thermal expansion of the clathrate-1 at the lowest experimental temperatures; this contribution varies linearly with the temperature.

Speaker Biography

Kirill Pilipenko is graduate student from Petrovsky Bryansk State University, Russia. He has 2 publications, and his publication H-index is 1.

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Accepted Abstracts

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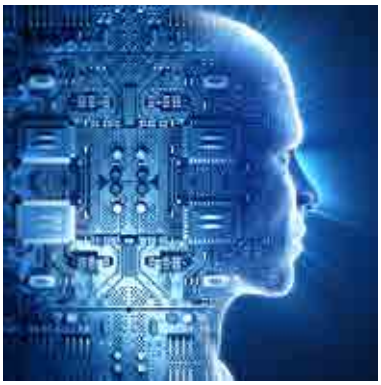

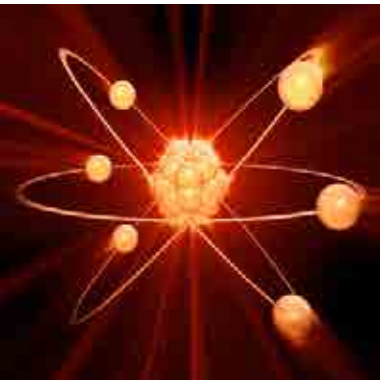

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Novelties in additive manufacturing and bio-printing

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Nonlinear conservation laws subject to random initial conditions pose fundamental problems in the evolution and interactions of shocks and rarefactions. Using a discrete set of values for the solution, we derive a hierarchy of equations in terms of the states in two different methods. This hierarchy involves the n-point function, the probability that the solution takes on various values at different positions, in terms of the n+ 1-point function. In the first approach, these equations can be closed but the resulting solutions do not persist through shock interactions. In our second approach, the n-point function is expressed in terms of the n+ 1-point functions, and remains valid through collisions of shocks.

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Functionalizing liquid crystals for phononic, biophotonic and multiphysics devices

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The knowledge on the manipulation of energy is of core importance for research, technological innovation and industry. However, in many of the related devices, it is used different materials and configurations to build them, beyond that they are monopurpose and monophysics, dealing with one type of energy. An alternative to bypass these problems is the usage of liquid crystals: inanimate or living ones. In this work, we show our results on modeling and simulating three kinds of diode (thermal, bio-optical and thermal-optical), a sensor based on the thermal Hall effect and a thermal-optical controller. We found that the rectification effect of our diodes can be created by an escaped radial disclination confined in a capillary tube, having an asymmetric molecular director and asymmetric physical tensors (dielectric, thermal conductivity, etc.). This asymmetry, studied by classical and geometrical models, generates the thermal and optical rectifications. For such diodes, we study them made by 5CB and a chromonic liquid crystal hosting the bacterium Bacillus subtilis. The sensor based on the thermal Hall effect uses a hypothetic chiral biaxial nematic liquid crystal with a magnetic dipole composing a strip, with an initial longitudinal temperature gradient. We found that such system produces a The thermal-optical controller consists of 5CB confined between two concentric cylinders, where, due to the action of an applied electric field, it is allowed to switch between two molecular configurations. We found simultaneous concentration and repulsion of heat and light. Our results present new examples of manipulating heat, light and both simultaneously using liquid crystals, allowing one to apply such materials for developing devices that process more information at the same time.

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Growth technology of InGaN/GaN nanocolumn-array LED crystals on 2-inch AlN/Si substrates useful for integrated micro-LED fabrication

Katsumi Kishino
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Using uniform arrays of GaN nanocolumns, monolithic integration of four-color InGaN-based nanocolumn LEDs has been demonstrated. Two-dimensional arrangement of such RGB micro-LEDs will, in principle, enable the fabrication of a semiconductor video panel, which function as a micro-LED display. The extended projection of the video image on a screen is expected to form a widescreen LED display. One of the basic technologies for achieving such micro-LED displays is the fabrication of InGaN-based nanocolumn LEDs on a wide-area, for example 2-inch size or more, Si substrates. Si is easily removed from InGaN/GaN heterojunction crystals grown on them, enabling the flip-chip process of nanocolumn LED crystals. The wiring on top and bottom of the LED is suitable for a high-density integration of micro-LED pixcels, and cost-effective fabrication of LED panels. In this study, triangular-lattice nanopillar-array templates with a lattice constant of 280 nm and with AlN disks on top of the underlying Si pillars were prepared on 2-in. AlN/Si substrates through nanoimprint lithography and dry etching. Regularly arranged GaN nanocolumn arrays with a 220-nm diameter were grown on the templates to fabricate wide-area emission InGaN/GaN nanocolumn LEDs. An LED chip with an ITO electrode with an area of 3 × 4 mm2 operated at a current of 100 mA emitted blue-green light (504 nm in wavelength) from the entire surface of the large emission area. The growth technology developed here will contribute to the fabrication of two-dimensionally arranged integrated nanocolumn micro-LEDs.

