

## DEFINITION OF PHYSICS<sup>1</sup>

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### ABSTRACT

What is physics? What would a good definition for it be, if possible at all? This question takes the author on a search for the most important in the history of physics starting in antiquity. Following that, he discovers a certain synthesis of philosophical and religious ideas that gave physics a new wind in Modernity, which he calls Pythagorean Faith. Recognizing the very specific character of the known laws of nature, namely, a particular minimax of their complexity, leads to a new formulation of the physico-theological argument, the Pythagorean argument for the intelligent design of the universe. In conclusion, the author comes to a new definition of physics.

## A NEW LOOK AT THE COSMOLOGY OF THE UNIVERSE

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### ABSTRACT

The theory of local expansion and contraction of the Universe makes it possible to abandon the Big Bang in the standard cosmological model  $\Lambda$ CDM ( $\Lambda$ - Cold Dark Matter), and the inflationary theory of the expansion of the Universe. The mechanism of the birth of matter in an infinite Universe was proposed by Professor Stephen William Hawking, as an effect of radiation of particles by a black hole and experimentally implemented by the Nobel Prize winner Andre Geim under laboratory conditions inside graphene, identical to those, in which matter arises from the vacuum in the vicinity of black holes and magnetars.

## PROTON POLARIZABILITY AND QUARK-GLUON PLASMA

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### ABSTRACT

The article deals with experiments performed at the National Laboratory named after Jefferson is associated with elastic and inelastic collisions of the proton nucleus by an electron beam with an energy of 4.56 GeV. It has been experimentally proved that the local maximum found near 33 GeV during the polarization of protons by a stream of electrons was reached in the Large Hadron Collider at an energy of 28 GeV, during p-p collisions. The article proposes to consider the estimate of the mean square radius of an electrically polarized proton  $r_E = 1.36 \pm 0.29$  square femtometers as overestimated because the contribution of inelastic collisions of electrons with the hydrogen nucleus was not taken into account in the kinematic scattering model. The

mean square of the radius of an electrically polarized proton can be determined at an energy of 28 GeV and its value will then be commensurate with the proton radius of 1 femtometer.

## PHYSICAL CATEGORIES – MASS AND DENSITY OF BODIES

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### ABSTRACT

Mass is a fundamental physical quantity that determines the inertial and gravitational properties of bodies from macroscopic objects to atoms and elementary particles. According to the completed study, body mass is the sum of the volumes of atomic nuclei contained in the body. The measure of density is the ratio of the nucleus volume of an element to the volume occupied by an atom in space. The proposed measure of mass and density is true for any physical body on any space object.

## GIANT NEUTRON NUCLEUS AND PROPERTIES OF NEUTRON STARS.

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### ABSTRACT

Considering a neutron star as a giant neutron nucleus composed of neutrons only, and using the binding energy,  $B(A, Z)$  expression, calculations are done for the number of neutrons  $A$ , in the giant nucleus along with the mass  $M$  and radius  $R$  of the neutron star. Two sets of calculations have been attempted. In one case the neutron star is treated as the giant nucleus, and in the calculations terms such as Coulomb energy are neglected in the expression for  $B$ . This gives  $A \approx 5 \times 10^{55}$ ,  $M = 0.042M_0$ ,  $R = 4.3\text{km}$ . In the second set of calculations, the neutron star is assumed to be in a superfluid state, where pairs of neutrons, like Cooper pairs, define the superfluid state. Pairing energy due to neutron pairs will play a definite role in determining the value of  $B$ . In this in the limiting case when  $B \rightarrow 0$ , we get  $A \approx 8.28 \times 10^{56}$ ,  $M \approx 0.7M_0$ ,  $R \approx 14\text{Km}$ . These values compare favorably with the corresponding values known and predicted by scientists. This in turn supports the hypothesis that a neutron star may exist in a superfluid state even at very high temperatures  $\approx 10^6$  K. It is quite possible that some other particles, hitherto unknown, and forces may exist inside the neutron star, and if they are taken into account in the value of  $B$ , values of  $A$ ,  $M$ , and  $R$  could be improved and the values may be closer to the values predicted so far.

