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Abstracts

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The conference focuses on the following issues: discussion of physical, geometric and mathematical interpretation of the theory of relativity and its modern generalizations; discussion of observed effects, and experimental verification of the theory of relativity; methods for recording gravitational waves; effects of relativistic electrodynamics and optics of moving media; astrophysical observations and space experiments.

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CONTENTS

Field Theory as Oscillator System

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In space, we consider a lattice of homogeneous oscillators, taken as an approximation of the field model (hereinafter –the field). In the equilibrium state, the energy of the field is subject to the distribution of Gibbs. The field is exposed to monochromatic radiation (point spectrum) and broadband radiation.

The field responses in the classical and quantum representation (interaction representation) are investigated. The conditions for the birth and destruction of the field particles are given.

The phase and group velocities of signals passing through the field are calculated.

The following characteristics of the studied field are calculated:

- Energy capacity.
- Attenuation.
- Signal transmission efficiency.
- Field relaxation time.
- Field stability.
- Internal field fluctuations.
- The occurrence of side signals.

Along with the abstract field, an example of an electromagnetic field and its quantum analogue is given.

The possibility of resonance and forced radiation of an abstract field is studied, and a comparison of these effects with their analogues for the electromagnetic field is given.

Reformulation of the O(4,2)xSU(3)xU(1) Gauge Theory of Quantum Gravity using the Generic Torus as Oyibo GUT Geometrical Object

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We review and demonstrate that the geometrical and quantization foundation of the Oyibo grand unification theorem (GUT) is the generic torus as its invariant geometric object founded on the Lorentz transformation which is the kernel of the Einstein's principle of relativity. It is natural to postulate that this common geometrical foundation is responsible for the remarkable correspondence of the Oyibo GUT with the Einstein's unified field equation (UFE) for conformal (including scale) invariant field theories. We are therefore led to re-opine that the Oyibo conformal transformations not only has a sound geometrical foundation like the usual characterization of conformal invariance in projective space-time geometry but also a quantization foundation for quantum gravity. By using this generic torus as its geometrical object, we reformulate our O(4,2)xSU(3)xU(1) gauge theory of quantum gravity.

Paraphoton lasing in periodic dielectrics

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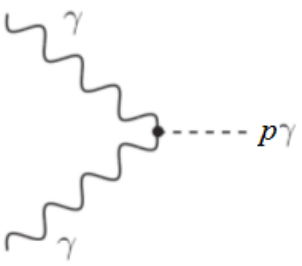
Paraphotons are "dark" pseudoscalar particles, arised by the photon pairing according to the diagram



However, the energy and momentum conservation allows the process in the vacuum only, so the $\gamma + \gamma \rightarrow p\gamma$ cross section is extremely low, and the paraphoton's birth and decay haven't been detected till now.

Nevertheless, these obstacles can be overcomed by the using of the Bose-Einstein unitary polaritons' condensate, formed by the electromagnetic field quanta interacted with medium's Lorentz oscillators, so the effective refractive index n = 1 as for a vacuum. Moreover, this way the periodic medium can be used as the tuned Fabry-Perot, so the conversion becomes resonant.

In the paper, we present the simulation results and the very first experimental data on paraphoton lasing in crystalline ruby Al_2O_3: Cr^{3+} and in the mesoporous photonic crystal film of aluminum oxide Al_2O_3.

The work is supported by the Russian Science Foundation (project No. 19-12-00242).

Парафотонная лазерная генерация в периодических диэлектрических средах

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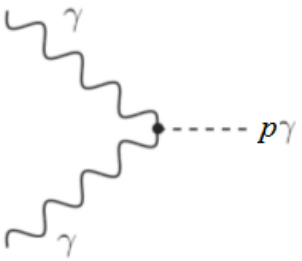
Парафотоны – "темные" псевдоскалярные частицы, возникающие в результате двухфотонного спаривания согласно диаграмме



При этом жесткие условия синхронизма (процесс разрешен только в вакууме) делают сечение реакции $\gamma + \gamma \rightarrow p\gamma$ ничтожно малым, что вызывает значительные трудности для регистрации процессов рождения и распада парафотонов.

Тем не менее, указанные затруднения можно разрешить на основе бозе-конденсата унитарных поляритонов – квантов электромагнитного поля в твердом теле, для которых взаимодействие с материальными осцилляторами приводит к эффективному значению показателя преломления n = 1, как для вакуума. При этом использование периодических сред позволяет добиться резонансного усиления процессов парафотонной конверсии и реконверсии,

поскольку в этом случае периодическая среда выступает в роли настроенного интерферометра Фабри-Перо.

В данной работе мы представляем результаты теоретического анализа и предварительные экспериментальные данные по парафотонной лазерной генерации в кристаллическом рубине Al_2O_3: Cr^{3+} и мезопористых фотоннокристаллических пленках оксида алюминия Al_2O_3.

Работа выполнена при поддержке Российского научного фонда (грант №19-12-00242).

Sagnac Dual-Polarized Ring Laser Interferometric Effects of Gravity on EM-Wave Polarization

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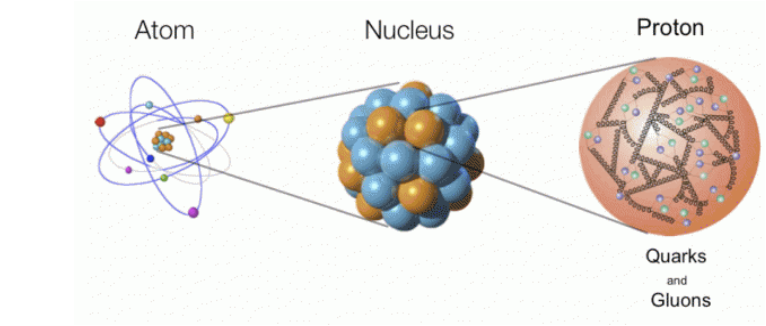
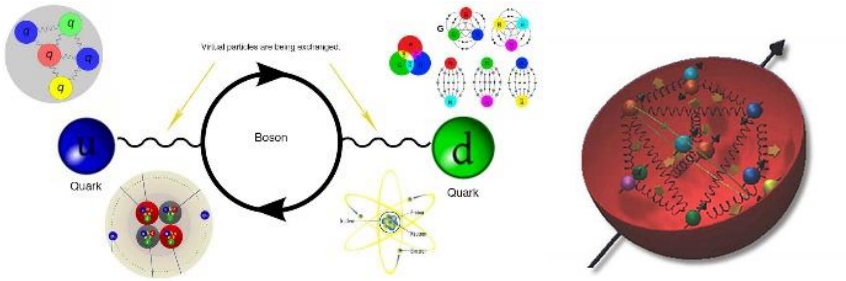
The utility of Sagnac Effect 4-mode dual-photon propagation ring laser apparatus for measuring the effects of gravitational interactions on the polarization of an EM-wave is described. The device is designed to study the nature/detection of gravitational waves in terms of Extended Electromagnetic Theory, where the postulated longitudinal $B^{(3)}$EM-field supports a photon mass anisotropy framework for G-wave detection. The 4 different beams have 4 different phase velocities, dependent upon polarization and propagation direction. Motivation was acquired serendipitously by noticing a disparity in wave packet dispersion/attenuation for seasonal patterns and periods of no service and intermittent (dropped) service in the region near the operational cutoff limit of 900 or 1800 MHz telecommunication EM-wave signals, where signal strength attenuates periodically by factors attributed to coupled oscillation between the solar field dynamo (physical process generating Sun's magnetic field) and the Earth's geomagnetic core dynamo - in conjunction with seasonal tilt of the Earth's axis and gravitational changes during sunrise/sunset periods. Since there are no known thermodynamic effects on the propagation of EM-waves, we are left to postulate G – EM interaction effects. Experiments conducted by R.M. Kiehn using dual polarized ring lasers verified that the speed of light can have these 4 different phase velocities depending upon direction and polarization; the 4-fold Lorentz degeneracy can be broken with parity and time-reversal symmetry breaking. In contrast to large-scale LIGO interferometers (current - L-shaped 4 km arms with 3,000 km separation, proposed - 40 km triangular arm configuration) for detecting cosmic gravitational waves; our apparatus is tabletop and designed to measure gravitational effects on photon polarization. Current thinking in Geometrodynamics assumes gravitational waves travel at the speed of light, where distance for LIGO interferometry corresponds to a difference in G-wave arrival times of up to 10 milliseconds. Our model requiring additional theory, suggests that neither

classical EM-theory nor quantum field theory provide a sufficient framework for describing these EM – G-wave polarization interactions; which for us requires a modified M-Theoretic topological approach integrating Newtonian instantaneity with Einsteinian relativity as described by a unified field mechanical Ontological-Phase Topological Field Theory.

Appendix. Quark structure and octonions [8].

The octonion (Cayley) algebra is studied in a split basis by means of a formalism that brings outs its quark structure. The groups SO(8), SO(7), and G2 are represented by octonions as well as by 8×8 matrices and the principle of triality is studied in this formalism. Reduction is made through the physically important subgroups SU(3) and SU(2) ⊗ SU(2)SU(2) ⊗ SU(2) of G2, the automorphism group of octonions.





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Generalized Lie Algebraic Geometry in R3×SO(3) Configuration Space for SU(3) of Elementary Particles and for Wave-packing of Atomic Structure

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In this paper, we show, by extending Lie's original 1871 thesis "on philosophical reflections upon the nature of Cartesian geometry" based on "transformation by which surfaces that touch each other are turned into similar surfaces between the Plucker line geometry and a geometry whose elements are the space's spheres" to include toroidal deformation of the sphere, how analgebraic geometric principle of duality between points, lines and planes of 3-diemsional space provides a sufficiently general framework for realizations of Lie-algebra and its Lie-isotopic and Lie-admissible generalizations in solid state configuration space $R3\times SO(3)$ compatible with translational periodicity of 3-dimensional space lattice. The generalization provide not only representation of $SU(3)$ symmetry of extended (string-like) elementary particles with complementary duality of leptons and baryons, but also dual wave-packet representation of atomic structure and the periodic table, highlighting the significance of the fact that Mendeleev originally moulded his two-dimensional rendering of the periodic system on the dual Sanskrit grammar/phonetics.

On the Habble-Lemaitre law

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The Habble-Lemaitre law considers a fundamental relation between velocity and distance. However, this relation is not true for large values of velocity and distance. The special theory of relativity allows us to conclude that the Habble-Lemaitre law remains true with a single change – the replacement of velocity with rapidity.

Space-time: from Indefinite at the Locality to Generality at the Infinite

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The article discusses physical and theoretical generalizations of the time-space metrics, based on invariant coordinate time transformations, set over the intervals of the observed periodic emission of neutron stars - pulsars, in spatial reference systems. The metric correspondence of the pulsar radiation intervals, expressed analytically by the observed rotation parameters, and the formal-mathematical ephemeris time, based on the laws of motion of the Solar system's celestial bodies, is shown. A generalization of the physical principle of Galilean relativity to the entire galactic space, in which the front of electromagnetic waves of periodic radiation of a pulsar extends, is substantiated.

Synchronization of spatial reference systems for the observed passage of the wave front of the coherent radiation of a pulsar corresponds to the axiomatic matching of the initial conditions of the space coordinates and time scales for the observed rotation parameters of the pulsar in the homogeneous Galileo space of the Galaxy. In that space all points and time moments are equal, all the directions of the coordinate axes are equal, all inertial systems are equal and, as a result, all physical processes in such coordinates systems, including the observed coherent radiation of a pulsar, are indistinguishable from each of them.

The physical characteristics of the accuracy and resolution of measured values of time and distance over any length within the galactic space of about 10^5 light years and duration within the estimated time interval of about 10^6 – 10^7 years typical for neutron stars were generalized. The estimated uncertainty of local measurements of the pulsar time intervals is in the range from 1 ms to 10^{-5} ns. The corresponding

uncertainty in the measurement of length, which is within the range from 0.3 cm to $3 \cdot 10^{-5}$ cm, shows a gradual decrease with an increasing measurement interval. The obtained estimates of accuracy and resolution, summarize the physical data on the timing of the pulsars B1919 + 21, B0809 + 74, B0834 + 06, B0329 + 54, B1822-09, B0531 + 21, J1509 + 5531, observed on the radio telescope BSA FIAN (Pushchino) for several decades (40 years or more), in combination with the data of modeling of coordinate-time intervals on galactic scales.

On the exponential decrease of the "cosmological constant" in the superearly Universe

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Based on the theory of Poincaré–Weyl–Dirac gravity, it is obtained that at the superearly stage of the Universe, the effective cosmological constant decreases exponentially from a huge value at the beginning of the Big Bang to its modern value.

At the early stage of the Universe, when the rest masses of elementary particles have not yet emerged, all interactions were carried out by massless quanta. In this case, these interactions have the property of scale invariance, as was suggested by Zel'dovich and Harrison. The symmetry group of the space is the Poincaré–Weyl group [1]. It was shown that the space-time is Cartan–Weyl space with curvature and torsion 2-forms, as well as the nonmetricity 1-form with the Weyl condition, and also, an addition to the metric tensor, a scalar field b appears that coincides with the scalar field introduced by Dirac.

The theory constructed is applicable to the superearly stage of a homogeneous isotropic and spatially flat Universe with the Friedman–Robertson–Walker metrics with a scale factor $a(t)$. If the values of the coupling constants of the Lagrangian are very small, we get an approximate solution of the gravitational field and the scalar field b equations in the form,

$$b(t) = \mathrm{cth} l\,(t + t_0),\ a(t) = a_0\left(16\,\mathrm{sh}^3 l\,(t + t_0) + \mathrm{ch}^{-1} l\,(t + t_0)\right),\ l = (\mathrm{L}/12). \quad (1)$$

The hypothesis on the exponential decrease of the effective cosmological constant $\beta^4\Lambda$ (as a consequence of the fields dynamics in the superearly Universe) was expressed in [2,3]. The main thing of the solutions (1) and that found in [3] is that these solutions for $\beta^4\Lambda$ exponentially sharply decrease at small t and approach Λ (but not zero) at large values of t.

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Экспоненциальное уменьшение “космологической постоянной” в сверхранней Вселенной

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На основе теории гравитации Пуанкаре–Вейля−Дирака установлено, что на сверхранней стадии Вселенной эффективная космологическая постоянная экспоненциально уменьшается от огромного значения в начале Большого взрыва до современного значения.

Nonmetricity plane waves in post Riemannian spacetime

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It is obtained that the nonmetricity of the plane wave is determined by five arbitrary functions of retarded time. A theorem on the structure of plane nonmetricity waves in a post Riemannian affine-metric space is proved.

Plane nonmetricity waves in an affine-metric space is studied. We call an affine-metric space (L_4, g) to be a plane wave type, and its metrics, torsion and nonmetricity to be plane waves, if its metrics $g_{\alpha\beta}$, torsion 2-form T^{α}, and nonmetricity 1-form $\mathrm{Q}_{\alpha\beta}$ admit a symmetry group G_5 of space-time motions with

the conditions, $\mathrm{L}_X g_{\alpha\beta}=0$, $\mathrm{L}_X \mathrm{T}^{\alpha}=0$, $\mathrm{L}_X \mathrm{Q}_{\alpha\beta}=0$, where L_X is the Lie derivative along the vector field $X=(a+b'x+c'y)\partial_{\mathrm{v}}+b\partial_x+c\partial_y$ [1]. Here $a=const$, $b(u)$, $c(u)$ are arbitrary functions of retarded time u, and b', c' are their derivatives.

It was obtained that the space (L_4, g) of the plane wave type is determined only by five arbitrary functions of retarded time [2].

Theorem [2]: The nonmetricity 1-form of the affine-metric space (L_4, g) of the plane wave type has the following structure: its three irreducible parts invariant under the Lorentz transformations, namely, the Weyl 1-form, the trace 1-form and the spin 3 1-form, are defined by one arbitrary function each, and the spin 2 1-form is determined by two arbitrary functions.

The results obtained proves the possibility of transmitting information with the help of nonmetricity waves, since the presence of arbitrary functions allows them to be arbitrarily encoded in the source of these waves.

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Плоские волны неметричности в постримановом пространстве-времени

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Получено, что неметричность плоской волны определяется пятью произвольными функциями запаздывающего времени. Доказана теорема о структуре плоских волн неметричности в постримановом аффино-метрическом пространстве.

Dark Fluid Electrodynamics

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We consider the Cosmic Dark Fluid as a quasi- medium, in which electromagnetic waves propagate, and magneto-electric field structures emerge and evolve. We use the concepts and mathematical formalism, elaborated in the framework of classical covariant electrodynamics of continua, and study dark analogs of the well-known medium-effects, such as optical activity, birefringence, piezo-magnetism, electrostriction and dynamo-optical activity.

The Dark Fluid is assumed to be formed by a duet of a Dark Matter (a pseudoscalar axionic constituent) and Dark Energy (a constituent with rheological properties). We focus on the models, which describe electrodynamic effects induced by the gravitational pp-waves propagating in the Dark Fluid environment. Our consideration is accompanied by examples of exact solutions to the extended master equations.

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The Cosmological Parameter: Constant or Dynamical

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The cosmological constant or parameter, Lambda, has a long and interesting history. It was first introduced by Einstein in 1917 [1] in order to obtain a static model of the universe. At that time, it was believed that the universe was static, and the evidence of an expanding universe came later with the observations of Slipher and Hubble. Thereafter Einstein abandoned the cosmological constant, calling it the biggest blunder of his life. However, as the saying goes, once a genie is let out of the bottle, it is very difficult to get it back in again. In 1988, the discovery of an

expanding universe has revived interest in the term, and it plays a very important role in explaining dark energy. The so-called ΛCDM model is the most widely accepted explanation for dark energy.

There are several problems associated with the cosmological constant, such as the cosmological constant problem [2]. Current observations indicate that the value of Lambda is fairly small, whilst particle physics predicts a much larger value by 120 orders of magnitude. This remains a major outstanding problem in theoretical cosmology today.

There have been several attempts to solve the cosmological constant problem. One simple idea is that of a dynamical Lambda [3]. The simplest way of introducing a variable Lambda is to make the cosmological constant Lambda a variable function of time in the field equations, with a corresponding change of the energy conservation equation. However this simple approach cannot be derived from a variational principle from an action. But, a variable Lambda arises naturally in some theories, such as scalar-tensor theories [4] and the scale covariant theory of gravitation [5].

A variable Lambda may also be regarded as being equivalent to a model with a generalised equation of state, which arises in some modified gravity theories [6]. The advantages of a variable Lambda are solutions to the dark energy problem, the cosmological constant problem, the entropy problem and avoidance of the initial singularity.

Hence, it is worthwhile to review the status of a dynamical Lambda term in cosmology.

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Cosmic transit behavior and anisotropic Cosmological models

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We have constructed some anisotropic cosmological models the framework of self interacting Brans-Dicke theory. Unified dark fluid equation of state has been considered to simulate the presence of dark energy and the associated late time cosmic acceleration phenomenon. The observational constraints on the unified dark fluid have been discussed. In the context of late time cosmic speed up phenomenon, it is believed that, the universe has undergone a transition from a phase of cosmic deceleration to a cosmic acceleration. A hybrid scale factor is used to obtain a cosmic transit behavior. The cosmic dynamics have been investigated in detail.