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Microbubble dynamics in a viscous compressible liquid subject to ultrasound

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This talk is concerned with microbubble dynamics in a viscous compressible liquid subject to ultrasound. The topic is associated with important applications in medical ultrasonics and ultrasound cleaning. The compressible effects are modelled using the weakly compressible theory of Wang & Blake (J. Fluid Mech. 730, 245-272, 2010 and 679, 559-581, 2011), since the Mach number associated is small. The viscous effects are approximated using the viscous potential flow theory of Joseph & Wang (J. Fluid Mech., 505, 365-377, 2004), because the flow field is characterized as being an irrotational flow in the bulk volume but with a thin viscous boundary layer at the bubble surface. Consequently, the phenomenon is modelled using the boundary integral method, in which the compressible and viscous effects are incorporated into the model through including additional terms in the dynamic boundary condition at the bubble surface. The numerical results are shown in good agreement with the experiments of Versluis et al. (Phys. Rev. E 2010, 82, 026321), for the development of shape modes after dozens cycles of oscillation. The model is accurate, highly efficient, stable for many cycles of oscillation and grid-free in the flow domain. Our computations show that when subject to an acoustic wave a microbubble initially oscillates spherically. Beyond a critical threshold of the acoustic pressure amplitude, nonspherical surface modes generate after several cycles of oscillation. The threshold decreases as the acoustic frequency is equal to the natural frequency of the bubble. As the pressure amplitude increases, non-spherical shape modes develop earlier. A shape mode can be activated if the driving acoustic frequency is equal to the natural frequency of the shape mode.

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Charge transport in branched conducting polymers: Quantum graphs based approach

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Conducting polymers has attracted much attention recently in the context of organic electronics. Some types of such polymers can have supramolecular (macroscopic) branching. Branched polymers occur when groups of units branch off from the long polymer chain. These branches are known as side chains and can also be very long groups of repeating structures. Branching polymers can be further categorized by how they branch off from the main chain. Polymers with many branches are known as dendrimers, and these molecules can form a webbing when cooled. This can make the polymer strong in the ideal temperature range. Such branched polymer chains can be modeled in terms of so-called quantum graphs, which are the set of nanoscale bonds connected at the vertices. The connection rule is called topology of a graph. Modeling of wave dynamics in branched conducting polymers require developing of effective methods allowing to take into account transition of the waves from one to another branches via the branching points. One of such approaches is based on the use of metric graphs as the models of the branched polymers. Within such approach, exciton dynamics can be modeled in terms of the Schrodinger equation on metric graphs.

In this work we use solve the problem of exciton dynamics and charge separation (via splitting of exciton into electron and hole) by modeling the whole system in terms of quantum graph. The main problem we studied is splitting of exciton from transmission from one branch to another one. Charge separation probability is explicitly calculated.

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Fifth-order superintegrable quantum systems separating in Cartesian coordinates: Doubly exotic potentials

Ismail Abouamal
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We consider a two-dimensional quantum Hamiltonian separable in Cartesian coordinates and allowing a fifth-order integral of motion. We impose the superintegrablity condition and find all doubly exotic superintegrable potentials (i.e., potentials V (x; y) = V1(x)+V2(y), where neither V1(x) nor V2(y) satisfy a linear ordinary differential equation), allowing the existence of such an integral. All of these potentials are found to have the Painleve property. Most of them are expressed in terms of known Painleve transcendents or elliptic functions but some may represent new higher order Painleve transcendents.

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Robust and optimal quantum control for some classes of linear quantum systems

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As experimental quantum technology continues to improve, the idea of manipulating microscale quantum processes rather than just observing them is rapidly gaining ground. In particular, the manipulation of quantum systems using continuous measurement and feedback control has generated increasing interest in the last few years due to its potential applications in metrology, communications and other quantum technologies. Also, the area of quantum control is of theoretical interest, since it connects the well-developed field of classical optimal control theory to fundamental questions regarding the structure of information and disturbances in quantum mechanics. Therefore, significant interest has emerged in the area of quantum feedback control systems.