## **ELECTRON-HOLE SUPERCONDUCTIVITY IN BI-LAYER GRAPHENE SUPERCONDUCTORS**

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### **ABSTRACT**

Superconductivity has been discovered in many different types of materials, such as metals, metallic alloys, doped semiconductors, cuprate oxides, heavy fermion superconductors, and so on; and now recently bi-layer and trilayer graphene superconductors. What is common among all these superconductors is that the super-current is due to the frictionless flow of pairs of charge carriers, called Cooper pairs, and the charge carriers can be electrons, holes in pairs, or electron-hole pairs. In this manuscript, the role of electron-hole pairs in determining the superconductivity in bi-layer graphene superconductors is studied theoretically. It is based on the spontaneous inter-layer phase coherence in a bi-layer quantum Hall system studied using graphene layers. The phase coherence state is assumed to be a gas of super-fluid electron-hole pairs whose components (electrons and holes) belong to two different layers which are one above the other and are separated by a dielectric of a very small thickness ( $d$ ), and the value of  $d$ , should be such that the state of phase coherence is not disturbed. For such a superconductor, specific heat ( $C_v$ ), entropy ( $S$ ), and transition temperature ( $T_c$ ) have been calculated and compared with values known so far.

## **MODELING OF KINETICS AND STRUCTURE FORMATION AT SOL-GEL TRANSITION**

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### **ABSTRACT**

Sol-gel is a modern technological process that is widely used in the production of inorganic sorbents, catalysts and catalyst carriers, synthetic zeolites, inorganic binders, ceramics with select physical, optical, magnetic, and electrical properties, glass, glass ceramics, fibers, etc. The creation of models of this process will make it possible to fine-tune the properties of the resulting materials. The sol-gel transition is a process of sol-particle association accompanied by the formation of "an infinite aggregate". Two ways of constructing mathematical models are suggested. The first approach is based on the methods of statistical thermodynamics, and the second one is hydrodynamical. Both methods make it possible to obtain the inter-consistent equations describing the relationship between the gelation time and the macroscopic parameters.

## OSMOTIC STABILITY OF INORGANIC ION-EXCHANGE MATERIALS

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### ABSTRACT.

One of the important problems in the synthesis and use of inorganic ion exchange materials is their osmotic stability in various solutions. The greatest destruction of ion exchanger particles occurs when the characteristics of the medium they are located change. In this work, we show that controlling the parameters of the synthesis and processing of inorganic sorbents is an important strategy for improving their osmotic stability. The problem of osmotic stability of ion-exchange materials is considered from the point of view of strength theory. In inorganic sorbents with a rigid structure, the difference in chemical potentials is compensated due to the separation of electric charges at the phase boundary, which is accompanied by the formation of a double electric layer at the interface between the electrolyte solution and the other phase. Overlapping of adsorption layers generates disjoining pressure. The disjoining pressure causes deformations in the granulate and creates the preconditions for the destruction of the granules. The ability of a granular material to withstand these deformations is characteristic of its osmotic stability. We have developed a model for forming the structure of the pore space of granules of inorganic ion exchange materials and analyzed some of the consequences of this model. It is shown that an important factor determining the properties of granules is the interaction of phases and the structural characteristics of granulates. The results of forming and transforming the pore space in the sorption material depend on the interaction of the solid phase and the solvent. To analyze the effect of this factor on the properties of inorganic sorbent granulates, we developed a corresponding theoretical model. This model is described by two main parameters: the volume fraction of the solid phase  $\varepsilon$  and the parameter  $K$ , which characterizes the ratio of probabilities of various variants of the mutual arrangement of the primary particles of the solid sorbent phase and the pore space. A decrease in the value of the parameter  $K$  leads to a decrease in the probability of neighboring dissimilar phases and, accordingly, to a decrease in the interfacial surface. These factors, in turn, determine the possible mechanisms for the occurrence of the structural instability of inorganic sorbents. The granulation of inorganic sorbents is associated with the system's transition from a viscous to a solid state. In some cases, this transition is provided by removing the solvent from the system. From the structural model proposed by us, it follows that at a constant volume fraction of the sorbent phase, with a decrease in the interaction parameter  $K$ , the probability of the formation of interphase contacts in the sorbent structure increases and, accordingly, the ability of the material to deform decreases. The proposed model makes it possible to adequately describe the influence of the interaction of the solid and liquid phases of the system on the formation of the pore structure of sorption materials during their drying. We have proposed a specific form of the probability distribution function for the existence of a portion of the solid phase of the sorbent of a certain length and evaluated the influence of various factors on its behavior. Based on this model, a complex criterion  $\gamma\sigma$  is proposed. An analysis of its behavior also showed that the factors contributing to the growth of the osmotic stability of granules are an increase in the volume fraction of the solid phase and a reduction in the interfacial surface. The use of binders in creating composite materials based on inorganic sorbents contributes to an increase in the osmotic stability of sorbents due to the complex factors considered.