Double layers in the Weyl+Einstein gravity

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Unlike General Relativity, where the singular hypersurface may contain, at most, the Dirac delta-function both in the matter energy-momentum tensor in the right-hand side of the Einstein equations and in the second derivatives of the metric tensor in their left-hand side, the so-called quadratic gravity allows the existence of the double layer, i.e., the derivative of the delta-function. But this derivative is absent in the energy-momentum tensor (no mass-dipole analogous to the charge-dipoles in the classical electrodynamics), so the double layer is a purely geometrical phenomenon ant it may be treated as the purely gravitational shock wave. The mathematical formalism was elaborated by J. M. M Senovilla for the generic quadratic gravity. Our choice of the Weyl+Einstein gravity is motivated by the fact that the latter differs from the generic case in some aspects and requires separate consideration. Moreover, we confined ourselves to the spherically symmetry, because in such a case the theory becomes, essentially, two-dimensional. The three-dimensional hypersurface reduces to the world-line, and it becomes much easier to understand every step in the calculations and interpretations of the results. The main results are the following. We derived the matching conditions for the spherically symmetric singular hypersurface in the Weyl+Einstein gravity. It was found that in

the presence of the double layer, the matching conditions contain an arbitrary function, and this result is quite new and very important. One of the consequences of such freedom is that the trace of the extrinsic curvature tensor of the singular hypersurface is necessarily equal to zero. We suggested the physical interpretation for the exterior flux and pressure of the surface matter energy-momentum tensor of the shell. In General Relativity they are zero by virtue of the Einstein equations. In the quadratic gravity they are not necessarily zero. Our interpretation is that these components describe the energy flow and the momentum transfer of the particles produced by the double layer itself. Moreover, the requirement of the zero trace of the extrinsic curvature tensor implies that exterior pressure equals zero, and this fact also supports our suggestion, because it means that for the observer sitting on the shell, the particles will be seen created by pairs, and the sum of their momentum transfers must be zero. We derived also the matching conditions for the null hypersurface, and this is, again, quite new. We found that the spherically symmetric null double layer in the Weyl+Einstein gravity does not exist at all.

Some remarks on the topological features of the relativity theory

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The gravitational analogues of two different physical phenomena are discussed, namely the electromagnetic Aharonov-Bohm and the Brownian motion. In the case of the Aharonov-Bohm effect it is solved the Klein-Gordon equation for some configurations of the gravitational field to show that the energy spectrum of a scalar particle in the region where the gravitational field vanishes depends on the flux associated to this field through the region from which the particle is excluded. Among the gravitational fields considered, a special emphasis is given to the cosmic string space-time, in which case the holonomy transformations are also calculated and the obtained results discussed.

The second physical phenomenon, which consists in the Brownian motion of charged point particles, induced by quantum vacuum fluctuations of the electromagnetic field arising from the effects of a non-trivial topology, are analyze, in an expanding universe. In particular, the topological manifolds of the spatial section are considered as being of the following kinds: 3-torus, half turn space, one quarter turn space, one third turn space and one sixth turn space. Thus, it is shown what are the influences of these topologies on the velocity dispersions which arises from the quantum vacuum fluctuations induced by these different topologies, with special emphasis to the different roles played by each one the topologies considered.

A New Solution of the Einstein-Maxwell Field Equations for a Compact Object

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The solutions of the Einstein-Maxwell equations which satisfy the physical criterion are of great interest because they can be considered as models for the compact object. We choose static spherical symmetric and charged space-time and obtained the solution of the Einstein-Maxwell field equations with linear equation of state. There is no singularity present in the solution and it matched with the Reissner–Nordström solution at the boundary. We checked that solution satisfied the physical criterion for specific values of the parameters and we discussed the stability of the solution in detail. This solution can be considered as a model for compact object.

On the conformal group of globally hyperbolic spacetimes

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In [1] Zeeman has shown that the group of causal automorphisms of Minkowski spacetime coincides with the group G generated by orthochronous Lorentz transformations, space-time translations and dilatations. Later, in [3] (applying results of [2]) D. Malament has generalized these results to arbitrary smooth time orientable Lorentzian manifolds M. More precisely, he showed that any causal automorphism of M is automatically a conformal automorphism. Hawking *et al.* have generalized these results to arbitrary strongly causal Lorentzian manifolds.

To the best of our knowledge, there is yet no general result concerning the (non)-triviality of the group of conformal automorphisms of a strongly causal spacetime. In this paper we intend to fill this gap using results from causal set theory, and techniques reminiscent of model theory. More precisely, we show the following:

For an infinite *random causal set*, (together with some extra assumption) it is possible for the causal automorphisms group to be non-trivial (i.e. there are non-identity causal automorphisms). Here a random causal set is intuitively thought of as a causal set obtained by a *Poisson process* on a, i.e. randomly sprinkling

Taking the continuum limit, we deduce that the group of causal automorphisms of a globally hyperbolic spacetime with no boundary is non-trivial.

On a slightly different vein, we describe how to recover Geroch's Theorem [4] on the existence of a splitting of a globally hyperbolic spacetime M into spacelike slices from our results in [5]. Furthermore, we show that for each causal automorphism Φ we have either:

Φ is a time translation,

Φ is a spatial homeomorphism,

There exists a finite partition of M into submanifolds M_i, such that for each i, the restriction $\Phi\big|_{M_i}$ satisfies either (a) or (b).

By analogy with the causal sets case [6], we describe a procedure for spacetime quantization using the results described above.

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A curved spacetime with DISIM$_b$(2) local relativistic symmetry and local gauge invariance of its Finslerian metric

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As is known, there are only two types of flat relativistically symmetric Finslerian spaces, and only one of them satisfies the correspondence principle to the Minkowski event space. The Finslerian space just mentioned is a flat event space with a partially broken 3D isotropy. Its metric admits an 8-parameter inhomogeneous group of relativistic symmetry, DISIM$_b$(2), and has the form $ds=\left[\left(n_i dx^i\right)^2 \Big/ \left(\eta_{ik}dx^i dx^k\right)\right]^{b/2}\sqrt{\eta_{ik}dx^i dx^k}$, where $n_i=\{1,-\mathrm{n}\}$, n is the unit constant 3-vector, i.e. $n^2=1$, $\eta_{ik}=diag\{1,-1,-1,-1\}$, $n^i=\{1,n\}$, $n_i n^i=0$ and b is a constant parameter. It is now clear that Finslerian metric describing a curved locally anisotropic spacetime with DISIM$_b$(2) local relativistic symmetry can be obtained from the above-written Finslerian metric of a flat spacetime by means of the following replacement: $\eta_{ik}\to g_{ik}(x)$, $n_i\to n_i(x)$, $b\to b(x)$. As a result, we arrive at the only possible viable Finslerian spacetime model with the metric

$$ds = \left[\left(n_i dx^i \right)^2 \Big/ \left(\eta_{ik} dx^i dx^k \right) \right]^{b/2} \sqrt{\eta_{ik} dx^i dx^k} \qquad (1)$$

where $g_{ik} = g_{ik}(x)$ is the Riemannian metric tensor related to the gravity field; $b \to b(x)$ the scalar field characterizing the magnitude of local space anisotropy, and $n_i = n_i(x)$ is the null-vector field indicating the locally preferred directions in spacetime. So, the correct Finslerian extension of the general theory of relativity (under which the physical meaning of local relativistic spacetime symmetry is preserved) must be based on the Finslerian spacetime model (1). At each point of a curved Finslerian spacetime (1), the flat tangent Finslerian spaces have their own values of the parameters b and n_i. These values are none other than the value of the fields $b(x)$ and $n_i(x)$ at the corresponding space-time points.

Obviously, the dynamics of a curved Finslerian spacetime (1) is completely determined by the dynamics of interacting fields $g_{ik}(x)$; $b(x)$; $n_i(x)$; and these fields form, along with the matter fields, a unified dynamic system. Therefore, in contrast to the existing purely geometric approaches to a Finslerian generalization of the Einstein equations, our approach to the same problem is based on the use of the methods of conventional field theory.

The key role in constructing the equations, which generalize the corresponding Einstein equations, is played by the property of invariance of the Finslerian metric (1) under the transformations $g_{ik} \to e^{2\sigma(x)} g_{ik}$, $n_i \to e^{(b-1)\sigma(x)/b} n_i$; where $\sigma(x)$ is an arbitrary function. Apart from the metric (1), these local transformations leave invariant all the observables. Therefore in the theory taking account of local anisotropy of spacetime the above-written transformations are local gauge transformations. Hence it is clear that the above-described dynamic system must be supplemented with a vector gauge field B_i; which, under local gauge transformations, is transformed as follows $B_i \to B_i + l\left[(b-1)\sigma(x)/b \right]_{;i}$; l is a constant.

Higgs boson and Dark energy in conformal supergravity

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We investigate Higgs inflation in the theory of supergravity. It is argued that in this theory the Dark energy problem can be addressed by assuming extra space-time symmetry: local conformal invariance. We aimed to construct conformal theory of supergravity with Kahler potential describing non-minimal coupling of Higgs field to gravity and to find cosmological inflationary solutions. We obtained action of the

theory that is invariant under local transformations of superconformal group and under gauge group of Standard Model $SU(3)\times SU(2)\times U(1)$. The theory can be considered as conformal generalization of Minimal Supersymmetric Standard Model (MSSM). The Higgs field is considered as inflaton. It is shown that inflationary solution corresponding to Hubble's low can be obtained. In this cosmological model the Hubble constant and the cosmological constant are defined by vacuum values of Higgs fields and coupling constants of the theory. Therefore, the investigation might shed light on the Dark energy nature. Furthermore, conformal theory of supergravity necessarily includes the massive neutral dilatino field that can be candidate for a role of Dark matter. The theory suggests the probability of experimental verification with next generation of colliders such as FCC (Future Circular Collider).

The Boulware-Deser spacetime: Solutions and features

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An overview of radiating Vaidya-like spacetimes in Einstein-Gauss-Bonnet gravity will be presented. We show that the Boulware-Deser spacetime can be made to radiate and the dynamics of a five-dimensional radiating star with three spacetime regions can then be modeled. The internal region of the star is a two-component fluid system consisting of standard null radiation and an additional string fluid with nonzero pressure and energy density, obeying all physically reasonable energy conditions. The middle region is a pure radiation zone which matches to a third and final region, the Boulware-Deser vacuum exterior. This approach allows all three regions of spacetime to be modeled by the same class of metric functions. Several large families of solutions are possible for various equations of state. A brief overview of the collapse dynamics of this spacetime will then be presented.

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Umov's thermomechanics of inertial thermal energies instead of Newtonian mechanics of cold masses

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The rest energy of Umov-Heaviside-Einstein $E_0 = mc^2$ contributes to the low-speed approximation of the Hamilton function $H = E$, which is full relativistic energy $E = -L + vP \approx mc^2 + \frac{mv^2}{2}$. In our analyses, the rest internal energy is not a universal constant in the Hamilton-Lagrange dynamics, but an inside kinematic variable that should facilitate the Lorentz transfer of any energy content. When to take a close look at the Lorentz energy-momentum transformations, $E_0 = (E - vP)\gamma$ and $P_0 = (P - vE)\gamma = 0$, between laboratory and co-moving reference frames, then Hamilton energy reveals inside and outside degrees of freedom for Umov's invisible self-enerent rgy k mc2 → mc2 / γ and energy of observable spatial translations $\beta 2E$,

$$E = \left(\frac{mc^2}{\gamma}\right) + \beta 2E = \left(\frac{mc^2}{\gamma}\right) + \beta 2mc^2\gamma = mc^2\gamma .$$

Here the relativistic energy of ordered spatial translations β2mc2γ and the path-dependent inside heat-energy mc2/γ are different degrees of freedom like color quarks in chromodynamics. In 1873, Umov introduced the dimensionless factor k (with that time non-relativistic estimations $\frac{1}{2} \le k \approx 1 - \frac{\beta 2}{2} \le 1$) into the thermal self-energy kmc^2 [1]. Now we claim that Umov's relativistic self-energy $\frac{mc^2}{\gamma}$ of inside heat-chaos and relativistic kinetic energy $\beta 2mc^2\gamma$ of ordered translations (observed in practice) have different physical meanings and degrees of freedom.

The laws of visible motion in thermomechanics of competing inside and outside energies at high translational speeds do not coincide with the relativistic dynamics of scalar masses modelled by degenerate degrees of freedoms without internal variables [2,3]. Newton's gravi-mechanics and its relativistic extensions know how to quantitatively describe the observed motion, but cannot comment on the physical nature of this motion. Umov\rq{s} mechanics of variable self-energies clarifies their dynamics through the tendency to an equipartition of external and internal kinetic energies and predicts chaos-order self-organization in a closed thermomechanical system instead of thermal death. Newton described the transport of masses with one

degree of freedom, while Umov related inertia with internal heat and translational kinetic energies. Different observable predictions of competing theories for the transport of cold masses and the transport of thermal energies will be discussed.

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Magic of the Kerr spinning gravity: unification of gravity with particle physics

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In particle physics Gravity is considered as the most weak interaction. However, it resists to quantization and its conceptual unification with particle physics meets insuperable difficulties.

On the other hand, the famous Kerr-Newman (KN) solution, being completely compatible with gravity by nature, displays several important properties of the spinning particle, in particular, it has the obtained by Carter gyromagnetic ratio of the Dirac electron. This phenomenon deserves study to arrange the gravity compatible with quantum theory. We investigate the structure of the Kerr-Newman spinning particle (electron model) and obtain that spin plays principal role in this model. The extreme high spin/mass ratio of spinning particles, about 1022 in the dimensionless ($G = c = \hbar = 1$) deforms space topologically, and the space-time acquires two-sheeted topology, reproducing the Einstein-Rosen bridge (or wormhole) with the throat $a = \frac{\hbar}{2m}$, about the reduced Compton wave length. This relation is consequence of the known Kerr relation $J = ma$ between angular momentum - J, mass - m, and radius of the Kerr singular ring - a.

Therefore, instead of the traditional estimations of the gravitational interaction by the Schwarzschild gravitational radius $rg = 2Gm$, one should use the inverse to mass radius $a = J/m$, which increases effective scale of gravitational interaction about 22 orders, from Planck to Compton scale!

Effective influence of Gravity on the Compton scale puts it on equal footings with Quantum theory.

It seems that conflict between them increases, but as shows the structure of KN spinning particle, there happens a miracle - instead of confrontation, KN gravity starts to cooperate with quantum theory, creating the disk-like shape of the dressed electron, several key quantum parameters and the string structure at the sharp border of the disk. We show, that metric of the KN solution determines the classical radius of the electron, the fine structure constant, and conditions for quantization of the angular momentum.

Meanwhile, the main miracle is the fact in itself that gravity becomes strong and influences at the Compton distances instead of the accepted Planck scale.

Restoration of compatibility with quantum theory is achieved by bag model, which is formed as a nonperturbative solution of the supersymmetric Landau-Ginzburg field theory. The supersymmetric Domain Wall forms two vacuum states: inside and outside the bag. The Higgs field is concentrated inside the bag, so that the domain wall interpolates between external KN gravity and the free from gravity superconducting state inside the bag. Superficial currents are created on the sharp border of the disk-like bag. Thus SUPERSYMMETRY plays important role in compatibility of gravity with quantum theory. Supersymmetry was failed recently as a theory of superpartners, but it does not concern the field theory, forming the famous Wess-Zumino SuperQED model.

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Sphericallу symmetric solutions in $f\left(R,(\nabla R)^2\right)$ gravity

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To study the modified theory of $f(R)$ gravity with a kinetic scalar curvature represented by the action

$$S=\int d^4x\sqrt{-g}\,f\left(R,(\nabla R)^2\right)$$

we use the standard procedure of reducing this model to the chiral cosmological model (CCM) with two scalar fields [1]. We use the functional dependence $f\left(R,(\nabla R)^2\right)$ in the form [2]

$$f\left(R,(\nabla R)^2\right)=f_1(R)+X(R)\nabla_\mu R\nabla^\mu R$$

The resulting CCM is described by the action

$$S=\int d^4x\sqrt{-g}\left[\frac{R}{2\kappa}-\frac{1}{2}h_{AB}(\varphi)\varphi^A_{,\mu}\varphi^B_{,\nu}g^{\mu\nu}-W(\varphi)\right]$$

where $A,B,\ \ldots=1,2$; target space metric components h_{AB} and the potential W take the form

$$h_{AB}(\varphi)=\begin{pmatrix}1 & 0\\ 0 & -e^{-\sqrt{\frac{2}{3}}\chi}X(\varphi)\end{pmatrix}$$

$$W(\varphi)=\frac{1}{4}e^{-\sqrt{\frac{2}{3}}\chi}\left(\varphi-e^{-\sqrt{\frac{2}{3}}\chi}f_1(\varphi)\right)$$

Here the fields φ^A are denoted as $\varphi^1=\varphi$, $\varphi^2=\chi$.

We derive the equations for the gravitational field and chiral fields for the spherically symmetric line element in the form

$$ds^2=e^{2\alpha}du^2+e^{2\beta}\left(d\theta^2+\sin^2\theta d\varphi^2\right)-e^{2\gamma}dt^2$$

In the present contribution we discuss solutions of the model with a special choice the $f_1(R)$ part, including Starobinsky model $f_1(R)=R+\alpha R^2$ and exponential dependence on scalar curvature $f_1(R)=e^{\lambda R}$.

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Photons as solitons

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The field model of space-time film is considered. New class of exact solutions is discussed. These solutions are solitons moving with the speed of light or light-like solitons. Subclass of these solutions with approximate helical symmetry or having twist is considered. Determinate conformity of twisted light-like solitons and photons is shown. In particular, the obtained expression of the soliton energy coincides with

the appropriate expression for photon in high-frequency approximation. Planck formula is obtained (in some approximation) for the equilibrium energy spectral density of the ideal gaze of the twisted solitons. An experimental check of the modified formula for the energy of photon (in low-frequency region) as the twisted light-like soliton is proposed.

Cosmological parameters in modified gravity theories

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The discovery of acceleration in expansion of the Universe at the end of XX century leads to active investigations of modified theories of gravity and their cosmological applications. The theory of gravity which naturally (without involving of "exotic" matter) describes this acceleration should be also consistent with the theory of early-universe inflation, i.e. it should gives theoretical predictions compatible with observation data from cosmic and terrestrial observatories, such as WMAP, Planck, BICEP2, on large-scale structure, temperature anisotropies and polarization of CMB radiation. Besides, the technological progress of the last few years, including detections of gravitational waves from astrophysical sources, requests theoretical prediction of existence black holes in modified gravity theories.

The standard request to inflationary cosmology is an agreement with observation data on e-folds number, power spectrum, spectral indexes, tensor-to-scalar ratio and velocity of gravitational waves propagation. Methods of calculating the cosmological parameters above are reliably tested for Friedmann cosmology based on GR. For cosmologies based on modified theories of gravity as scalar-tensor, $f(R)$-, $f(R)$-gravity with higher derivatives and Einstein-Gauss-Bonnet gravity, the procedure of cosmological parameters calculation is actively discussed and request further development.

In the present contribution it will be considered methods of the cosmological parameters calculation (and connection of them throw conformal transformation) in generalized scalar-tensor, tensor-multi-scalar and $f(R)$ cosmologies, also for cosmology based on $f(R)$ gravity with higher derivatives theory of gravity.