Extending classical control theory to the quantum domain; i.e., to physical systems whose behaviour is not governed by classical physics but dominated by quantum effects, has become an important area of research. It is also an essential prerequisite for the development of novel technologies such as quantum information processing, as well as new applications in quantum optics, quantum electronics and quantum chemistry.

The most effective strategies in classical control applications involve feedback control. However, the implementation of classical feedback control for quantum systems poses severe challenges since quantum measurements tend to destroy the state of the system (wave-packet reduction). Nevertheless, the possibility of continuous monitoring and manipulation on a natural time-scale has recently become realistic for some quantum systems. This may be viewed as a first step in the direction of closing the gap between quantum feedback control and classical control theory.

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Global solar radiation on tilted surfaces in Tunisia: Measurement, estimation and gained energy assessments

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A very important factor in the assessment of solar potential for the installation of photovoltaic plants is the availability of global irradiation data measurements. Such data must be collected over a period of time longer than 11 years and must be accurate. In some countries, it is difficult to have databases of these measures. To overcome this problem, we propose, the use of numerical models to estimate the monthly, seasonally and annually solar energy irradiation (global diffuse and direct solar radiation), especially on tilted surface.

The results obtained from the numerical models are compared to the data collected from three regions on Tunisia: Bizerte (in the north), Nabeul (near to the north east) and Djerba (in the south). The actual measurements taken from the meteorological stations and the measurements generated by the numerical models are very close.

After the validation of the numerical models, we tried to calculate the best tilt angle for each period of the year to position a photovoltaic panel, in a given region, to reach maximum energy recovery. The practical validation, of the optimal tilt angle search and the adequate period, was conducted at the Research and Technology Center of Energy of Borj_Cedria. The obtained results are satisfactory and prove the reliability of the constructed numerical models.

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Polaritons in a nonideal array of microcavities with ultracold quantum dots

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A A Galkin Donetsk Institute for Physics and Engineering, Ukraine

The report is devoted to elucidation of the effect of point-like defects on polariton dispersion in a 1D and 2D microcavity array with embedded one-level quantum dots. It is shown that the presence of vacancies in the microcavity (resonator) and atomic (quantum dots) subsystems results in a substantial renormalization of polariton spectrum and thus in a considerable alteration of optical properties of the structure. Introduction of defects leads to an increase in the effective masses of polaritons and hence to a decrease of their group velocity. Our model is primarily based on the virtual crystal approximation, which is often employed to examine quasiparticle excitations in sufficiently simple disordered superstructures. More complex systems usually require the use of more sophisticated methods such as the (one- or multinode) coherent potential approximation, the averaged T-matrix method and their various modifications. The obtained numerical results contribute to our understanding of composite polaritonic structures and the prospects of their utilization for construction of solid-state devices with controllable propagation of electromagnetic waves.

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Peculiarities of the BCS theory of superconductivity

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We study the effect of the relative value of the chemical potential with respect to the middle of the attraction band, on the results of the BCS theory of superconductivity. In this way, we observe that the phenomenology predicted by the theory is much richer than previously expected. If the attraction band (i.e. the interval in which the pairing interaction is manifested) is not symmetric with respect to the chemical potential, then the equation for the energy gap has two solutions, the superconductor-normal metal phase transition temperature is changed, and the phase transition may become of the first order. The phase transition temperature decreases with the asymmetry, so, if the asymmetry can be modified by dopping of the superconductor or by applying pressure, then a structure similar to the so called “superconducting dome” is formed if we plot the transition temperature vs. dopping or pressure.

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Generation of exact analytic solution of position-dependent mass Schrodinger equation

Hangshadhar Rajbongshi
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Extended Transformation, a method of mapping a known system into a new system is applied to generate exact analytic solution of position-dependent mass Schrodinger equation. Some exactly solvable potentials are taken as known systems and the first order transformation is performed on D-dimensional radial Schrodinger equation with constant mass providing exactly solvable potentials equipped with energy eigenvalues and corresponding wave functions for different choices of mass functions for each known system. The transformation is performed on D-dimensional radial position-dependent mass. Schrodinger equation also where the systems with mass functions generated in the first order transformation are taken as known systems. The important fact is that the solutions which are meant for central potential with radially symmetric mass functions are fitted for "Zhu and Kroemer" ordering of ambiguity. Another result is that all the wave functions corresponding to non-zero energy eigenvalues are normalizable and the normalizability condition of the wave functions remains independent of mass functions. Thirdly, some of the generated potentials show a family relationship among themselves where power law potentials also get related to non-power law potentials and vice versa through the transformation.