## **Bi<sub>2</sub>Te<sub>3</sub>-SiO<sub>2</sub> NANOCOMPOSITE MATERIALS**

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### **ABSTRACT**

The Bi<sub>2</sub>Te<sub>3</sub>-SiO<sub>2</sub> nanocomposite materials were obtained by microwave solvothermal recovery of oxide precursors of bismuth and tellurium with simultaneous hydrolysis of tetraethylorthosilicate (TEOS). The compacting was carried out by the method of cold isostatic pressing with the following sintering. The resulting system can be regarded as a thermoelectric semiconductor material SiO<sub>2</sub> containing structural inhomogeneities in the form of inclusions with low thermal conductivity. It was proved that composite is a single-phase bismuth telluride uniformly distributed in the bulk of amorphous silicon dioxide. It was also found that the tunnel type of conductivity is realized in the obtained material at temperatures from about 80 to 180 K.

## **DISTORTION AND PARACRYSTALLINITY OF C1β CRYSTALLITES**

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### **ABSTRACT**

The interplanar spacings and unit cell parameters of C1β crystallites are not constant but vary within a limited range of values. Such structural changes are caused by the distortion of the crystal lattice. It was shown that the paracrystalline fraction of crystallites introduces the main contribution to the distortion of the crystalline lattice. The decrease in the content of this fraction led to the reduction in distortion parameters, interplanar spacings, and the volume of the crystalline unit cell. As a result, the undistorted crystalline unit cell of C1β macrocrystals can be proposed with the following parameters:  $a_0 = 0.772$  nm,  $b_0 = 0.815$  nm,  $c_0 = 1.040$  nm,  $\gamma_0 = 96.5^\circ$ . In addition, the specific volume and specific gravity of such macrocrystals,  $V_{c,0} = 0.604$  cm<sup>3</sup>/g and  $G_{c,0} = 1.655$  g/cm<sup>3</sup> were calculated. It was also found that by knowing the content of the paracrystalline fraction in the C1β crystallites, one can predict several important properties of cellulose.

## **DISTINCTIVE FEATURES OF CELLULOSE NANOCRYSTALLITES**

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### **ABSTRACT**

**In this paper, a set of methods was used to study the structural characteristics and properties of cellulose nanocrystallites and free cellulose nanocrystalline particles (CNCs). It was shown that cellulose nanocrystallites have three main distinctive features. The first distinctive feature of cellulose nanocrystallites is their rod-like shape with a quite high aspect ratio and a low percolation threshold. The second distinctive feature of nanocrystallites is their highly developed specific surface area that leads to the spontaneous crystallization and aggregation of rod-like crystallites by their lateral planes. This aggregation process is thermodynamically favorable because it leads to a decrease in the specific surface area of nanocrystallites and a reduction of the thermodynamic potential. The third distinctive feature of cellulose nanocrystallites is the paracrystalline structure of their surface layers, which significantly affects structural characteristics such as lattice distortion, interplanar spacings, parameters, and volume of the crystalline unit cell, etc. The paracrystalline fraction affects also important physical and physical-chemical properties of cellulose, such as accessibility to deuteration, the content of CII-allomorph after cellulose alkalization, the melting point of nanocrystallites, etc. Correlation equations were derived that provide to predict the structural characteristics and properties of nanocrystallites using the content of the paracrystalline fraction.**