Cosmological parameters for $f\left(R,(\nabla R)^2\right)$ theory of gravity

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We study $f\left(R,(\nabla R)^2\right)$ theory of gravity with the choice: $f\left(R,(\nabla R)^2\right)=f_1(R)+X(R)\nabla_\mu R\nabla^\mu R$ cosmological aspects of which was considered in [1]. It is possible to transform such model to Einstein gravity with two scalar field [2] with the action

$$S=\int d^4x\sqrt{-g_E}\left(\frac{R_E}{2}-\frac{1}{2}g_E^{\mu\nu}\chi_{,\mu}\chi_{,\mu}+\frac{1}{4}f_1(\varphi)\exp\left(-\sqrt{2/3}\chi\right)-\frac{1}{4}\varphi\exp\left(-\sqrt{2/3}\chi\right)\right.$$
$$\left.+\frac{1}{2}X(\varphi)\exp\left(-\sqrt{2/3}\chi\right)g_E^{\mu\nu}\chi_{,\mu}\chi_{,\mu}\right)$$

The action is nothing but a Chiral Cosmological Model (CCM) with two chiral fields: $\varphi^1=\chi$, $\varphi^2=\varphi$ [3]. In general, it is difficult to find cosmological parameters, so we reduce the problem to the case of one-field by the relation: $\varphi(t)=k\chi(t)$. In this case, the potential takes the form: $V(\chi)=\frac{1}{4}\exp\left(-\sqrt{2/3}\chi\right)\left(k_\chi--f_1(\varphi)\exp\left(-\sqrt{2/3}\chi\right)\right)$. To simplify cosmological dynamic equations we choose the function $X(\chi)$ in the form $X(\chi)=exp\left(\sqrt{2/3}\chi\right)$. Using freedom of choice in the function $f_1(\varphi)$ we can use the potentials corresponded to exact solutions and listed in [4].

In the present contribution we discuss cosmological parameters for the cases of a massive field (quadratic potential), Higgs potential, trigonometric and exponential potentials. We agreed the obtained results by the method described in [5] and confront them with the Planck-2018 data.

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Homogeneous anti de-Sitter black strings in General Relativity and Lovelock gravities

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In this talk an original method to construct homogenous black strings in anti-de Sitter spacetimes is shown. The method is based on a particular scalar dressing of the extended coordinates of the spacetime. Each extended coordinate is dressed with a minimally coupled scalar field such that the scalar field only depend on that coordinate. This allows to obtain Schwarzschild anti-de Sitter black strings in any dimension in General Relativity. The same method is extended to the case of Lovelock gravities by including scalar dressings with non-minimal kinetic couplings. It is obtained for first time the black string extension of the Boulware-Desser black hole in any dimension. The procudure can be extended to any Lovelock theory. Finally it is shown how to construct black strings when matter fields are present, for example, the case of charged black strings.

Giving mass to the mediating boson of Hypersymmetry by a field transformation applying Higgs mechanism beyond the Standard Model

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According to gauge theories, interaction mediating spin-0 bosons must be massless. Theory of hypersymmetry (HySy) predicted massive intermediate bosons. Hypersymmetry field rotation, to be described in this paper, gives mass to the HySy mediating boson. Hysy rotation is performed in the velocity dependent D field – a

gauge field defined beyond the Standard Model (SM). Its angle is something similar to the weak mixing Weinberg angle that gives mass to the neutral weak vector boson; as well as it is similar to the fermion flavour mixing Cabibbo-Kobayashi-Maskawa angles that justify the mass change under weakly interacting quarks' mixing, respectively. Mass of intermediate bosons must arise from dynamical spontaneous breaking of the group of HySy. The mass of the discussed (fictitious) Goldstone bosons can be removed by the unitarity gauge condition through the Higgs (BEH) mechanism. According to the simultaneous presence of a SM interaction's symmetry group and the HySy group, their bosons should be transformed together. Spontaneous breakdown of HySy may allow to perform a transformation that does not influence the SM physical state of the investigated system. The paper describes a field transformation that eliminates the mass of the intermediate bosons by the application of the BEH mechanism, rotates the SM and HySy bosons' masses together, while leaves the SM bosons intact. The result is a rotation angle that characterises the HySy mechanism. In contrast to the known SM intermediate bosons, the HySy intermediate bosons have no fix mass. The mass of the HySy intermediate bosons (that appear as quanta of a velocity dependent gauge field D) depends on the relative velocity of the particles whose interaction they mediate; therefore the derived transformation angle is a function of that velocity.

This paper was prepared in the framework of a long-term bilateral cooperation project between the Hungarian and Russian Academies of Sciences under the item 5 in the complex working plan entitled Non-linear models and symmetry analysis in biomechanics, bioinformatics, and the theory of self-organizing systems.

A new embedding class one type anisotropic compact stellar model using Karmakar Condition in General Relativity

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In the present paper, a new anisotropic solution of embedding class one type for a spherically symmetric spacetime have been obtained. A physically reasonable form of one of the metric functions gtt has been used to obtain the other metric function grr by utilizing the Karmakar embedding condition. The closed-form interior solutions of the Einstein field equation thus obtained has been used to develop compact stellar models for observed pulsars. The exterior spacetime is assumed as described by the exterior Schwarzschild solution. The model parameters have been determined from the smooth matching of the interior and exterior spacetime metric and setting the radial pressure zero across the boundary. By exploring the physical properties of relevant parameters graphically, the developed model is shown to compatible with observational data of compact object like 4U 182030. The current estimated masses

and radii of few more pulsars are also tasted to show that the developed model meets all the requirements of a realistic star. The stability of the present model is also discussed.

Silhouette of the black hole event horizon

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We demonstrate that a dark silhouette of the black hole illuminated by a thin accretion disk and seen by a distant observer is in fact a silhouette of the event horizon hemisphere. The boundary of this silhouette is a contour of the event horizon equatorial circle if a thin accretion disk is placed in the black hole equatorial plane. The event horizon silhouette is projected on the celestial sphere within a position of the black hole shadow. A luminous matter plunging into black hole from different directions provides the observational opportunity for recovering a total silhouette of the invisible event horizon globe. A total silhouette of the event horizon is a gravitationally lensed projection on the celestial sphere of the whole surface of the event horizon globe. As a result, the black holes may be viewed at once from both the front and back sides. The lensed image of the event horizon may be considered as a genuine silhouette of the black hole.

Gravitational Waves through the collisions of SMBHs in Merging Galaxies

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Gravitational waves: Violent events, such as the collision of two black holes, are thought to be able to create ripples in space-time known as gravitational waves. In 2016, the Laser Interferometer Gravitational-Wave Observatory (LIGO) announced that it found evidence of these tell-tale indicators. By the date, LIGO and LISA have observed more than 10 events of binary mergers along with the successful detection of Gravitational Waves in each case. With advanced interferometers coming in a row the detection rates will increase significantly and many unknown facts will be known. Apart from the astrophysical sources of Gravitational waves like binary black holes,

neutron stars including pulsars etc. the possibilities of generation of gravitational waves from supermassive black holes sitting in the heart of galaxies are still considered to be high. As the mergers of SMBH during galaxy collisions is a potential candidate of gravitational waves it also has a big drawback that we need to wait for millions of years for these mergers to take place for direct observation by presently available technology and their low sensitivity.

In this context here we propose the work done in the field of the simulations of mergers and the detection of GWs and its broad scope even apply for any forthcoming SMBH merging event to be observed in near future.

GW & Galaxy Mergers: By the advancement of technology direct observations of many galaxy mergers events can be observed and related data from the highest resolution optical, X-ray and Gamma ray telescopes are available. These are being widely used for the simulation techniques for measuring other parameters along with production of GWs. This astrophysical event is important in the sense of merger of supermassive black holes as well. Thus, these are strong candidates of gravitational waves. I hereby present a detailed correlation between mathematical relativity principles involved in Galaxy mergers and the resulting possible gravitational waves. The study includes the theoretical approach in the mathematical domain of relativity related to heavy masses collisions along with situational techniques involved to predict the resulting gravitational waves in galaxy merger events.

Cosmological Inflation from the Quantum-Mechanical Uncertainty Relation

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Inflation is nowadays a commonly-accepted paradigm in cosmology. However, the corresponding inflaton fields are usually postulated quite arbitrarily and are not supported by any particular entities in the elementary-particle physics. A less model-dependent approach to inflation is the Starobinsky scenario, which is based on the high-order curvature corrections to the Lagrangian. Here, we propose yet another model-independent mechanism of inflation, following from introduction of the quantum-mechanical uncertainty relation into the cosmological Friedmann equation.

As a result, it was found that the scale factor of the Universe changes by a “quasi-exponential” law (namely, proportional to the exponent of the square root of time), and the effective Lambda-term decays gradually up to the present time. So, it becomes unnecessary to introduce a few substantially different (exponential and power-like) stages, and the entire evolution of the Universe is described by the same

universal law. Besides, the total lifetime of the Universe in this scenario turns out to be much greater than in the standard one.

Космологическая инфляция из квантово-механического соотношения неопределенностей

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На сегодняшний день инфляция является общепринятой парадигмой в космологии; однако генерирующие ее поля (инфлатоны) обычно постулируются весьма произвольно и не ассоциированы с какими-либо конкретными элементами современной физики элементарных частиц. Менее зависимый от модели подход к инфляции – это сценарий Старобинского, который основан на поправках высшего порядка по кривизне к лагранжиану. Нами предлагается еще один модельно-независимый механизм инфляции, получающийся при введении квантово-механического соотношения неопределенностей в космологическое уравнение Фридмана.

В рамках такого подхода оказывается, что масштабный фактор Вселенной должен изменяться по “квази-экспоненциальному” закону (а именно, пропорционально экспоненте от квадратного корня времени), а эффективный лямбда-член спадает постепенно, вплоть до настоящего времени. Таким образом, отпадает необходимость вводить несколько существенно различных (экспоненциальных и степенных) этапов, и вся эволюция Вселенной описывается одним и тем же универсальным законом. Кроме того, полное время жизни Вселенной в таком сценарии оказывается значительно больше стандартного.

On conservation laws in Teleparallel Gravity

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Last decades, Teleparallel Equivalent of General Relativity (TEGR) and its modifications are developed very intensively [1]. Dynamic variables in TEGR are components of the tetrad field. Being coordinate covariant, TEGR is covariant with respect to local Lorentz rotations, unlike the usual tetrad GR in the Moller

presentation. This nice property is achieved due to introducing a special spin connection with zero curvature. The goal of our study is to construct conservation laws and conserved quantities in TEGR. Applying directly Noether's theorem, we obtain conserved currents that are expressed through divergences of superpotentials (antisymmetric tensor densities). Currents describe local quantities, like energy density, whereas superpotentials permit to construct global quantities in the form of surface integrals that is charges. Essential property of conservation laws is a presence of an arbitrary displacement vector. In the case of a timelike Killing vector, e.g., one can interpret a charge as a mass of a system; in the case of a proper vector of observer one can interpret components of a current as related densities; etc. The advantage of our results is that currents and superpotentials are both coordinate covariant and Lorentz covariant that permits construct conserved quantities keeping covariance of both the kinds. Unlike this acceptable picture, in the standard presentation [1] either one can derive conserved quantities in fully covariant form that does not give conserved charges, or one can construct conserved charges, but in a non-covariant form.

To apply and check our results we calculate in the framework of TEGR, first, mass of the Schwarzschild black, second, the energy density in the frame of a freely falling observer in the spatially flat Friedmann world. To obtain an acceptable result it is necessary to choose a spin connection in a correct way. Because the spin connection expresses the inertial effects of a frame, on the one hand, and it is connected with a physical tetrad, on the other hand, it has to be chosen in the frame under the consideration with the absence of gravitation. Thus, the choice will be connected with a concrete tetrad and a coordinate system. As a result we obtain, first, the standard and acceptable mass for the Schwarzschild black hole; second, the freely falling observer in a non-perturbed spatially flat Friedmann world measures a zero energy density.

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Velocities of distant objects in General Relativity: definitions, interpretations, misconceptions

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In General Relativity and cosmology, various definitions of velocities of remote objects are used. One can often find different mistakes in literature associated with

inappropriate use of these definitions, what leads to some widespread misconceptions.

We consider two most popular definitions of velocities of remote objects in General Relativity. First definition is the velocity as derivative of proper distance to the object with respect to the proper time of the observer. This definition is widely used in cosmology, however, it has a feature which can be considered a disadvantage - this velocity can be superluminal. In cosmology, in this case we speak of superluminal recession of galaxies. To avoid superluminal values, another definition is used - the velocity defined by parallel transport of the initial emitter's 4-velocity along some curve in 4-dimensional space-time to the observer. However, this definition is also not free from counterintuitive properties. Here we consider them all in detail.

Another important part of our work is the generalization of the formula connecting these two velocity definitions in Friedmann-Lemaître- Robertson-Walker (FLRW) metric found by Chodorowski (M. Chodorowski, The kinematic component of the cosmological redshift. MNRAS, 413, 585 (2011)). We show that it is valid for any synchronous spherically symmetric metrics. Then we extend this formula to non-zero peculiar velocities of the emitter.

Global geometry of the Vaidya spacetime

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The transformation from initial coordinates *(v,r)* of the Vaidya metric with light coordinate *v* to the physical diagonal coordinates is obtained and analyzed from the point of view of global geometry. The exact solutions have been obtained in the case of a linear form of the mass function *m(v)*. In the diagonal coordinates under consideration, a narrow region has been revealed near the visibility horizon of the Vaidya accreting black hole, in which the metric differs qualitatively from the Schwarzschild one and cannot be represented as a small perturbation of the Schwarzschild solution. The global geometry of the Vaidya metric between two (inner and outer) Schwarzschild region is constructed and the corresponding matching conditions are discussed. The propagation of light beams in the Vaidya metric in the case of accretion is investigated and the times of the boundary surfaces crossings are calculated.

Глобальная геометрия пространства-времени Вайдья

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С точки зрения глобальной геометрии получено и исследовано преобразование метрики Вайдья, записанной в начальных координатах *(v,r)* со световой координатой *v*, в физические диагональные координаты. Точные решения найдены в случае линейного вида массовой функции *m(v)*. В рассматриваемых диагональных координатах обнаружена узкая область вблизи горизонта видимости черной дыры Вайдья, в которой метрика качественно отличается от метрики Шварцшильда и не может быть представлена как малое возмущение решения Шварцшильда. Построена глобальная геометрия метрики Вайдья, заключенной между двумя (внутренней и внешней) областями Шварцшильда, и рассмотрены соответствующие условия сшивки решений. Исследовано распространение световых лучей в метрике Вайдья в случае аккреции и рассчитаны времена пересечения лучами граничных поверхностей.

Gravitational Radiation from Minihole Coalescence and Quadrupole Transitions of Hydrogen-Like Atoms

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A The gravitational radiation in the Universe is considered, whose sources are hydrogen atoms and primordial black holes of minor masses, i.e. miniholes [1-2]. The latter can capture particles forming graviatoms. The gravitational radiation arises from minihole coalescence and quadrupole transitions of hydrogen atoms and hydrogen-like graviatoms. A contribution of these microsystems to the gravitational background in the Universe is estimated comparing it with the observed gravitational radiation from the coalescence of stellar mass black holes.

The number of coalescences of two identical miniholes with masses M is given by formula $N = \frac{1}{2} n^2 c \pi r_g^2$, where n is the number of minihole in a unit volume and $r_g = \frac{2GM}{c^2}$. The coalescences occur during the radiation-dominant stage. The total

gravitational radiation $E_{tot} = 0.1Mc^2 N_{tot}$, where N_{tot} is the number of coalescences of all miniholes.

Consider the gravitational radiation in the transition 3d→1s of graviatoms which consist of a minihole capturing an electron. The gravitational radiation intensity $I_{ga} = \frac{3m_e^2 c^4 a_g^9}{2^7 \hbar}$, where $a_g = \frac{GMm_e}{\hbar c} = 0.6$. The total gravitational radiation energy $E_{ga} = I_{ga} N_{gr} t_T$ where N_{gr} is the number of graviatoms, t_T is the time corresponding to the temperature of the black radiation whose maximum intensity falls on the frequency of the above transition $\omega_{13} = \frac{4m_e c^2 a_g^2}{9\hbar}$.

The total gravitational energy for hydrogen atoms $E_{gH} = \frac{I_{gH} N_H}{H}$, where I_{gH} is the gravitational radiation intensity of hydrogen atom, N_H is the number of hydrogen atoms, H is Hubble's constant.

The gravitational background from minihole coalescence and quadrupole transitions of hydrogen atoms and graviatoms prove to be of the same order as the observed gravitational radiation from the coalescence of stellar mass black holes.

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On the issue of gravitational radiation and thermonuclear fusion

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The papers [1-3] model a particle in a way that enables calculation of the quantum states generated by the gravitational interaction. Modeling involves no extra assumptions or constructions other than the equations of quantum mechanics and the equations of the relativistic theory of gravitation with Λ-term. The demonstration is made by the existence of the spectrum of stationary states in the proper gravitational field at numerical values of $K \approx 5.1 \times 10^{31}$ Nm^2kg^{-2} and $\Lambda = 4.4 \times 10^{29}$ m^{-2}. In the future, it can be used as a part when building a more complex picture of the world (in particular, when using the unremovable curvature on a quantum level as a building element).

It is believed that according to General Relativity (GR), only system with variable quadrupole or higher multipole moments can generate gravitational radiation. As it follows from above, the fallacy of this formula lies not in using the quadrupole approximation but rather in the calculation scheme. The presence of stationary states in the proper gravitational field makes it possible to correctly calculate the power of gravitational radiation in the strict quantum approximation proceeding from the spectrum of transitions between stationary states, and already with the constant K. A system can emit only at certain quantum states. This is an axiom of quantum mechanics as well as the existence of an elementary radiation source which possesses these states. No gravitational waves with the constant G exist or can exists that are allegedly emitted by a system of bodies with a variable but arbitrary quadrupole moment.

Moreover, GR does not give any quantitative estimates on the spectrum of radiation of gravitational waves. For them the noise of unknown origin is given out, and the frequencies of such jamming change from time to time, and the classical theory does not predict them. Gravitational radiation can be excited in a dense high-temperature plasma [1,3] and amplified under certain conditions. However the amplification will cause the radiating system to compress. Hence, with the gravitational radiation being amplified, one will observe not the gravitational radiation itself, but only the result of its action. In this case, the quantitative characteristics of the spectrum of gravitational radiation can be determined by the broadening of the spectrum of electromagnetic radiation [3]. The very fact of plasma compression by a radiated gravitational field can be used for the purpose of thermonuclear fusion [3].

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К вопросу о гравитационном излучении и термоядерном синтезе

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В работах [1-3] без привлечения каких-либо дополнительных предположений и построений (используя только уравнения квантовой механики и уравнения релятивистской теории тяготения с Λ-членом) получена модель частицы, дающая возможность расчёта квантовых состояний порождаемых гравитационным взаимодействием. Это совершенно конкретная задача (доказательством служит наличие спектра стационарных состояний в собственном гравитационном поле при численных значенияхс $K \approx 5.1\times10^{31}$ Nm^2kg^{-2} и $\Lambda = 4.4\times10^{29}$ m^{-2}) и она может быть в дальнейшем элементом более сложных построений картины мира (в частности, с использованием такого элемента как неустранимая кривизна на квантовом уровне).