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"Local symmetry – shape – size" relation of the channel for transport of atoms, molecules from the variation principles

Nadezhda Krylova
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For the transfer of foreign atoms (ions, molecules) in different bodies transport channels play an important role, the transverse dimensions of which are comparable or exceed several times the size of the transported atoms (ions, molecules).

In the work it was possible to show, in an explicit form, the influence of the local symmetry type of the transport channel on its inner "radius" of the cavity. It turned out that the channel with helical symmetry has an internal radius substantially greater than the radius of the channel with cylindrical symmetry. Since the general principle of minimal action of the system were used to clarify this situation, it can be assumed that, in most cases, when organizing transport channels for the transfer of atoms (molecules, ions), the preferred type of symmetry will be the structure of the channel showing the properties of screw symmetry.

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The theory of gravitational

Majid Neemah
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This study, we will present a new theory that has not been addressed before. It falls within the competence of theoretical physics. This theory states that there is a process of attraction between the unequal particles of energy from an energetic particle with high energy with a weak particle with weak energy. Which paves the way for the formation of spaces, but equal particles in energy does not get attracted to them, but gets dissonance.

This theory is based on two fundamental concepts, which are also new: the theory of attractive space and space of repulsive. The attractive space consists of some particles that are free of matter as a result of motion (velocity or heating). The particles collect in one mass and each particle is free. A coherent space attracts other particles,when this space is formed, it can attract other spaces that are an attractive force.

The space of repulsive is the space that is made up of equal electrons or equal spaces because the attractive space is the space made up of particles that have great energy and the space itself has a strong magnetizing force because it contains strong particles (high energy).

The attractive space is not able to attract such strong particles, because the attractive space attracts weak or small particles and closes them in a certain space and as a result of the movement (speed or heating), the energy between them increases and a strong attractive space attracts Particulate matter the other is in contrast with the other space containing strong particles.

Which can be called (the theory of everything), Which, if proved to be correct, would explain many of the mysterious scientific cases that were puzzling to scientists, such as the nature of light, whether it is wave or particle? Explain a precise mechanism of Higgs boson mechanics and put a circular and answer the number of other questions that remained puzzling to many scientists, for example, why the earth's gravity is weak on the ground, and we will give a lot of scientific examples that support our theory.

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Particles acceleration processes in the laser plasma

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To date, as a result of a large series of experimental and theoretical studies scientists managed to identify the role and nature of the absorption of laser radiation in a plasma, the mechanisms of energy transfer between different components, the main properties of kinetics of the ionization state and dynamics of expansion of the laser-plasma torch. A significant contribution to the experimental research has been made, in particular, due to the development and application of laser mass spectrometry, allowing one to determine the charge composition of the plasma, the properties of the processes of ionization, acceleration, and recombination in laser plasma. Numerous studies have established that the laser plasma is an intense emitter of charged and neutral particles: the electrons, ions, and atoms. The mechanisms of the energy spectra of ions and neutral particles have been studied in detail, and laser sources of particles, which have found application in accelerators, cyclotrons, and mass spectrometers, have been developed and technically implemented. A laser-plasma generator of multiply charged ions produces a large number of heavy ions in the regime of short periodic pulses, which is of interest for ion accelerators operating in the pulse periodic regime. The source of this type is also promising for research in the field of heavy-ion fusion. The laser-plasma generator is based on the physical phenomenon of generation of highly excited states of atoms by a high-power laser pulse focused on the surface of a solid target. With expanding a high-temperature laser plasma into vacuum a high-power flux of charged particles is produced.

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Selective laser spectroscopy of solids: A history, fundamentals and applications

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A history of the development of selective laser spectroscopy of solids is described, beginning from a pioneering work by Yu. V. Denisov and V. A. Kizel in 1967, who were the first to demonstrate removing the inhomogeneous broadening of luminescence spectra of ions in glasses upon monochromatic resonance excitation. Selective excitation of optical centers is achieved due to existence of very narrow homogeneous zero-phonon lines in the spectra of impurity centers in solids, which are hidden in broad inhomogeneous optical bands upon usual nonselective excitation. The fundamentals of zero-phonon transition spectroscopy are considered and the mechanism of removing the inhomogeneous broadening of optical spectra of ions and molecules in crystals and amorphous solids under selective laser excitation of luminescence and persistent hole burning in absorption spectra is analyzed in detail. Various applications of selective laser spectroscopy for fundamental and applied studies are discussed.