Принято считать, что согласно Общей Теории Относительности (GR), гравитационное излучение могут генерировать только системы с переменным квадрупольным или более высокими мультипольными моментами. В таком предположении мощность соответствующего гравитационного излучения пропорциональна тензору квадрупольного момента распределения масс излучающей системы Qi j, а константа G, входящая в эту зависимость даёт порядок величины мощности излучения. Неправомерность использования этой формулы, как следует из вышеизложенного, заключается не в использовании квадрупольного приближения, а в схеме расчёта. Наличие стационарных состояний в собственном гравитационном поле даёт возможность правильного вычисления мощности гравитационного излучения, в строгом квантовом приближении исходя из спектра переходов по стационарным состояниям, причём уже с константой K. Система может излучать, только находясь в определённых квантовых состояниях. Это аксиома квантовой механики, также как и наличие элементарного источника излучения ,имеющего эти состояния. Гравитационных волн с постоянной G, якобы излучаемых системой тел с переменным, но каким угодно квадрупольным моментом нет и не может быть. При этом ОТО и не даёт никаких количественных оценок по спектру излучению гравитационных волн, а за них выдаются помехи неизвестного происхождения, причём частоты таких помех меняются разу от разу, а классическая теория их и не предсказывает.

Гравитационное излучение может возбуждаться в плотной высокотемпературной плазме [1,3] и в определенных условиях усиливаться, но его усиление будет приводить к сжатию излучающей системы. Следовательно,

в условиях усиления гравитационного излучения будет наблюдаться не само гравитационное излучение, а лишь результат его действия. При этом, количественные характеристики спектра гравитационного излучения могут быть определены по уширению спектра электромагнитного излучения [3].Сам же факт сжатия плазмы излучаемым гравитационным полем может быть использован в целях термоядерного синтеза [3].

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The general relativistic cosmological solutions in modified gravity theories

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The special class of the exact solutions in cosmological models based on the Generalized Scalar-Tensor Gravity with non-minimal coupling of a scalar field to the Ricci scalar and to the Gauss-Bonnet scalar in four dimensional Friedmann universe corresponding to similar ones in General Relativity is represented. The parameters of cosmological perturbations in such models correspond to the case of Einstein gravity with a high precision. As the example of proposed approach, some verified cosmological models are constructed.

Dynamical symmetry breaking in geometrodynamics

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A new tetrad is introduced within the framework of geometrodynamics for non-null electromagnetic fields [1-2]. This tetrad diagonalizes the Einstein-Maxwell stress-energy tensor, any stress-energy tensor in a local and covariant way, and

allows for maximum simplification of the expression of the electromagnetic field, in any curved four-dimensional Lorentzian spacetime, allowing for the identification of its degrees of freedom in two local scalars. The Einstein-Maxwell equations will also be simplified. New isomorphisms are proved. The local group algebra of electromagnetic gauge transformations is isomorphic to the new groups LB1 and LB2, independently. We know that the local algebra of the U(1) group, that is the real numbers R or local scalars Λ is homomorphic to the local group of Abelian electromagnetic gauge transformations U(1). A new internal-spacetime mapping is established using these new tetrads. It is possible to map the local algebra of the U(1) group into the transformation groups of tetrad vectors on two local orthogonal planes. The planes that diagonalize the stress-energy tensor. LB1 is the group of local tetrad transformations comprised by SO(1,1) plus two different kinds of discrete transformations. One of these two discrete transformations is the full inversion or minus the identity two by two. All the elements that arise by composing the full inversion and SO(1,1) are present in the image of this mapping even though the full inversion itself is not, however, it is an accumulation point in the image of the mapping. The other discrete transformation is not Lorentzian because it is a reflection or flip with zeroes in the diagonal and ones off-diagonal also two by two. The local group algebra of electromagnetic gauge transformations is isomorphic to the local group of tetrad transformations LB2 on the orthogonal local plane as well. LB2 is SO(2) minus the full inversion. The full inversion is however an accumulation point in the image of this mapping. The existence of these isomorphisms between the local algebra and these LB1 and LB2 groups on local orthogonal planes is possible since in reality LB2 is SO(2) minus the full inversion or minus the identity two by two and similar for LB1. Therefore, we proved previously that LB1 is homomorphic to LB2 in a two to one relation. These group results amount to proving that the no-go theorems of the sixties like the S. Coleman- J. Mandula, the S. Weinberg or L. O'Raifeartagh versions are incorrect. Not because of their internal logic, but because of the assumptions made at the outset of all these versions. The explicit isomorphic link between the Abelian local “internal” electromagnetic gauge transformations and the local tetrad transformations on special orthogonal local planes is manifest evidence of these incorrect assumptions as has been proved. Simply because the Lorentz transformations on a local plane in a four-dimensional curved Lorentzian spacetime do not commute with Lorentz transformations on a different local plane in general, element of contradiction with the no-go theorems assumptions. LB1 homomorphic to LB2 which is SO(2) means that the boosts plus two discrete transformations can be put in a two to one relation to SO(2) which also contradicts the assumptions made at the outset of the no-go theorems. By topological closure we can map the missing full inversion in LB1 to the missing full inversion in LB2 since both are simultaneous limits of one to one sequences. We will discuss through a first order perturbative formulation the local loss of symmetry when a source of electromagnetic and gravitational field interacts with an agent that perturbs the original geometry associated to the source3. It has already been proved that the local gauge groups algebras are isomorphic to local groups of transformation of special

tetrads [1-2]. These tetrads define at every point in spacetime two orthogonal planes or blades such that every vector in these local planes is an eigenvector of the Einstein-Maxwell stress-energy tensor. As the local gauge symmetry in Abelian or even non-Abelian field structures in four-dimensional Lorentzian spacetimes is displayed through the existence of local planes of symmetry that we will refer to as blades one and two, the loss of symmetry will be manifested by the tilting of these planes under the influence of an external agent. In this strict sense the original local symmetry will be lost. We will be able to prove in this way that the new blades at the same point will correspond "after the tilting generated by perturbation" to a new symmetry. The purpose of this talk is to show that the geometrical manifestation of local gauge symmetries is dynamic [3]. Despite the fact that the local original symmetries will be lost, new symmetries will arise. A dynamic evolution of local symmetries will be manifested. This result will produce a new theorem on dynamic symmetry evolution [3]. This new classical model will be useful in order to better understand anomalies in quantum field theories. These new tetrads are useful in astrophysics spacetime evolution algorithms since they introduce maximum simplification in all relevant objects, specially in stress-energy tensors making the evolution relativistic differential equations simpler [4-5].

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Entanglement in composite systems due to external influences

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Entanglement is a pure quantum property which is associated with a quantum non-separability of parts of a composite system. Entangled states became a powerful tool for studying principal questions both in quantum theory, in quantum computations and information theory. Recently it was proposed a two-qubit photonic quantum processor that implements two consecutive quantum gates on the same pair of polarization-encoded qubits. Different views on what is actually happening in the process of quantum entanglement may be related to different interpretations of quantum mechanics. We believe that the complete understanding of the nature of quantum entanglement still requires a detailed consideration of a variety of relatively simple cases, not only in nonrelativistic quantum mechanics, but in QFT as well. This explains recent interest in study general problems of quantum entanglement in QFT and in considering specific examples in QFT of systems with unstable vacuum. In all these cases models with exact solutions are very useful. We consider examples of entanglement in two-qubit systems and an example of entanglement in QFT using existing exact solutions. In the beginning we consider an entanglement of two spin states by a magnetic field, and then an entanglement of two photon beams interacting with Dirac electrons. In turn, these electrons are placed in a magnetic field. The magnetic field affecting electrons affects photons and thus, causes an entanglement of the photon beams. The third example is related to the effect of production of electron-positron pairs from the vacuum by a strong electric-like external field. In course of the particle production there appears two separated to a certain extent subsystems of the created electrons and positrons. Then we use a general nonperturbative expression for the density operator of the system under consideration. Applying a reduction procedure to this density operator, we construct mixed states of electron and positron subsystems. Calculating the von Neumann entropy of such states, we obtain the loss of information due to the reduction and, at the same time, the entanglement measure of electron and positron subsystems. Such a process can be considered as an example of an entanglement in QFT.

Configuration manifolds of a spherically-symmetric system of gravitational and electromagnetic fields

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We study the properties of the configuration space for a spherically-symmetric system of gravitational and electromagnetic fields with the metric and the potential

$$ds^2 = N^2c^2dt^2 - L^2\left(dr - N^r cdt\right)^2 - R^2d\sigma^2, \qquad A = A_0dx^0 + A_rdr$$

We write the Hamiltonian action of system in the form

$$S = \int dx^0 \int dr\left(P_L\dot{L} + P_R\dot{R} + P_{A_r}\dot{A}_r - NH - N^rH_r - A_0H_A\right)$$

where H and H_r are Hamiltonian and radial momentum constraints, H_A is the Gauss law constraint, P_L, P_R, and P_{A_r} are the momenta conjugate to the configuration variables L, R, and A_r. Note that for this system there is a conservation law of the total mass:

$$M = \frac{c^2}{2\kappa}\left[R - \frac{R}{L^2}\left(R_{,r}\right)^2 + \frac{\kappa}{c^3}\frac{\left(P_L\right)^2}{R}\right] + \frac{Q^2}{2c^2R}$$

Finding from here the impulse P_L and substituting into the Hamiltonian constraint H we find

$$P_R = \frac{c^3}{\kappa\sqrt{F_{tot}}}\left\{\frac{R}{L}R_{,rr} - \frac{R}{L^2}L_{,r}R_{,r} + \frac{R_{,r}^2}{L} + \left(\frac{\kappa m}{c^2} - 1\right)L\right\}.$$

In addition, we have

$$P_L = \frac{c^3}{\kappa R}\sqrt{F_{tot}}, \quad P_{A_r} = \frac{Q}{c}, \quad F_{tot} = \frac{R_{,r}^2}{L^2} + F_0, \quad F_0 = -1 + \frac{2\kappa m}{c^2R} + \frac{\kappa Q^2}{c^4Q^2}.$$

Furthermore, the momentum constraint is performed identically. The system of equations

$$\frac{\delta S}{\delta L} = P_L, \quad \frac{\delta S}{\delta R} = P_R.$$

is the integrable. From here follows the hypersurface action, as the solution of the Einstein-Hamilton-Jacobi equation:

$$S = \frac{c^3}{\kappa}\int drLR\left\{F_{tot} - \frac{R_{,r}}{L}\sinh^{-1}\frac{R_{,r}}{R\sqrt{F_0}}\right\} + \frac{Q}{c}\int A_r dr + C\left(M,Q\right).$$

Variations of S with respect to mass M and charge Q lead to motion trajectories in a mini-superspace for an arbitrary imbedding of hypersurfaces $t = const$ in space-time. The family of these curves corresponds to the solutions of

the Einstein equation for different M and Q. According to the method of [2], the minisuperspace metric is constructed and its geometry is studied. It is shown that for the trivial embedding hypersurface in the T-region of space-time of a charged black hole, minisuperspace is flat. This allows us to enter pseudo-Cartesian 3D coordinates in which the mini-superspace metric takes the Lorentz form. Therefore, the mini-supermetric admits the motions group O(1,2). For an arbitrary embedding, these variables give a quasi-Cartesian metric in a nonholonomic basis. Further, we study the relationship between the space-time and the configuration space of system.

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Mathematical model of optical radiation propagation in a microsatellite moving in near-earth orbit

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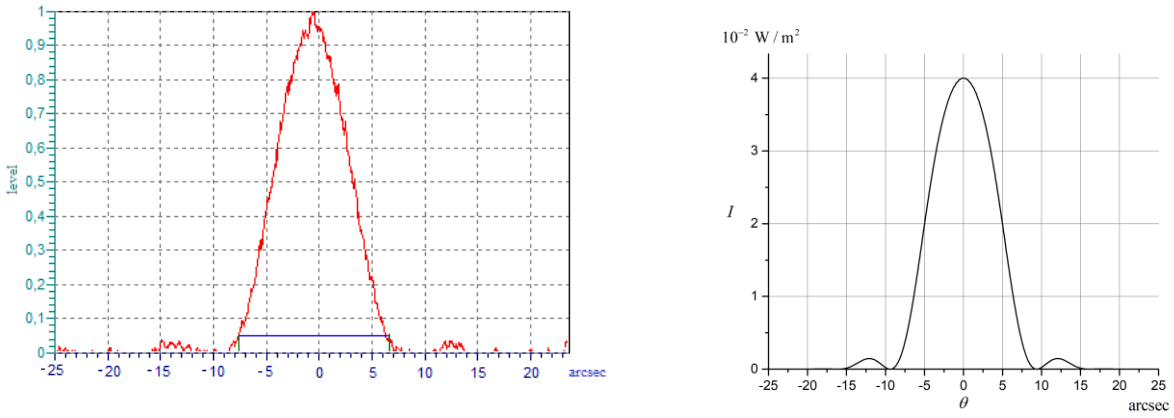
Improving the accuracy of global positioning systems can be achieved by launching passive laser satellites [1]. These satellites can provide a fundamental level of accuracy in determining spatial and temporal coordinates and can be used to conduct scientific experiments in the field of electrodynamics of moving media and the theory of relativity. The main element of the optical system designed to form reference echoes is the spherical Luneberg lens, which under certain conditions can work as an angle reflector [2].

This paper focuses on the problem of laser location of a reference low-orbit satellite “BLITZ-M”, which is a two-layer spherical gradient lens. The satellite optical response is of a complex spatial structure, which depends on the speed of the lens in its orbit [3]. Currently, the design of such satellites does not take into account the effects of the optics of moving media, which may adversely affect the capabilities of the laser location system. Therefore, the purpose of this work was to implement a mathematical model describing the propagation of electromagnetic radiation in a moving heterogeneous environment, to build an interference pattern of the intensity distribution of the radiation reflected by a moving satellite, and to determine the dependence of the signal-to-noise ratio in the reception area on the speed.

The numerical experiment was carried out with the following parameters: the number of rays is $N = 10^5$, the wavelength is $\lambda = 532$ nm, the intensity of the central beam is $dI = 5 \cdot 10^{-7}$ W/m^2, the dependence of the amplitude on the coordinate of the beam incident on the lens has a Gaussian distribution with a standard deviation

$\sigma = 8 \cdot 10^{-4}$, the angles of incidence are $\vartheta = 0..3^{o}$, the phase summation interval for the radiation pattern is $d\theta = 0.5$ of angular seconds.

The calculation was carried out in the near / far zone modes (10 m / 1500 m, respectively), taking into account / without taking into account the speed (satellite linear velocity is 7100 m/s).

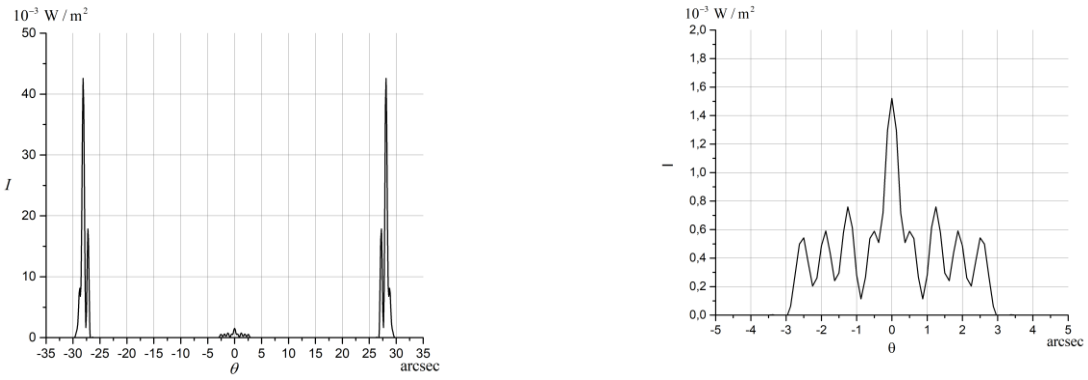


a) b)

Figure 1. a) The view of the radiation pattern at the measuring stand, lens velocity is $V = 0$ m/s

b) The radiation pattern of the reflected radiation in the near zone, without taking into account the velocity of the satellite. The signal recording surface is located 10 m from the center of the lens.

The result of the calculations is the check of the mathematical model of the electromagnetic radiation propagation. In this case, the value of the side peaks in a numerical experiment depends only on the value of the standard deviation of Gauss distribution.



a) b)

Figure 2. Radiation pattern of reflected radiation in the far zone with velocity. The signal registration surface S is located at a distance of 1500 km from the center of the lens; the satellite velocity is $V = 7100$ m/s

a) in the range $\theta = -50..50$ of angular seconds

b) in the range $\theta = -5..5$ of angular seconds

A numerical experiment showed that the beams are reflected at different angles and the optical response in the reception area depends not only on the distance between the lens and the radiation recording surface, but also on its speed, which for example affects a significant change in the intensity in the signal reception area ($I = 1{,}52 \times 10^{-3}$ W/m^2 in the case of taking into account the speed against $I = 4{,}10^{-2}$ W/m^2 in the case when the speed is not taken into account). This may influence the reliability of the laser location system. Hence we draw the conclusion that when developing the GLONASS optical segment, it is necessary to take into account the effects of the optics of moving media.

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Математическая модель процессов распространения оптического излучения в микроспутнике, движущемся по околоземной орбите

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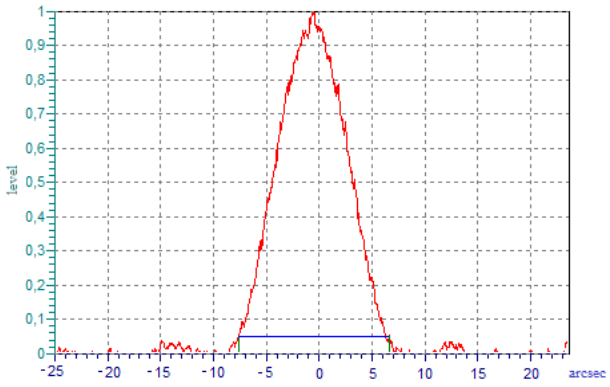
Повышение точности глобальных систем позиционирования может быть обеспечено путем запуска пассивных лазерных спутников [1]. Эти спутники могут обеспечивать фундаментальный уровень точности определения пространственных и временных координат и использоваться для проведения научных экспериментов в области электродинамики движущихся сред и теории относительности. Главным элементом оптической системы, предназначенной для формирования эталонных отраженных сигналов, является сферическая линза Люнеберга, которая при определенных условиях может работать как уголковый отражатель [2].

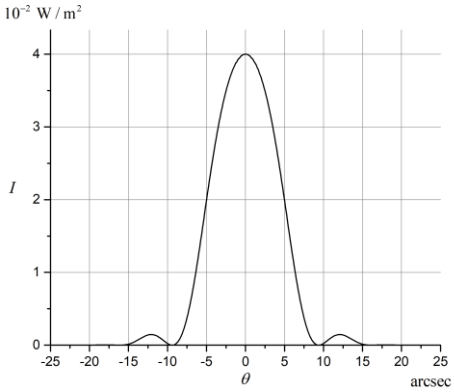
В данной работе рассматривается задача лазерной локации эталонного низкоорбитального спутника “БЛИЦ-М”, представляющего собой двуслойную

сферическую градиентную линзу. Оптический отклик спутника имеет сложную пространственную структуру, которая зависит от скорости движения линзы по орбите [3]. В настоящее время при конструировании таких спутников не учитываются эффекты оптики движущихся сред, что может негативно отразиться на возможностях системы лазерной локации. Поэтому целью данной работы являлась реализация математической модели, описывающей распространение электромагнитного излучения в движущейся гетерогенной среде, для построения интерференционной картины распределения интенсивности отраженного движущимся спутником излучения, выявления зависимости соотношения сигнал/шум в области приема от скорости движения.