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Integrating gravity and magnetic field data to delineate structurally controlled gold mineralization in the Sefwi Belt of Ghana

Bernard Konadu Amoah
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Gravity and magnetic surveys were used to delineate potential gold mineralization zones in the Sefwi belt of Ghana. The study area is an intrusive dominated area that hosts pockets of smallscale mining operations locally referred to as Galamsey. These Galamsey operations are not guided by a scientific approach to back the trend of gold mineralization which is conventionally mined. The study aimed at mapping lithological units, structural setting and relating Galamsey sites to delineate potential zones of gold mineralization. A Scintrex CG5 gravimeter and GEM's Overhauser magnetometer were used for gravity and magnetic data acquisition respectively. The magnetic data were corrected and enhancing filters such as reduction to the pole (RTP), analytical signal and first vertical derivative were applied using Oasis montaj 7.1. Gravity data were also reduced to the geoid using the Oasis montaj software to produce a complete Bouguer anomaly map. The regional/residual separation technique produced a residual gravity map. The RTP and analytical signal filters from the magnetic data and residual gravity anomaly map from the gravity data helped in mapping belt type (Dixcove) Birimian granitoids and mafic intrusive unit, interpreted as gabbro. The first vertical derivative filter was useful in mapping NE/SW minor faults and crosscutting dykes largely concentrated in the belt type Birimian granitoids. All the three mapped Galamsey sites fell on a minor fault and are associated with the belt type granitoids which were used in delineating four potential zones of gold mineralization.

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Local broken symmetry and spin transport in the frustrated two-dimensional model

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The local spontaneous symmetry breaking is a general phenomena in condensed matter physics. It is characterized by the fact that the action has a local symmetry but the quantum theory, instead of having a unique vacuum state which respects this symmetry, has a family of degenerate vacua that transform into each other under the action of the symmetry group. A simple example is given by a ferromagnetic model in which the action governing its microscopic dynamics is invariant under spatial rotations. A kind of local gauge invariance or spontaneous breaking of U(1) gauge symmetry is realized in nature in the phenomenon of superconductivity. We have proposed the Meissner mechanism for the spin supercurrent in quantum spin systems. Besides, we study the behavior of the AC spin conductivity in neighborhood of quantum phase transition in a frustrated spin model such as the antiferromagnet in the compass lattice with single ion anisotropy at T=0. Our results show the curve of conductivity varying strongly with the behavior of the critical anisotropy Dc and J.

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The effects of bauxite, metakaolin, and porosity on the thermal properties of prepared Iraqi clays refractory mortars

Mustafa Hassan Omar
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One of the most important requirements for the manufacture of refractory mortars, especially those used in the construction of thermal systems (building or plastering), is the balance between thermal insulation properties and porosity. Where, increasing porosity of mortar to a large amount may be always undesirable, because the absorption of liquid and gases emitted from industrial system is decline the bonded with bricks and structural properties of mortars. Refractory mortars prepared from either fired bauxite or metakaolin clays with different percentages of kaolin (10, 20, 30, and 40 wt. %). Bauxite rocks were fired at 1200 °C and metakaolin was obtained by firing kaolin up to 700 °C then crushed and grinded. Grog was added to mixture to reduce the shrinkage. Cylindrical specimens are prepared and then sintered at 1200 °C. All mixtures maintained a low thermal conductivity within the limits of thermal insulation material (less than 0.5 W/m. K); it was done by controlling the porosity which reached a maximum value approximately 25%. The volumetric heat capacity and thermal diffusivity was ranged between (1–10 MJ/m3 K), (0.06–0.2 mm2/s), respectively.

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The H-theorem and equation of state for kinetic model of imperfect gas

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For molecules interacting among each other with the potential having both repulsive and attractive components, a system of kinetic equations is derived using the Bogolyubov method, which takes into account the effect of forming bound states by molecules. This system implies all conservation laws and their corollaries that are invariant under the Galilean transformation. With consideration of the relaxation problem for the given system of kinetic equations, the H-theorem can be obtained. It is noted that the equation of state, which is derived in this case, coincides in form with the van der Waals equation of state.

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