Численный эксперимент проводился со следующими параметрами: количество лучей $N = 10^5$, длина волны $\lambda = 532$ нм, интенсивность центрального луча $dI = 5 \cdot 10^{-7}$ Вт/м^2, зависимость амплитуды от координаты падения луча на линзу имеет гауссово распределение со стандартным отклонением $\sigma = 8 \cdot 10^{-4}$, углы падения $\vartheta = 0..3^o$, интервал суммирования фаз для диаграммы направленности $d\theta = 0.5$ угловых секунд.

Расчет проводился в режимах ближней/дальней зоны (10 м / 1500 м соответственно) с учетом/без учета скорости (линейная скорость спутника 7100 м/с).



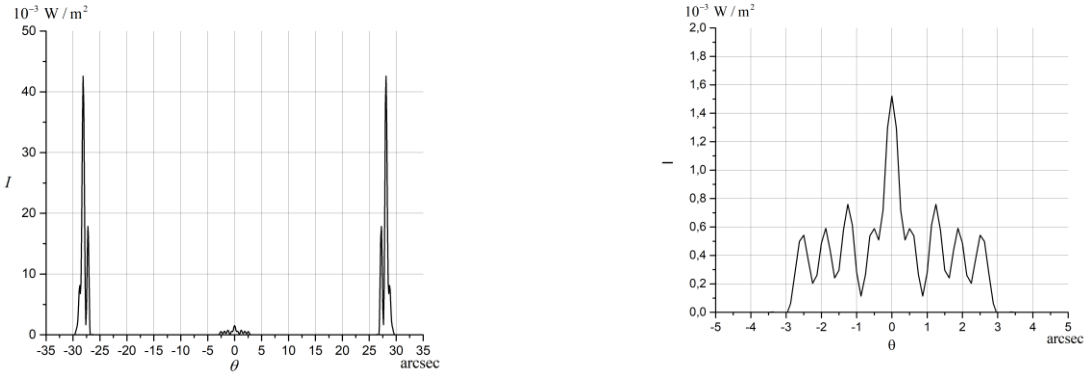


а) б)

Рис.1. а) Вид диаграммы направленности на измерительном стенде УИК, скорость линзы V=0 м/с

б) Диаграмма направленности отраженного излучения в ближней зоне без учета скорости спутника. Поверхность регистрации сигнала находится на расстоянии 10 м от центра линзы.

Результатом выполненных расчетов является проверка математической модели распространения электромагнитного излучения. В данном случае величина боковых пиков в численном эксперименте зависит лишь от величины стандартного отклонения распределения Гаусса.



a) b)

Рис. 2. Диаграмма направленности отраженного излучения в дальней зоне со скоростью. Поверхность регистрации сигнала S находится на расстоянии 1500 км от центра линзы, скорость спутника V=7100 м/с

а) в диапазоне $\theta = -50..50$ угловых секунд

б) в диапазоне $\theta = -5..5$ угловых секунд

Численный эксперимент показал, что лучи отражаются под разными углами и оптический отклик в области приема зависит не только от расстояния между линзой и плоскостью регистрации излучения, но и от скорости её движения, что например сказывается на значительном изменении интенсивности в области приема сигнала ($I = 1{,}52 \cdot 10^{-3}$ Вт/м^2 в случае с учетом скорости против $I = 4{,}10^{-2}$ Вт/м^2 в случае без учета скорости), что может повлиять на надежность работы системы лазерной локации. Отсюда следует вывод, что при разработке оптического сегмента ГЛОНАСС необходимо учитывать эффекты оптики движущихся сред.

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Calibration of high precision surfaces of gravitational wave telescope optics

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For the purposes of experimental detection of gravitational waves of cosmic origin the gravitational waves telescopes are utilized. There are several international projects designed to detect and accurately measure gravitational waves based on earth or in space: the American-Australian project LIGO, the German-British GEO600, the Japanese TAMA-300 and the Franco-Italian VIRGO and European LISA. Telescopes include flat optical components with high-precision surfaces, about 0.2nm rms and aperture diameter more that 250mm.

The precision control of the manufactured optics is significant problem of optical industry. The manufacturers have production facilities and polishing technologies of optical mirrors with a large aperture and strict requirements of the surface quality. However, measurement of optics associated with a number of difficulties: metrology tools should be capable of measuring with significant vibration immunity, as there is no possibility to move optics under control from the production; measurements should be carried out in a wide spatial frequency range; metrology instrument should allow to determine the quality parameters of surface with high accuracy.

This work is dedicated to the development of the absolute calibration method based on the method of the two-flat test, and its accuracy characteristics. The developed technique of calibration allows to certificate the large aperture surfaces with high precision in the vibration conditions.

Current paper presents the results of the numerical simulations of the absolute calibration, the system errors and procedure errors of calibration developed during the real experiment in a production environment on the basis of LZOS factory.

Разработка методов абсолютной калибровки оптических поверхностей для контроля крупногабаритной оптики гравитационно-волновых телескопов

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Для задач экспериментального обнаружения гравитационных волн космического происхождения используются устройства регистрации волн - гравитационные телескопы. Существует несколько международных проектов наземного и космического базирования такого типа: американо-австралийский проект LIGO, немецко-английского GEO600, японский TAMA-300 и франко-итальянский VIRGO. Схемы подобных телескопов включают в себя плоские оптические детали, поверхности которых должны быть выполнены с точностью до 0.2 нм RMS (среднеквадратическое отклонение высот по поверхности) и диаметром апертуры от 250мм.

Контроль качества изготовления поверхностей таких деталей является существенной проблемой оптической промышленности. Заводы-изготовители обладают производственными мощностями и технологиями изготовления оптических зеркал с большими апертурами и высокой точностью доводки поверхностей. Однако контроль качества изготовления поверхностей связан с рядом трудностей: метрологическое обеспечение должно позволять контролировать поверхности непосредственно на производстве в присутствии вибраций, так как перемещение измеряемых деталей может привести как эффекту “перетекания материала”; измерения должны проводиться в широком пространственно-частотном диапазоне; контроль должен позволять определять параметры качества с высокой точностью.

Данная работа посвящена разработке метода абсолютной калибровки, основанному на методе двух поверхностей и анализу его точностных характеристик. Разработанная методика калибровки позволяет контролировать и аттестовать поверхности высокой точности с большими диаметрами апертуры в производственных вибрационных условиях.

В работе представлены результаты математического моделирования метода абсолютной калибровки, также представлены методические и системные ошибки разработанной калибровки при проведении реального эксперимента в производственных условиях на базе ОАО “ЛЗОС”.

Bound State of Photons and High Frequency Gravitational Waves excited in Media by Laser Emission

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The appearance of intense lasers opened the opportunity to observe the different nonlinear phenomena in dielectric media: Second Harmonic Generation, Two-photon Excited Luminescence, Stimulated Raman Scattering, Parametric Light Processes and others. In this work, the opportunity of high frequency gravitational waves [1-4] exciting in dielectrics because of Comb Parametric Simulated Raman Scattering processes is analyzed. Due to the strong photon-photon anharmonicity, realized in Comb Parametric Simulated Raman Scattering processes the bound two-photonic states [5] in media may be created. If the frequency of exciting laser emission is ω_0, the created scalar bound two-photonic state is described as scalar gravitational wave with frequency $2\omega_0$. Thus in this nonlinear processes the high frequency gravitational waves may be excited. The theory of bound two-photonic states forming because of optical excitation of dielectric media is developed. The preferable conditions for bound two-photonic states existence are the Fermi Resonance presence. In this case, the scalar exciton states with energy, close to the bound two-photonic states with frequency $2\omega_0$, are in electronic spectra of media. After bound two-photonic states in media creating due to pulsed laser excitation, the corresponding scalar gravitational waves propagated in spare space. Elemental excitations of such waves is known as paraphoton or hidden photon [6-8]. For detection of high frequency scalar gravitational waves, the same media, in which bound two-photonic states were excited, is proposed. The experimental results of investigations of Comb Parametric Simulated Raman Scattering in various condensed dielectric media (CaCO3, quartz, NaBrO3, Ba(NO3)2 and others), excited by ultra short (60-80 ps) YAG:Nd3+ laser pulses are presented. The second optical harmonic of a YAG:Nd3+ laser with wavelength λ = 532 nm and laser emission with a wavelength λ= 1064 nm turned out to be very effective for the excitation of the Comb Parametric Simulated Raman Scattering Raman spectra in discussed dielectric media. The different experimental schemes [9-10] for the generation and detection of scalar high frequency gravitational waves during Comb Parametric Simulated Raman Scattering are proposed.

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The signs of relativistic binary star systems' influence on the Earth's electric field

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Signs of relativistic binary star systems' (RBSS from the Johnston's list) influence on the Earth's electric field are discovered using eigenoscopy that is covariance matrices' eigenvectors' spectra analysis of the long time series of the Earth's electric field at four space-diversed stations.

The components of vertical projection of Earth's electric field strength are discovered which have significant amplitude and are spectrally localized at doubled rotation frequencies of forty three RBSS having small eccentricity and at higher harmonics of the rotation frequencies of six RBSS which have big eccentricity.

These components have statistically significant growth of space correlation on diverse observation stations and statistically significant growth of spectral localization. The amplitude-period relation also shows the statistically significant pecularity.

The observed signs have extremely small probability of random occurrence which is estimated using Bernoulli scheme and Smirnov-Kolmogorov criterio as small as 10^{-3} to 10^{-11}.

Признаки воздействия релятивистских двойных звездных систем на электрическое поле Земли

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С использованием айгеноскопии — анализа амплитудных спектров собственных векторов матриц вторых начальных смешанных моментов многолетних временных рядов напряженности электрического поля Земли на четырех пространственно разнесенных станциях наблюдений выявлены признаки воздействия релятивистских двойных звездных систем из списка В. Дж. Джонстона на электрическое поле Земли.

Выявлены значимые по амплитуде компоненты вертикальной составляющей напряженности электрического поля Земли, спектрально локализованные на удвоенных частотах обращения 43-х релятивистских двойных звездных систем с малым эксцентриситетом и на высоких гармониках частот обращения шести релятивистских двойных звездных систем с высоким эксцентриситетом.

На этих компонентах обнаружено статистически значимое увеличение пространственной корреляции по разнесенным станциям наблюдения и степени спектральной локализации. Зависимость амплитуды от периода также демонстрирует статистически значимые особенности.

Как показали оценки, произведенные с использованием схемы Бернулли и критерия Смирнова-Колмогорова, случайное возникновение наблюдаемых признаков крайне маловероятно (от 10^{-3} до 10^{-11}).

Phase transitions in geometrothermodynamic model of charged generalized-NUT black holes

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A series of modern cosmological models are constructed in the framework of thermodynamic approaches, which are developed on the grounds of standard thermodynamics of the 1-st order phase transitions. In particular, there are examined the large class of asymptotically anti-de-Sitter black holes [1], charged de Sitter black

holes [2], black hole in dark matter background [3]. It has been proposed in [4] that the features of behavior of galaxy rotation curves can be considered as effects of velocity on matter. In the present work we utilized the geometrothermodynamical approach developed in [5] to the first-order phase transition of charged anti-de-Sitter black holes to construct the model of a charged generalized-NUT black hole. Previously [6] we showed that the two-dimensional first-order phase transition with the distribution of relaxation times can be described in a configuration space $\left(\vec{r},t,\dot{\vec{r}}_\tau,\dot{t}_\tau;\tau\right)$, where $\vec{r}$ is a 2D radius-vector, t is time, dots are defined the derivatives with respect to evolution parameter τ. Now we studied the geometrothermodynamics of such system occurring in space-time with generalized Newman–Unti–Tamburino (NUT) metric. We approximated the numerically calculated dependences of relaxation times on radius r by the metric (lapse) function $f(r)$ of different types and then calculated corresponding dependences of the Gibb' s free energy on the Hawking temperature. We have found that the bifurcation of pitch-fold type is revealed that is a characteristic feature of the phase transition in charged black NUT-holes.

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C^3-Criterion for matching asymptotically flat space-times in General Relativity

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Based upon the analysis of the eigenvalues of the Riemann curvature tensor and their derivatives, we present a criterion for finding the minimum distance at which an interior and an exterior solution of Einstein's equations can be matched. As an illustration, we apply this C^3-criterion to a whole class of spherically symmetric spacetimes and find in all the cases physically reasonable conditions.

An Electrodynamic Study of Shapiro Time Delay

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Electromagnetic entities like electric charges, electromagnetic fields and light possess momenta and energies that we experience with our sense organs. Therefore, these are real physical entities (objects). All physical objects experience gravitational pull. They are carried along with the Earth, they move and spin too, with the Earth at the near the vicinity of its surface, feel Coriolis force when they are the parts of the Earth system and move with respect to that system and suffer the actions of other fictitious forces, too, when they are stationary at that system. All electromagnetic entities (objects) should similarly behave and act. We have demonstrated in many PIRT papers that this simple consideration derived from Newton–Maxwell is a complete electrodynamic alternative to the relativity theory-special and general. In some cases, however, this consideration succeeds brilliantly where the relativity theory lamentably fails. In this paper we shall show that Shapiro time delay could easily be explained from this simple electrodynamic consideration.

Critical behavior of black holes in massive gravity

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Considering de Rham–Gabadadze–Tolley theory of massive gravity, we introduce charged-AdS black hole solutions in diverse dimensions. We compute thermodynamic quantities in the extended phase space by considering the variations of the negative cosmological constant and massive couplings. We also prove that such variations are necessary in order to satisfy the extended first law of thermodynamics as well as associated Smarr formula. We find that the phase structure and critical behavior of topological AdS black holes are drastically restricted by the free parameters of the theory.

Category forms of Non-Signalling and Local Causality and their duals

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Two fundamental (meta)physical principles – NS (the Non-Signalling condition which bans communication by means of physical correlations) and LC (the principle of Local Causality which separates classical correlations from those responsible for non-locality) are considered in the framework of category theory. The original form of these principles operates with properties of common probability distributions for outcomes of measurements implemented in two space-time regions. The suggested category form consists of some assertions about special commutative diagrams. To any common probability distribution in the discourse, an arrow (morphism) in these diagrams is associated. In fact, LC turns into the condition of the arrow being able to factor through a definite standard arrow. NS looks like uniqueness of an arrow which makes commutative a special diagram which incorporates the distribution arrow. These diagrams operate with the monad of distributions – a special endofunctor in the category of sets. By associating a pair of adjoint functors to the monad, one can construct duals to the considered notions. If duality is among ultimate laws governing our World the duals of NS and LC must find their place in it.

Теоретико-категорная форма условий локальной причинности и запрета коммуникации и их дуальные партнёры

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Важнейшие (мета)физические положения – принцип NS (запрет на отправку сигналов посредством физических корреляций) и LC (принцип локальной причинности, отделяющий корреляции классического типа от корреляций, демонстрирующих нелокальность) рассмотрены с точки зрения теории категорий. Исходные формулировки этих принципов имеют дело со свойствами совместного распределения вероятности исходов экспериментов, проводимых в двух различных пространственно-временных областях. Новые

формы является утверждениями о свойствах определённых коммутативных диаграмм. Каждому совместному распределению сопоставлена стрелка (морфизм) в этих диаграммах. Принцип LC превращается в утверждение о возможности пропустить эту стрелку через некоторую стандартную, а принцип NS – в утверждении о единственности морфизма, превращающего определённую диаграмму с участием выбранного морфизма-распределения в коммутативную. Эти диаграммы оперируют монадой распределений – специальным эндофунктором в категории множеств. Сопоставляя пару присоединенных функторов монаде распределений, можно построить дуальные формы рассмотренных понятий. Если дуальность входит в число первостепенных свойств нашего Мира, дуальные формы принципов NS и LC должны найти в нем свое место.

A precision clock network as an antenna for millihertz gravitational waves

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Reliable experimental confirmations about the existence of cosmic nature gravitational waves (GW) necessity rout us to study a detailed picture of the events of the various astrophysical objects collapse. This aim is provided by new methods of GW registration.

The direct detection of GW is crucial for a number of reasons. One of the most important is the ability to get an answer to the fundamental question: is GR the correct theory of gravity or simply the best of what we have at the moment? If the latter is true, then we can hope to answer the question of when and under what circumstances GR will also be wrong.

This can allow us to take a step towards finding out whether there are other and previously unimaginable theories that are superior to GR in describing everything: from the evolution of the Milky Way and other galaxies to the formation and deployment in time of our Universe.

A network of precision clocks (for example, atomic clocks), which are located at the nodes of a huge space-based system is offered in the report. The location of clocks in the network situated on Earth orbit is given. Estimates of the accuracy of the clock for recording events are given. We describe possible measurement results and their significance. Analogues of the proposed structure are the existing VLBI network and the Event Horizon network, based on several continents.

The operating principle of the proposed event registration scheme is as follows. It is known that the field approach can be used far from the source and it can be used

to determine the effect of gravitational signals on measuring instruments. It is also known that the propagation of the gravitational potential leads to a change in the position of small masses, therefore, to a change in their velocity. The velocity varieties the phase of a clock signal. Therefore, using precise instrument and the adequate separating software we have the possibility of separating the gravitational signal by measuring the difference in the time of arrival (TOA) of the signal from an operating clock and the interval between the tiks of the standard one, remote from the former. Pulsar or laboratory atomic clocks can be used as a reference. The technique of registering millihertz GW by a sequence of pulses received from an initially regular sequence is known as the Pulsar Timing method. The main source of millihertz GW are supermassive binary black holes (billions of solar masses), which are supposed to exist in the universe at the centers of galaxies as a result of previous mergers of these galaxies.

The method is based on the assumption that GW contributes to a change in the phase of the signal. Since the time characterizing a sequence of pulses of the pulsar radiation is highly stable, a change in the TOA of the signal can be registered. The error of modern laboratory atomic clocks is $\sim 3.7 \cdot 10^{-18}$ ($\sim 2.3 \cdot 10^{-14}$ for clock of space-based). The error of pulsars is $\sim 10^{-19}$. The system of space-based operating clocks covering a large spatial area on the Earth's orbit will form a chronometric space network (CSN).The registered variation of the TOA from the reference clock will signal the amplitude and frequency of the gravitational wave. The delay of signals from different network nodes can be associated with the direction of the front of a gravitational wave and its polarization. It is possible to obtain other data (for example, the position of the apparatus with the clock and their relative movement), verification of the GR conclusions (Shapiro's delay). The functioning CSN will play the role of a gravitational antenna.

Сеть прецизионных часов как антенна для миллигерцовых гравитационных волн

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Многочисленные экспериментальные подтверждения вывода о существовании гравитационных волн космической природы, делают необходимым изучение детальной картины событий коллапса астрофизических объектов, обеспечиваемого новыми способами его регистрации.

В докладе рассмотрена сеть прецизионных часов (например, атомных), которые расположены в узлах огромной системы космического базирования.

Приведена схема расположения часов в сети около Солнца. Даны оценки точности показаний часов для регистрации событий. Описаны возможные результаты измерений и их значимость. Аналогами предлагаемой структуры являются существующая сеть VLBI и сеть Event Horizon, базирующаяся на нескольких континентах.

Прямое обнаружение ГВ имеет решающее значение по ряду причин. Одной из самых важных является возможность получить ответ на фундаментальный вопрос: является ли ОТО правильной теорией гравитации или просто лучшей из того, что у нас есть на настоящий момент. Если верно последнее, то мы можем надеяться ответить на вопрос, когда и при каких обстоятельствах ОТО также окажется неверной.

Это может позволить нам сделать шаг к тому, чтобы узнать существуют ли другие и ранее невообразимые теории, которые превосходят ОТО в описании всего: от эволюции Млечного Пути и других галактик до формирования и развертывания во времени нашей Вселенной.

Принцип работы предлагаемой схемы регистрации событий заключается в следующем. Известно, что вдали от источника можно использовать полевой подход и с его помощью определять влияние гравитационных сигналов на измерительные инструменты. Известно также, что распространение гравитационного потенциала приводит к изменению положения малых масс, следовательно, к изменению их скорости. Поэтому существует возможность выделения гравитационного сигнала по измерению разности хода операционных часов и темпа хода эталона, удалённого от первых. В качестве эталона можно использовать пульсар или лабораторные атомные часы. Техника регистрации миллигерцовых ГВ по последовательности импульсов, получаемых от изначально регулярной последовательности, известна как метод Pulsar Timing. Основой метода служит допущение, что ГВ вносит вклад в изменение фазы сигнала. Так как время, характеризующее импульс пульсара, высокостабильное, то изменение времени прибытия сигнала может быть зарегистрировано. Погрешность современных лабораторных атомных часов составляет $\sim 3.7 \cdot 10^{-18}$ ($\sim 2.3 \cdot 10^{-14}$ часов космического базирования). Погрешность пульсаров как часов $\sim 10^{-19}$. Система операционных часов космического базирования, охватывающая большую пространственную область на орбите Земли, будет образовывать хронометрическую космическую сеть (ХКС).

Зарегистрированная вариация последовательности импульсов, получаемых от эталонных часов, будет сигнализировать об амплитуде и частоте гравитационной волны. Задержку сигналов от разных узлов сети можно связать с направлением фронта гравитационной волны и её поляризацией. Возможно получение других данных (например, положения аппаратов с часами и их относительное движение), проверки выводов ОТО (задержка Шапиро). Функционирующая

Instability States and Uncertainty Relation

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A In fact, it is difficult to find an inertial reference frame, since there are always the background of random external fields and waves, but we can assume that the inertial frame exists theoretically. Physics of Non-Inertial Reference Frames [1-3] is needed in order for us to add one of the most important properties of micro-objects of quantum mechanics - non-locality. In this case, the role of non-local hidden variables is played by acceleration and its higher derivatives with respect to time. The description of mechanical systems by non-inertial mechanics is performed using high-order derivatives differential equations in the form of Ostrogradsky Formalism.

A state of the physical system is considered stable if it returns to the initial state after finished the action of external factors. It is possible use the variance of the state for analyzes of instability states [4]. The variance of the stability states is equal to zero and of the instability is not. Analysis shows that classical mechanics describes stable trajectories, and quantum mechanics describes instable ones.

The article provides an analysis of instable states in the macro-world which gives the differential equation for instability trajectories due the influence of the background of random fields and waves. The paper argues that a complete description of such experiments with the correct direction of the resultant force can be obtained by postulating a description of the dynamics of mechanical systems by differential equations with high-order derivatives of coordinates to time. This is true for complex motions and non-inertial reference systems with complexly changing inertia forces. If we neglect such effects, then we can restrict ourselves to second-order differential equations, since in mathematics, there is a method of lowering the order of a differential equation, for example, when a third-order differential equation can be replaced by two differential equations of order no higher than the second. But such a description will not be complete, because at the same time, the sign (direction) of the quantities which expressing the third derivative is lost.

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Majorana Fermions, Braiding and the Dirac Equation

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This talk will discuss how the Dirac equation arises from Clifford algebraic considerations and how examining the action of the Dirac operator on a plane wave gives rise to an algebraic reformulation of the Dirac equation (equivalent to the original) that has solutions in terms of nilpotent elements of the Clifford algebra. These nilpotent elements can be regarded as annihilation operators for a fermion. We point out how the nilpotents decompose into Majorana operators and discuss how this point of view is related to the braiding of Majorana Fermions and to the original work of Majorana on the Dirac equation. We also discuss how this work is related to the ground-breaking work of Peter Rowlands and how it is related to the author's program for elucidating discrete physics in terms of non-commutative algebra.

Metrological support of technogenic systems based on the study of the influence heliogeophysical space

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The article is given in fundamental scientific research; approaches related to the prediction and estimation of position the planets. It is shown that the well-known relationship for coordinate and pulse uncertainties, a similar relationship for energy and time uncertainties is not fundamental and can be overcome by modern technical means in the discrete stroboscopic counting mode.

Superluminal Fields in Bimetric Space-Time Theory

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The possibility of the motion with super light speed is discussed in the framework of the model proposed earlier by the author. The discussion of such

possibility in the framework of standard relativity theory was initialized by Einstein in 1907 and continues until to the present. The particles which move with superlight speeds are called tachyons. In standard theory such particles if they are exist cannot move with smaller then light speeds.

In the considering model the coexisting of two nonequivalent Lorentzian structures with different universal speeds is supposed. This assumption leads to the coexistence in space-time of two classes of particles and fields whose dynamics are determined by the corresponding Lorentz structures. The interaction between particles and fields of the different classes may be realized by gravitation field (only nonquantum model is considered). One of the features of the model under consideration is that it is allowed the existence of particles, which, unlike the classical tachyons, can move with both light and superlight speeds.

We discuss the main principles of the building of the model under consideration, consider some geometrical properties of space-time, including causality problems, and possible contribution of superlight particles to the dark matter.

Macroscopic Nonlocal Correlations in Reverse Time by Data of the Baikal Experiment

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Consideration of macroscopic entanglement in the framework of action-at-a-distance electrodynamics leads to rather simple description of macroscopic quantum nonlocal correlations between random dissipative processes in the source and detector. These correlations have both the retarded and advanced component. The latter means correlation in reverse time. Therewith the advanced component through an absorbing medium exceeds the retarded one. For diffusion entanglement swapping the retardation and advancement can be very large. Such correlations with large-scale random heliogeophysical processes were observed in the previous lab experiments. These correlations are detected at extremely low frequencies and characterized by the large time shifts. But these experiments are very difficult in a usual laboratory because of various local interferences.

The experimental problem is elegantly solved under deep-sea conditions. The Baikal long-term experiment has started in 2012 at Baikal Deep Sea Neutrino Observatory. It aims, first, study of nonlocal correlations between the electrode

detectors at horizons z=50 m and z=1340 m in the lake and the remote one in the land laboratory (z=0), and second, study of correlations between the detector signals and large-scale natural dissipative processes with big random components.

The long-term observations demonstrated that detector signals respond to the random heliogeophysical (global) processes and causal connection of the signals directed downwards: from the Earth surface to the Baikal floor. This nonlocal causal connection proved to contain considerable time reversal component, exceeding time respecting one. This excess depends on the mass of the absorbing medium separating the detectors. Nonlocal nature of observed correlations has been confirmed by violation of the steering inequality with combination of solar and magnetispheric source-processes. Next, advanced nonlocal correlations of the detector signal with two regional random source-processes: strong earthquake and low frequency macroturbulence in the lake were revealed. It should be stressed causal nature of observed advanced correlations. In fact this means observation of the random future. The possibilities of the forecasts of random components of solar and hydrological activities on correlations in reverse time have been demonstrated.

Макроскопические нелокальные корреляции в обратном времени по данным Байкальского эксперимента

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Рассмотрение макроскопической запутанности в рамках абсорбционной электродинамики ведет к довольно простому описанию макроскопических квантовых нелокальных корреляций между случайными диссипативными процессами в источнике и детекторе. Эти корреляции имеют запаздывающую и опережающую компоненты. Последняя означает корреляцию в обратном времени. При этом опережающая корреляция через поглощающую среду превышает запаздывающую. Для диффузионного обмена запутанностью запаздывание и опережение могут быть очень велики. Такие корреляции с крупномасштабными случайными гелиогеофизическими процессами наблюдались в предшествующих лабораторных экспериментах. Они выявляются на крайне низких частотах и имеют большие временные сдвиги. Но эти эксперименты очень трудны в обычной лаборатории из-за различных локальных помех.

Экспериментальная проблема элегантно решается в условиях глубоководного эксперимента. Долговременный Байкальский эксперимент начался в 2012 г. на Байкальской глубоководной нейтринной обсерватории. Он направлен, во-первых, на изучение нелокальных корреляций между электродными детекторами на горизонтах z=50 м и z=1340 м в озере и в удаленной наземной лаборатории (z=0), и, во-вторых, на изучение корреляций между сигналами детекторов и природными крупномасштабными процессами с большими случайными компонентами.

Длительные наблюдения показали, что сигналы детекторов откликаются на случайные гелиофизические (глобальные) процессы, а причинная связь направлена вниз: от земной поверхности к дну Байкала. Оказалось, что эта причинная связь содержит значительную обратно-временную компоненту, превышающую прямую. Это превышение зависит от массы поглощающей среды, разделяющей детекторы. Нелокальная природа наблюдаемых корреляций была подтверждена нарушением неравенства стирингов с комбинацией солнечного и магнитосферного процессов-источников. Далее, были выявлены нелокальные корреляции сигналов детекторов с двумя региональными процессами-источниками: сильными землетрясениями и низкочастотной макротурбулентностью в озере. Следует подчеркнуть причинный характер наблюдаемых опережающих корреляций. Фактически, это означает наблюдение случайного будущего. Продемонстрированы возможности прогнозов солнечной и гидрологической активности на основе корреляций в обратном времени.

On the metrizability of the affine connectivity space and the unified theory of fundamental interactions

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We propose in the gravitation theory the background connectivity (which for the first time had been introduced by A.N. Chernikov [1]) interpret as the empirical connectivity, received as the particular case of the transition operator, which had been by induced by the collision integral. Approximating the transition operator by the differential operator and demanding minimum variance of the given operator from the transition operator (employing the method of least squares for the definition of the metric tensor). As a result we receive with the help of the variation formalism the differential equation of the regression, solving of which can find the metric tensor. By the help of the given tensor we receive the Christoffel symbols, which are

interpreting as the components of the theoretical connectivity. Using the metric tensor and the Christoffel symbols can construct both the Einstein gravitation theory and the Chernikov gravitation theory with the two connectivity's and the one metric tensor [1]. Con-structing the empirical connectivity in our gravitation theory we shall use the generalized functions that implies the change of the space-time topology.

We shall not consider the space-time as the connected space (closed trajectories of observable particles may not be pull together in a point) in the quantum theory, that does not contradict to the existence of Fadeev-Popov "ghosts" (unobservable zero-spin fermions, introduced in the quantum chromodynamics for the renormalizability of the theory [2]). As a result all parameters, characterizing of fundamental elementary particles are quantized [2]. Considering "ghosts" as original particles of an Universe matter, which's are characterized by the $SU(3)$ symmetry, the transition to leptons (neutrinos and antineutrinos), which's are characterized by the $SU(2)$ symmetry, may be regard as the phase transition and may be interpreted as the process, which is connected with the spontaneous breaking of symmetry (we have the freezing-out of freedom degrees). In our opinion Cooper pairing of noncharged leptons with a formation of a Bose liquid, which must cause to the density reduction of original leptons and to the appearance of photons, fundamental massive vector bosons and charged leptons [2].

Because we assume that the energy E of any fundamental interactions must depend on a number of all particles and quasi-particles participating in the interactions, then the it dependence on space coordinates is defined by means of an average number of bosons, which's exchanged two particles. By this the charge form of the fundamental particle is defined by the help of the given boson form and as well as by the help of the rate of its emission. The rate of its emission defines the "coat" quantity of virtual particles, surrounding the charge, which can become a unobservable one at large distances. Because of it the magnetic charge (the monopole) is the unobservable charge [3].

The appearance of photons (playing the role of standards in the relativity theory) caused to the domination of electromagnetic interactions in experimental data and to the division of the all Universe matter into two subsystems (slow and rapid). The matter of the slow subsystem (a thermostat) does not participate in electromagnetic interactions and play the catalyst role of stochastic processes, which it may observes by the matter of the rapid subsystem. As a result the particles of the rapid subsystem play the role of Brownian particles. They allow to study the properties of slow subsystem particles.

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Domain growth in a cosmology phase transition model with axially symmetric metrics

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According to standard cosmology at the electroweak scale, an electroweak phase transition associated with the spontaneous symmetry breaking has occurred ($t \sim 10^{-11}$ s) [1-2]. While within the minimal Standard Model the electroweak phase transition is considered to be the second order, the first-order electroweak phase transitions proposed in the background of Beyond Standard Models may solve some cosmological problems, like the generation of the baryon asymmetry of the universe, production of gravitational waves, formation of topological defects like the cosmic strings or the domain walls. We develop a geometrothermodynamic model of cosmological first-order phase transition based on a theory of the 1st-order phase transition in a contact statistical manifold [3-4]. Nucleation and following evolution of true-vacuum bubbles with axially symmetric Newman–Unti–Tamburino (NUT)-like metrics have been considered. A manifold of evolving bubbles is a Finsler statistical manifold of such thermodynamic system. We have shown that the NUT-theory parameter n is the gauge parameter of the scalar field which plays a role of fifth dimension. Finsler-Lagrange dynamic has been studied taking into account the heterogeneity of nucleation processes, notably a relaxation times distribution of bubbles. The Finsler billiard model has been proposed to describe a shape of domain wall in phase transition process. It has been found out that the generation of bubbles with large relaxation times would result in distortion of round-shape domains and formation of elongated ones.

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Laser Noise Control in the Optoacoustical GW Antenna

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The aim of the OGRAN project [1] is to register oscillatory acoustic oscillations of the aluminum bar with length of $L_G = 2$ m. In 1967, Braginsky had proposed a conceptual scheme to register relative displacements x of Fabry-Perot interferometer mirrors through registration deviations $\delta\nu_{RS}$ of mode frequency ν_R [2]: $\frac{x}{\delta\nu_{RS}} = \frac{L_G}{\nu_R}$. To this purpose laser beam passing through optical resonator enters a photodiode. Laser frequency should be returned from a peak of amplitude-frequency response so that power $P_{PH} = P_0/2$ falls on the photodiode, where P_0 is radiation intensity at the peak. Signal power variations $\delta P_{PHS} = D_P \delta\nu_{RS}$ appear on a slope, where $D_P = \pi(1-R)^{-1} P_0 L_G / c$ is a decrement. For photocurrent we have: $\alpha = \delta I_S / x = F_G P_0 \lambda^{-1} \eta / (h\nu)$. Here $F_G = \pi(1-R)^{-1}$ is finess. Potential sensitivity of this meter is determined by shot noise of photoelectrons: $S_{IE}(f) = 2eI_0 = \eta e^2 P_0 / (h\nu)$. The threshold signal x_N $(S/N = 1)$ is determined by noise adduction to input: $S_x(f) = S_{IE}(f)/\alpha^2$: $x_{N0} = \frac{\lambda}{F_G}\left(\frac{h\nu}{\eta P_0}\right)^{1/2} (\Delta f)^{1/2}$. Numerical estimation is relevant; for OGRAN values [1]: $F_G = 3000$, $\eta = 0.7$, $\lambda = 1.06$ μm and supposing $P_{PH} = 40$ mW we find $x_{N0} = 6.5 \cdot 10^{-17}$ cm/$(\text{Hz})^{1/2}$ and $x/\delta\nu_{RS} = 0.7 \cdot 10^{-12}$ cm/Hz. In ref. [1] 4-16 photodiodes are mentioned.

Earlier, the progress in development of capacitive registrators for GWA had led to control of amplitude and phase-frequency stochastic variations in RF generators. Laser also demonstrates powerful technical non-Poisson intensity fluctuations. To take them into consideration, Braginsky had introduced the phenomenological factor B into forecast x_{N0} [2]:

$$x_{NI} = \frac{\lambda}{F_G}\left(B \cdot \frac{h\nu}{\eta P_0}\right)^{1/2} (\Delta f)^{1/2} \qquad (1)$$

Technical noises determine instrumental sensitivity. In 1996, formula (1) had been enclosed into theoretical basis of the OGRAN project [arXiv:gr-qc/0411083;

PIRT-2007,-2011,-2015]. V.N. Rudenko gave the expert assessment: "$B=1-10^3$" [1]. In article [3], the perspectives of applying the $B=10$ value in new projects has been shown. In article [4], the meaning of the factor had been clarified: "The factor B determines the reduction in sensitivity due to a variety of noise sources, relative to the photon noise level". As example a sample of determining it had been given: the evaluation was $B=104$. There had been used tests of the 40 m Caltech interferometer in 1983. Now, according to OGRAN installation tests, we can obtain an updated estimation. So, "the measured level of the spectral density of the total antenna noise (background above which a thermal peak dominates) … is $\sim 0.003\ \text{Hz}/(\text{Hz})^{1/2}$" [1]. There is a reason to believe that it is suppressed laser frequency noise [PIRT-2009]. This main result seems to be quite reliable, since the controlled peak of the low-resolution spectrogram with a level of $0.2\ \text{Hz}/(\text{Hz})^{1/2}$ exceeds the noise of the displacement meter by 37 dB. Using the relationship $x/\delta v_{RS}=0.7\cdot 10^{-12}$ cm/Hz we find implemented resolution $x_N=2\cdot 10^{-15}$ cm/$(\text{Hz})^{1/2}$. From comparison with above forecast x_{N0} we find $B\approx 2\cdot 10^3$.

Two phenomenological components can be distinguished in technical laser noise. So, in the theory of heterodyne reception there is representation of "power noise": $P(t)=P_0\left[1+\xi(t)\right]$ [5], where $\xi(t)$ is a dimensionless modulating process having the spectral density $m_L(f)$. There are also references to laser "frequency noise" as a chaotic process $v_N(t)$ of frequency deviations with spectral density $S_v(f)$. Then two component noise of power variations at a photodiode are given: $\delta P_N=P_{PH}\xi(t)+D_P v_N(t)$. For photocurrent fluctuations, an expression that determines factor B follows: $S_I(f)=I_0^2 m_L+\left(\frac{D_P\eta e}{h\nu}\right)^2 S_v+2eI_0=2eI_0B$. There is the estimation: $m_L=10^{-12}$ Hz^{-1} [5]. Using the above estimate $S_v=S_{v1}$ and values [1], we obtain: $B=7.5\cdot 10^4$ and $x_{NI}=2\cdot 10^{-14}$ cm/$(\text{Hz})^{1/2}$.

In the OGRAN project, the FP resonator mirrors are fixed at the bar ends, and a Pound-Driver-Hall (PDH) scheme is applied [6]. Using RF modulation and synchronous demodulation, the error signal of the automatic frequency control system is formed. It's output voltage is zero if $\Delta_{RL}=v_L-v_R=0$. The PDH system provides accurate, fast-acting laser frequency following the signal deviations δv_{RS}, and frequency-manipulated radiation is formed. The PDH technique performs the second function: laser frequency follows the bar length temperature drift. This feature degrades sensitivity of the precision meter circuit. In the discriminator PDH, channel frequency modulation transudes on the slope of it's error signal curve. This technique in the first approximation allowed to eliminate LF power noise (PN). Also frequency noise was taken under control [PIRT-2009], However, the excess noise remained. As a result of investigation, an explanation version of the LF PN penetration mechanism was presented [5]: it is eliminated under the condition $\Delta_{RL}=0$. It is violated both in

quasistatics and in dynamics. Accordingly, two new noise sources emerged. The first is a result of bar temperature length drift. The second is caused by vibration background, namely, it manifests at the output U_{SDD} of the discriminator synchronous detector (SD).

It should be decided to what values it is necessary to reduce the contributions of main three sources of noise. The "Ulitka" GWA (Astron.Rep.v.56.p.638) has resolution 10^{-14} cm/(Hz)$^{1/2}$. For OGRAN pilot model, the published design value is 10^{-16} cm/(Hz)$^{1/2}$ [arXiv:0411083]. For the general GWA the design resolution is not known, but the desired value is pointed out: $3\cdot10^{-16}$ cm/(Hz)$^{1/2}$ [1]. Obviously, the three noise sources should be limited by $2\cdot10^{-16}$ cm/(Hz)$^{1/2}$.

1. To reduce suppressed frequency noise by 20 dB, the feedback depth at 1300 Hz must be increased by 20 dB, that is, from 10^3 to 10^4; or raise to $3\cdot10^3$ and the compensation method should be applied [PIRT-2009].

2. The frequency mismatch Δ_{RLT} as a tracking error determines SD output voltage of the [5]: $U_{SDG}=D_{SDG}\left[\Delta_{RLT}\left(1+\xi\right)+\delta v_{RS}\right]$. Here, the term $\Delta_{RLT}\xi$ is the new noise, which makes a contribution $x_{NT}=\left(L_G/v_L\right)\Delta_{RLT}m_L^{1/2}\left(\Delta f\right)^{1/2}$. Then the following condition must be satisfied: $\left|\Delta_{RLT}\right|\le 250$ Hz. This is achieved by raising the statics feedback depth to $K_{00}=10^7$, whereas the laser retune range is ±2.5 GHz; it corresponds to bar temperature change of 0.4 K. But now (2013) [1], $K_{00}<10^4$. Accordingly, the peak of the second spectrogram, where accumulation time is more, has the height of 30 dB yet. It is proposed to create a method of bar heating and cooling and introduce it into the active system of temperature auto-control using the voltage at the input of the laser tuning piezoelectric element as a temperature sensor in zero-indicator mode.

3. To suppress vibration interference at the SD by means of circuitry, discriminator equations are written: $U_{PH}=D_D\left(\delta v_L-\delta v_R\right)$; $U_{SDD}=K_D\left(U_{PH}+U_N\right)$; $\delta v_D=K_L\beta U_{SDD}$. The solution is: $U_{SDD}=K_D\left(D_D\delta v_L+U_N\right)\left(1+K_DK_L\beta D_D\right)^{-1}$. Here $K_{0D}=1+K_DK_L\beta D_D$ is attenuation. While decreasing frequency the factor $K_L\left(f\right)$ must increase harshly. The article [1] says: "At frequencies above 100 Hz feedback is suppressed". From the decision we can conclude that it is not necessary to implement condition $K_{0D}=1$ at the signal frequency of 1.3 kHz; it is offered to make $\left|K_{0D}\right|=3\div5$ or more to provide a normal steep slope at signal frequency. Wherein, potential sensitivity of the installation is not reduced: $\delta v_{\min}=U_N/D_D$. [PIRT-2007]. That is, the cut-off frequency from 100 Hz should be increased by 30-100 times to controlled decreasing of vibration interference and noise by 20-26 dB.

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On physical and non-physical time in Cosmology and Quantum Mechanics

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Using the example of two branches of theoretical physics – Cosmology and Quantum Mechanics, we show the serious problems and contradictions that follow from the insufficient attention towards the physical sense of the notion of time.

The Special Relativity was first to discover the new quality of time and space – their dependency on the observer's movement speed. We learned that when observing the object that moves in relation to us with a great speed, we can see the processes that take place on it in different way they are seen on the object itself. But the formal mathematical approach to the notion of time did not allow to fully evaluate and use all the conclusions that follow from it.

In the quantum mechanics – the conclusion that for the objects moving with the light speed the intervals of space and time, not depending on their value in our coordinates, are equal strictly to zero. During the time equal to zero no physical changes can happen to the object, which allows to explain the perplexities and paradoxes appearing in the experiments with photons. Dirac introduced the principle of the superposition of states and the quantum leap to explain them. From the point of view of the described approach both these principles are simply not needed. And together with them all the paradoxes of the orthodox quantum mechanics, built on them, disappear.

In cosmology the formal mathematical approach to the time has led to the fact that The Big Bang Theory which is the basis of the cosmology today and describe the Universe, developing in time, is built on the metrics for the stationary, not developing Universe. This contradiction in metrics is the basis of all other contradictions and inconsistencies in The Big Bang model. To overcome they many additional assumptions were already made – on inflationary expansion, on intangible "dark energy", etc. All of it could have been avoided if we were more attentive to the physical time. It cannot be seen as a general mathematical value that can be both time and some function from time. Because the function will always have a different physical sense and another meaning than the time itself

The phenomenon of the central symmetry and antisymmetry of the celestial sphere and its significance for the cosmological model of The Big Bang

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We have studied the dependency of the manifestations of the central symmetry in quasars distributions on the level of their detalization and have shown the statistically significant correlation of the pair of the opposite distributions of the quasars from the catalogue SDSS-DR10 at the sizes of the inhomogeneities of 10-30 angular degrees. We performed the analysis of the centrally symmetrical and centrally antisymmetrical components of the microwave background temperature distribution on WMAP maps and show that the zones of the predominant influence of the symmetrical and antisymmetrical components take different areas of the celestial sphere which leads to the significant influence of the central symmetry and antisymmetry on the final distribution of the microwave background.

The influence of this phenomenon onto the cosmological model of The Big Bang, currently taken as a standard, is related to the fact that for the existence of the central symmetry and antisymmetry of the celestial sphere, the lifetime of the Universe should be enough for the signal from the observed object, whether it is a quasar, a galaxy or an inhomogeneity of a proto-matter at the period of hydrogen recombination, could reach the observer not only directly but also in a reverse direction around the closed Universe. The Big Bang cosmological model does not give enough time for that.

We should note that all the variants of The Big Bang model, including its modern version (ΛCDM model) are associated with the name of the Russian physicist Alexander Friedmann, but they do not consider the important Friedmann's idea about re-definition of time, which he could not implement himself because of his tragic death in 1925, when there were no astronomic data about real expansion of the Universe.

The mentioned by Friedmann necessity to re-define the time is related to the fact that these cosmological models are built on the metrics introduced by Einstein in his pioneer work on cosmology when studying the stationary, non-expanding Universe. At that, in the transformations performed by Einstein, that exclude from the metrics the fictional 4th coordinate introduced by him and exchange it to the space curvature radius, the differential of this radius that is equal to zero in the stationary Universe, is excluded from the study.

This way, the cosmological model of The Big Bang is built on the metrics of the stationary Universe. According to the mentioned above Friedmann's idea, this discrepancy could have been eliminated by the re-definition of the time variable, i.e.

changing the variable “t” to t’ = f(t). However, in fact this re-definition was not performed. Due of this, in the equations of the cosmological models that do not consider the non-zero differential of the space curvature radius, we have to see the variable «t» not as time but as some function of time. And it means that all the time characteristics given within this model including the Universe lifetime, must be seen as doubtful.

The existence of the phenomenon of the central symmetry and antisymmetry proves this uncertainty and the necessity to review and modify the cosmological model by changing the time component of the metric tensor by using the non-zero differential of space curvature radius.

Einstein Numbers

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In presenting the special theory of relativity often emit so-called paradoxes of relativity. One of these paradoxes is the formal occurrence of velocities exceeding the speed of light. According to the authors, most of these paradoxes arise due to the incompleteness of relativistic calculus over velocities. The velocities form a group under addition. However, for calculations in the case of such paradoxes, an expansion of operations to algebra is required. However, conventional non-relativistic operations are used instead. The authors propose a technique that allows obtaining a relativistic record in a transparent manner for the ratio of arbitrary complexity. For this, a complex representation of the Cayley-Klein projective model is used.

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При изложении частной теории относительности зачастую выделяют так называемые парадоксы теории относительности. Одним из таких парадоксов является формальное возникновение скоростей, превышающих скорость света. По мнению авторов, большая часть подобных парадоксов возникает из-за неполноты релятивистского исчисления над скоростями. Операции над скоростями образуют группу по сложению. Однако для вычислений в случае

таких парадоксов требуется расширение операций до алгебры. Однако вместо этого используются обычные нерелятивистские операции. Авторы предлагают методику, позволяющую прозрачным образом получать релятивистскую запись для соотношения произвольной сложности. Для этого используется комплексное представление проективной модели Кэли-Клейна.

An updated constraints on the variations of the fine-structure constant from strong gravitational fields

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We use the observed spectra from the white dwarf star G191-B2B with strong gravitational fields to constrain the space-time variation of the fine-structure constant, $\alpha = \frac{e^2}{4\pi\varepsilon_0 \hbar c}$. The analysis was combined with laboratory and astronomical lines in [Ni V] to find $\frac{\Delta\alpha}{\alpha} = \left(-0.003 \pm 0.072\right) \times 10^{-6}$. The obtained result suggests a comparison with previous studies looking at cosmological variations of α using QSO spectra. In this way, we can expect higher sensitivity from the white-dwarf spectra than the QSO spectra. Therefore, this study should have more orders of magnitude higher sensitivity per system than the previous quasar studies and we should be reaching the statistical and systematic errors in high accuracies. This result represents the most stringent limit on $\frac{\Delta\alpha}{\alpha}$ compared with the results using the same data published in the literature.

Inequivalence between active gravitational mass and energy of a composite quantum body

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We determine active gravitational mass operator of a simplest quantum body with internal degrees of freedom – a hydrogen atom - within the semiclassical approach to the Einstein's equation for a gravitational field. We show that the

expectation value of the mass is equivalent to energy for stationary quantum states. On the other hand, it occurs that, for quantum superpositions of stationary states with the constant expectation values of energy, the expectation values of the gravitational mass exhibit time-dependent oscillations. This breaks the equivalence between active gravitational mass and energy [1] and can be observed as a macroscopic effect for a macroscopic ensemble of coherent quantum states of the atoms. The corresponding experiment could be the first direct observation of quantum effects in General Relativity.

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COSMOLOGICAL DISTANCES SCALE: The scale factor

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In 2017, “Carnegie-Chicago Hubble project” experts pointed out a statistically significant, more than 3σ, discrepancy in the estimates obtained for the Cepheids “ladder of distance” $H_0 = 74 \pm 3\ \mathrm{km \cdot s^{-1} \cdot Mpk^{-1}}$ and microwave radiation measurements: $H_0 = 67.3 \pm 1.2\ \mathrm{km \cdot s^{-1} \cdot Mpk^{-1}}$ [1]. The head of “Hubble Space Telescope Key Project” V. Friedman, called this situation in cosmology a dead end [2], and she sees a way out of it in raising to 1% the accuracy of the scale of extragalactic distances. The analogous dynamics of the accuracy of estimates of the fundamental gravitational constant G, which plays an equally important role in cosmology, was noticed at the end of the 20th century. Then the confidence intervals of three of the four best definitions of G did not overlap at all, and in connection with the analysis of experiments on the search for neutrino oscillations, the problem of “incorrect confidence intervals” was considered. Therefore, in 1998, the Committee on Data for Science and Technology recommended a new value of $G = 6.673(10) \cdot 10^{-11}\ \mathrm{m^3 s^{-2} kg^{-1}}$. It was a “step back” relative to the value of 1986: $6.67259(85) \cdot 10^{-11}\ \mathrm{m^3 \cdot s^{-2} \cdot kg^{-1}}$. Further, in units of $10^{-11}\ \mathrm{m^3 \cdot s^{-2} \cdot kg^{-1}}$, the succession was: $2008 - 6.67428(67);\ 2010 - 6.67384(80);\ 2014 - 6.67408(31)$. And in 2014, a method of precision atomic interferometry was used to obtain an unexpected estimate of accuracy $G = 6.67191(99) \cdot 10^{-11}\ \mathrm{m^3 \cdot s^{-2} \cdot kg^{-1}}$. The discrepancy between the definitions of the fundamental constant T. Kinn from the International Bureau of Weights and Measures at a special meeting of the British Academy of Sciences called it the “metrological and scientific impasse”.

In this regard, the report examined the problem of the structural-parametric identification of the scattering characteristics of the Friedmann–Robertson–Walker model and its approximations as models of cosmological distance scales according to data on SN Ia supernovae, which were used in detecting “acceleration of the Universe expansion”. It is shown that the deviations from the position characteristics of these models as a function of distance – the scale factor – are multiplicative. In the class of truncated distributions, estimates are obtained for convolutions of random and non-parametric non-excluded systematic components of the errors of inadequacy of scale models. The scale factors of the models for the random component of the truncated distributions were:

19.8% Cauchy with an offset of –9.40% with convolution boundaries [–89.5; +29.7]% for the Friedmann–Robertson–Walker model with zero curvature parameter; 16.4 % in Laplace at a bias of –0.85 % with convolution boundaries [–72.2; +48.8] % for an anisotropic model based on the Heckman approximation; 13.9 % Cauchy at an offset of 11.6 % with convolution boundaries [–48.7 %; +44.6 %] for the interpolation model.

In general, the “metrological and scientific impasse” turned out to be with a statistical aspect.

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ШКАЛА КОСМОЛОГИЧЕСКИХ РАССТОЯНИЙ: Фактор масштаба

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В 2017 году специалисты проекта Carnegie-Chicago Hubble указали на статистически значимое, более чем на 3σ, расхождение оценок, полученных по цефеидам “лестницы расстояний” $H_0 = 74 \pm 3$ км·с$^{-1}$·Мпк$^{-1}$ и данным измерений микроволнового фонового излучения: $H_0 = 67.3 \pm 1.2$ км·с$^{-1}$·Мпк$^{-1}$ [1]. Руководитель Hubble Space Telescope Key Project В. Фридман назвала эту ситуацию в космологии тупиковой [2], и выход из нее она видит в повышении до 1% точности шкалы внегалактических расстояний. На аналогичную динамику точности оценок фундаментальной гравитационной постоянной G,

которая в космологии играет не менее важную роль, обратили внимание еще в конце 20-го века. Тогда доверительные интервалы трех из четырех лучших определений G вообще не перекрывались, а в связи с анализом экспериментов по поиску нейтринных колебаний рассматривалась проблема «неправильных доверительных интервалов». Поэтому в 1998 г. Committee on Data for Science and Technology рекомендовал новое значение $G = 6.673(10)\cdot 10^{-11}$ м^3·с$^{-2}$·кг$^{-1}$. Это был "шаг назад" относительно значения 1986 г.: $6.67259(85)\cdot 10^{-11}$ м^{3}с$^{-2}$кг$^{-1}$. Далее в единицах 10^{-11} м^3·с$^{-2}$·кг$^{-1}$ последовало: $2008 - 6.67428(67)$; $2010 - 6.67384(80)$; $2014 - 6.67408(31)$. А в 2014 г. методом прецизионной атомной интерферометрии была получена неожиданная по точности оценка $G = 6.67191(99)\cdot 10^{-11}$ м^3·с$^{-2}$·кг$^{-1}$. Расхождение определений фундаментальной константы Т. Кинн из Международного бюро мер и весов на специальном заседании Британской академии наук назвал "метрологическим и научным тупиком".

В этой связи в докладе рассмотрена задача структурно-параметрической идентификации характеристик рассеяния модели Фридмана–Робертсона–Уокера и ее приближений в качестве моделей шкал космологических расстояний по данным о сверхновых типа SN Ia, которые были использованы при обнаружении "ускорения расширения Вселенной". Показано, что отклонения от характеристики положения этих моделей как функция расстояния – масштабный фактор – носят мультипликативный характер. В классе усеченных распределений получены оценки для сверток случайных и непараметрических неисключенных систематических составляющих погрешностей неадекватности моделей шкал. Масштабные факторы моделей по случайной составляющей усеченных распределений составили:

19,8% по Коши при смещении –9,40% с границами свертки [–89,5; +29,7]% для модели Фридмана–Робертсона–Уокера при нулевом параметре кривизны; 16,4 % по Лапласу при смещении –0,85 % с границами свертки [–72,2; +48,8] % для анизотропной модели на основе приближения Хекмана; 13,9 % по Коши при смещении +11,6 % с границами свертки [–48,7 %; +44,6 %] для интерполяционной модели.

В целом "метрологический и научный тупик" оказался со статистическим аспектом.

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Analysis of gravitational experiments

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A probabilistic analysis of the problem of detecting of metric perturbations during the merger of black holes (neutron stars) is carried out.

Estimates of the statistical noise characteristics of two Hanford (H1) and Livingston (L1) observatories are obtained. The correlation of the noises of two observatories according to the registration data of events GW150914, GW170814, GW170817 is established.

The detection of chirp signals is complicated by the presence of a multitude of glitches (more than 125 million during the registration of two LIGO observatories). To screen them, it is proposed to use tests that use the properties of chirp-signals.

The useful signals have an amplitude $\approx 10^{-21}$, which is 3 orders of magnitude lower than the noise level $\left(SNR \le 10^{-3}\right)$. To highlight weak useful signals, it is proposed to apply special methods of digital processing.

Анализ гравитационных экспериментов

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Проведен теоретико-вероятностный анализ задачи обнаружения возмущений метрики при слиянии черных дыр (нейтронных звезд).

Получены оценки статистических характеристик шумов двух обсерваторий Hanford (H1) и Livingston (L1). Установлена коррелированность шумов двух обсерваторий по данным регистрации событий GW150914, GW170814, GW170817.

Обнаружение чирп-сигналов усложнено наличием множества глюков (более 125 млн. за время регистрации двух обсерваторий LIGO). Для их отсеивания предлагается использовать тесты, использующие свойства чирп-сигналов.

Полезные сигналы имеют амплитуду $\approx 10^{-21}$, что на 3 порядка ниже уровня помехи $\left(SNR \le 10^{-3}\right)$. Для выделения слабых полезных сигналов предлагается применять специальные методы цифровой обработки.

Binary stars light curves interpretation using 3D hydrodynamical simulation

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The results of 3D hydrodynamical simulations of accretion flow in the eclipsing dwarf nova V1239Her and PHL1445 are presented. The model [1,2] contains the optical star filling its Roche lobe, a gas stream emanating from the inner Lagrangian point of the binary system, and the accretion disc structure. The cold hydrogen stream coming from L1 lagrangian point to accretor vicinity is modelled using Euler system of equations for compressible inviscid partially-ionized gas. The Roche gravitational potential, matter radiative cooling and binary star system rotation are taken into account in mathematical problem formulation.

The numerical scheme for governing equations solution is based on Runge – Kutta Discontinuous Galerkin method written for unstructured tetrahedral meshes. Well-known HLLC numerical flux [3] is adapted for calculations with non-perfect partially-ionized gas. The scheme algorithm is implemented in parallel solver for cluster computational systems. The solver is good scalable up to 500 processor cores.

The light curve of the system is calculated using obtained hydrodynamical solution as the volume emission of optically thin layers along the line of sight. The calculated eclipse light curves show good agreement with observations.

The work is supported by Russian Foundation for Basic Research (projets 18-31-20020, 18-01-00252).

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Exact models: symmetries of equations and spacetime

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We study exact models in spherically spherically symmetric spacetimes. There exist several solution generating algorithms for generating exact solutions to the Einstein field equations. Here we use the geometrical approach of Lie point symmetries to study the problem by finding the associated five-dimensional Lie algebra of symmetry generators. We find a general class of models containing vacuum models, constant density models, metrics with linear equations of state and the Buchdahl representation of the polytrope with index five. For a different particular symmetry generatorwe obtain a Riccati equation which admits particular solutions.In addition, some geometrical and physical properties are studied by considering conformal symmetries on the spacetime manifold.

Nucleus decay oscillations as possible quantum gravity effect

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Recently, several experiments reported temporary decay rate and life-time variations for alpha and beta-decay of heavy nuclei [1,2]. Beside standard exponential time dependence of nuclei decay rate, they found additional periodic terms of the order .05% corresponding to annual and daily decay rate oscillations. These results suppose that decay rate variation can be related to temporary l variation of Sun gravitation potential U in lab., resulting from elliptic form of Earth orbit and its daily rotation [1]. We argue that emergent gravity theory, in which gravity effects induced by scalar bilocal field Φ describe such effects consistently [3,4]. It's shown that Φ interaction with bilocal nucleus operators can influence its evolution in the similar way. For Gamow alpha-decay theory, such nonlinear Hamiltonian induces significant nucleus decay rate variations, which generally agree with experimental results for Po-214 alpha-decay [2].

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Modified Starobinsky inflation

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An extension of the Starobinsky model is proposed. Besides the usual Starobinsky Lagrangian, a term proportional to the derivative of the scalar curvature, $\partial_\mu R \partial^\mu R$, is considered. The analyzis is done in the Einstein frame with the introduction of a scalar field and a vector field. We show that inflation is attainable in our model, allowing for a graceful exit in the metric formalism. We also build the cosmological perturbations and obtain the leading-order curvature power spectrum, scalar tilt and tensor-to-scalar ratio. The tensor and curvature power spectrums are compared to the most recent observations from BICEP2/Keck collaboration. We verify that the scalar-to-tensor rate r can be expected to be up to three times the values predicted by Starobinsky model. For details see arXiv:1810.08911.

Black hole and dark matter. Phase equilibrium

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A possibility of equilibrium state of a gravitating scalar field inside a black hole, compressed to the state of boson matter, in balance with a longitudinal vector field (dark matter) outside is considered. Analytical analysis, confirmed numerically, shows that there are static solutions of the Einstein equations with no limitation on the mass of a black hole, in which the metric tensor component $g^{rr}(r)$ changes sign twice. One just has to abandon the tacitly existing opinion that the signature of the metric tensor remains unchanged even with the unlimited collapse of a black hole. The behavior of the gravitational field and material fields in the vicinity of these two

Schwarzschild radii has been studied in detail. The equality of the energy-momentum tensors of the scalar field and the longitudinal vector field at the interface supports the equilibrium of these phases. Considering the gravitating scalar field as an example, a possible internal structure of a black hole and its influence on the dark matter at the periphery of a galaxy are clarified. In particular, the dependence of the speed on the plateau of a galaxy rotation curve on the visible mass of a black hole is determined.

The space-borne gravitational wave detector TianQin: mission concept and realization

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TianQin is a space-borne detector of gravitational waves in the millihertz frequency range. The experiment relies on a constellation of three dragfree spacecraft orbiting the Earth. Inter-spacecraft laser interferometry is used to monitor the distances between the test masses. The initial goal of TianQin is a calibration which implies detecting a signal with high confidence from a single source of gravitational waves within a few months of observing time. We describe the preliminary mission concept for TianQin, including the candidate source and experimental designs. We present estimates for the major constituents of the experiment's error budget and discuss the project's overall feasibility. Given the current level of technological readiness, we expect TianQin to be flown in the second half of the next decade and will serve as a space-based observatory for a wide class of astrophysical sources of gravitational waves.

The work was supported by the Russian Foundation for basic Research (project no. 18-52-53018).

New approach to study the dynamical cosmic behaviour in extended gravity

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A new mathematical formalism has been developed to study the dynamical aspects of cosmological model in an extended gravity theory. We have adopted a simplified approach to obtain cosmic features, which in fact equires more involved calculations. The cosmological model is constructed in an extended theory of gravity by considering the functional $f(R,T) = R + 2\Lambda_0 + \beta T$, where Λ_0 is a constant. This model reduces to the usual General Relativity equations with a cosmological constant in the limit of a vanishing coupling constant β. A dynamically changing universe with a feature of early deceleration and late time cosmic acceleration is simulated through a hybrid scale factor (HSF). The parameters of the HSF are constrained from some physical basis to reproduce the transition redshift as obtained from different observational analysis. This HSF provides a good estimate of the deceleration parameter and the Hubble rate at the present epoch. Recently, there has been a belief that, we are at the peak of the cosmic acceleration and the universe is now slowing down. We have investigated such a feature of the universe employing the HSF and obtained that there is no such slowing down in recent past or recent future.

From some general expressions of the physical quantities, we have derived the expression of the equation of state parameter and the effective cosmological constant. The effect of anisotropy and the coupling constant β are investigated. It is observed that, with an increase in the coupling constant the equation of state parameter assumes a higher value. Anisotropy is observed to affect largely to the dynamics of the model. The equation of state parameter undergoes an increased rate of growth with an increase in the anisotropy. We anticipate, the present study will definitely put some light in the context of the uncertainty prevailing in the studies of the late time cosmic phenomena. The deceleration parameter and energy conditions have been obtained for the constructed model. Scalar fields have been reconstructed from the present model in the extended gravity. Different diagnostic methods have been applied to analyse the viability of the constructed model. The present model almost looks like a cosmological constant for a substantial cosmic time zone and does not show any slowing down feature in near future.

Vacuum and space-time signature in the theory of superalgebraic spinors

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Based on the superalgebraic representation of spinors, formulas for the Lorentz operators and gauge charge transformations of spinors are derived. It is shown that the condition for the existence of a vacuum imposes restrictions on possible variants of Clifford algebras: only real algebra with one timelike basis Clifford vector corresponding to the zero gamma matrix in the Dirac representation can be realized. In this case, the signature of the four-dimensional space-time, in which there is a vacuum state, can only be (1,-1,-1,-1), and there are two additional axes corresponding to the inner space of the spinor, with a signature (-1,-1).

Вакуум и сигнатура пространства-времени в теории супералгебраических спиноров

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На основе супералгебраического представления спиноров выведены формулы для операторов лоренцевских и калибровочных зарядовых преобразований спиноров. Показано, что условие существования вакуума накладывает ограничения на возможные варианты клиффордовых алгебр: может быть реализована только вещественная алгебра с одним времениподобным базисным клиффордовы вектором, соответствующим нулевой гамма-матрице в представлении Дирака. При этом сигнатура четырехмерного пространства-времени, в котором имеется вакуумное состояние, может быть только (1,-1,-1,-1), и имеется две дополнительные оси, соответствующие внутреннему пространству спинора, с сигнатурой (-1,-1).

About principal propositions of the special relativity theory

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We mean Einstein's postulates on the basis of which the special relativity theory (SRT) and in general a relativistic physics is founded by principal propositions of the special relativity theory (SRT).

The work purpose – to show that not everything is made in respect of comprehensive discussion of postulates. Not all arguments are adduced to disclose their logical interrelation, to remove an apparent inconsistency, to make them more clear and more evident. The reasonings which are pulling together the postulates with classical physics showing validity of their acceptance are given. Widespread mistakes in the description of some experiments are specified.

The following points are discussed:

1. The classical principle of relativity (PR). A strong argument in favor of generalization of the mechanical PR - there are no purely mechanical phenomena.

2. PR and the concept of a short-range interaction are compatible only if there is a finite invariant rate of transmission of interactions. The PR itself does not require this.

3. The postulate of constancy of the speed of light: a) chosenness of light velocity; b) covariance of Maxwell's equations; c) Lorentz transformations.

4. Classical law of a velocity addition. The contradiction between the classical law of addition and constancy of light velocity is removed.

5. V. de Sitter's proof of constancy of speed. The mistake which is often found at statement of this proof significantly reduces all its significance.

6. Experience with round-the-world clocks doesn't grant permission a paradox of twins, and only confirms dependence of the rate of clocks on gravitational field.

Kinetic scalar curvature extended f(R) gravity

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The general formalism for the kinetic scalar curvature extended $f(R)$ gravity has the following action

$$S = \int d^4x\sqrt{-g}\left(X\left(R\right)R_{,\sigma}R^{,\sigma} + f\left(R\right)\right) + S_{matter} \quad (1)$$

where $X\left(R\right)$ and $f\left(R\right)$ are differentiable functions of the Ricci scalar, and S_{matter} stands for the action. We have shown that the corresponding field equations are

$$A_\nu^\mu X + B_\nu^\mu X' + C_\nu^\mu X'' + F_\nu^\mu X''' - \frac{1}{2}\delta_\nu^\mu f + f' R_\nu^\mu + \left(\delta_\nu^\mu \Box - \nabla^\mu\nabla_\nu\right) f' = \kappa T_\nu^\mu, \quad (2)$$

where the A_ν^μ, B_ν^μ, C_ν^μ, F_ν^μ tensors are made from combination of the Ricci scalar and it's derivatives, and primes denote derivation with respect to the Ricci scalar. It is possible to solve (2) for the FRW metric for particular cases such as de Sitter and power law evolution.

Using the formalism proposed in Ref. [1] we get the equivalence of the theory at hand with a scalar-tensor theory with the following action

$$S_{ST} = \int d^4x\sqrt{-g}\left(\psi R - U\left(\psi, \varphi_\mu, \nabla_\mu\varphi^\mu\right)\right) + S_{matter} \quad (3)$$

with the scalar potential U

$$U\left(\psi, \varphi_\mu, \nabla_\mu\varphi^\mu\right) = \xi\left(\psi + \nabla_\mu\varphi^\mu\right) - f + \frac{\varphi^\mu\varphi_\mu}{4X} \quad (4)$$

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Geometrical interpretation of time and new formulation of the general theory of relativity

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The new geometrical model for the space of events of special relativity is suggested on the base of geometrical interpretation of time. Instead of pseudo Euclidean Mincowski space the space of events is considered as a real four dimensional affine space, where time is defined as a length of geodesic lines of this space and where the Lorentz transformations appear to be the group of automorphisms of the space. This means that the surrounding three dimensional space is not Euclidean one, and it may be considered as Euclidean space only for motions with not relativistic velocities. Within the suggested model existence of the limiting velocity of motions and specific effects of special relativity (reduction of time and length) are consequences of affine geometry of the space-time. New geometrical representation of the space of events leads to changes in mathematical

formulation of general theory of relativity. Solution of new equations coincides with the known results for motions with not relativistic velocities in weak constant gravitational field.

Anisotropic Tilted Spherical False Vacuum Model

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In this paper, a tilted spherically symmetric cosmological model with perfect fluid distribution along with heat conduction has been considered. To get a generalized solution, I have assumed the model to be False Vacuum (i.e. $p+\rho=0$), where ρ being the isotropic pressure and is the matter density of the fluid. The various physical properties of the model are also discussion as the concluding remark.

Entanglement entropy in strongly correlated systems dual to anisotropic gravitational models

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Experiment results show that the quark-gluon plasma (QGP) in the RHIC experiment exhibits strong coupling dynamics which does not have a proper description in terms of standard perturbative methods. Another difficulty in description of QGP is the anisotropy. We use the holographic approach to description QGP, which has been widely used for the description of plasma transport and thermalization. We continue studying the holographic model proposed by I. Arefyeva and K. Rannu which is the gravitational theory dual to the anisotropic field theory defined by the Einstein-Dilaton-two-Maxwell action. The main focus of our work is the description of entanglement in the anisotropic holographic model. The entanglement entropy can be useful to probe correlations in the background measuring an entanglement of a quantum system. In this model we investigate the behavior of the entanglement entropy near criticality. Our main goal is to relate QGP observables such as multiplicity and its angular dependence with entanglement characteristics of the model.

Basic properties of the time field

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In papers [1,2] it is shown, that the time can be consider as the scalar potential, closely related with the wave equation and its extensions, such as Poisson, Helmholtz, Klein-Gordon equations. In the corresponding model the pace of time, in general case, has not constant value, but substantially depends on external conditions. Meanwhile the following of Einstein's equations dependence of the speed of time on the presence or absence of gravitational bodies is not unique way to cause acceleration or deceleration of time. There seem to be much less exotic ways to change the speed of time, at least locally.

In this report it is suggested two principal ways to control of the pace of time. The first way is connected with the creation of powerful mechanical shocks. After its realization laboratory quartz clock demonstrate the frequency deviation from own base frequency, registered without shocks, in the vicinity of a few meters from the point of impact for about one millisecond. In this case, it is shown, that deviation is not result of spreading of usual shock wave in air and solid.

The second way is connected with idea of realization of fast-flowing electromagnetic pulse with certain parameters. This process as it's shown by received equations can lead to focus background time in the certain space-time point (in this case it's quoted the formula, which is analog of the formula of calculus focal length for thin optical lens), in which there is extreme value of many physical parameters, among them, creation of new substance nuclei.

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Основные свойства поля времени

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В работах [1,2] было показано, что время можно рассматривать как скалярный потенциал тесно связанный с релятивистским волновым уравнением

и его расширениями, наподобие уравнений Пуассона, Гельмгольца, Клейна-Гордона и др. В соответствующей модели темп времени в общем случае не является постоянной величиной, а в определенной степени зависит от внешних условий. При этом следующая из уравнений Эйнштейна, зависимость скорости течения времени от наличия или отсутствия гравитирующих тел - не единственный способ вызвать замедление или ускорение времени. Похоже, существуют на много менее экзотические способы изменить скорость течения времени, во всяком случае, локально.

В данном докладе предложены два принципиальных способа управления течением времени и оба они проверены в лабораторных условиях. Первый способ связан с созданием мощных механических ударов. После его производства, в окрестности нескольких метров от точки удара в течение примерно одной миллисекунды, лабораторные кварцевые часы показывают отклонение собственной частоты от базовой, регистрируемой в отсутствии внешних ударных возмущений. При этом показано, что данное воздействие не является следствием распространения обычной ударной волны в воздухе или в твердом теле.

Второй способ связан с идеей реализации быстропротекающего электромагнитного импульса с определенными параметрами. Данный процесс, как предсказывают полученные уравнения, может приводить к фокусировке фонового времени в одну конкретную пространственно-временную точку (при этом приводится формула, аналогичная формуле расчета фокусного расстояния для тонкой оптической линзы), в которой наблюдаются экстремальные значения многих физических параметров, в том числе, возникновение новых ядер вещества.

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Penrose effect in the rotating coordinate system

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It is shown that the observer using uniformly rotating coordinates in flat space-time will observe effects similar to those observed in the vicinity of the rotating black hole: the existence of the surface out of which no unmovable objects are possible and

particles with zero and negative energies are present [1]. This surface plays the role of the static limit in the ergosphere of the black hole and the Penrose effect is possible in the region out of it. The example of the situation when one of the particles being the result of the decay of some particle on two particles out of the static limit is moving with the energy larger than the initial particle and is registered inside the static limit is considered. Limitations for the relative velocity of the decay products in the Penrose process in rotating coordinate system are obtained. The problem of the definition of the energy in the noninertial reference frame is considered. Particle states with minimal energy in the rotating reference frame are found and the relation of this energy to the tangent Doppler effect of the shift of the radiation frequency is considered.

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Эффект Пенроуза во вращающейся системе координат

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Показано, что для наблюдателя, использующего равномерно вращающиеся координаты в плоском пространстве-времени возникают эффекты, подобные случаю вращающейся черной дыры: появляется поверхность, вне которой никакое тело не может быть неподвижным, а энергия частиц может быть равной нулю или отрицательной [1]. Вне этой поверхности, аналогичной пределу статичности для вращающейся черной дыры, возможен эффект, подобный эффекту Пенроуза. Рассмотрен пример, когда один из осколков частицы, распавшейся на две вне предела статичности, прилетает во вращающуюся систему отсчета внутри предела статичности и имеет энергию, большую энергии исходной частицы. Получены ограничения для относительной скорости продуктов распада в процессе Пенроуза во вращающейся системе координат. Рассмотрен вопрос об определении энергии в неинерциальной системе отсчета. Для равномерно вращающейся системы отсчета рассмотрены состояния частиц с минимальной энергией, показана связь этой величины со сдвигом частоты излучения вращающегося тела при поперечном эффекте Доплера.

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On properties of constant curvature black holes in the Einstein-AdS gravity

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The results of two papers by Guilleminot P., Olea R. and Petrov A.N. [Constant curvature black holes in Einstein-AdS gravity: I. Constant curvature black holes in Einstein-AdS gravity: Conserved quantities, *Phys. Rev. D*, **95**, 124039 (2017); II. Euclidean action and thermodynamics, *Phys. Rev. D*, **97**, 064046 (2018)] are presented. The constant curvature black holes (CCBHs) are geometrical objects in D dimensions which locally are equivalent to the anti-de Sitter (AdS) space although globally they differ from the usual AdS space. The CCBHs are constructed by special identifications in the usual D-dimensional AdS space analogously to construction of BTZ black holes in 3 dimensions. The BTZ black holes are interesting because they have properties of usual BHs in dimensions $D \geq 4$. Indeed, they have well defined mass, angular momentum and thermodynamic properties. In last decade, some publications appeared where analogous properties are defined for the CCBHs in D dimensions. We demonstrate that such results are wrong in dimensions $D \geq 4$.

The topology of the CCBHs for $D \geq 4$ does not permit to use the standard methods in definition of conserved quantities. The reasons are in the following: for CCBHs there is no a limit when the horizon radius goes to zero; the horizon itself has the topology of the circle – one-dimension object; etc. In our study, we use the technique of counter terms without using background structures that has been elaborated for asymptotically locally AdS solutions. It is based on specially regularized action. We show that always in dimensions $D \geq 4$ CCBHs have zero mass and zero other conserved quantities. For the case of odd dimensions the energy is divided onto two parts: the energy itself and the Casimir energy. It turns out that for the CCBHs the last cannot be interpreted as physically permissible. Thus such objects, like CCBHs, are not observable.

Concerning the thermodynamic properties we have shown that the CCBHs have no them at all. Indeed, 1) in a classical notion the entropy is connected directly with the horizon square, whereas for CCBHs the horizon is a circle only; 2) because locally CCBH at every point is equivalent to AdS space it is impossible to define gradients at the horizon, that is impossible to define the black hole temperature and

black hole evaporation by Bekenstein's and Hawking's prescription. We support this result after rewriting the regularized action in the Euclidean version (the Helmholtz free energy) and analyzing it.

On the "Special" Relativity Genesis: Russian Connection

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In this talk I present an account of an important contribution to the proper and most general formulation of the relativity theory made in 1910-11 by the Russian physicist Vladimir Sergeyevitch Ignatowski. The analysis of his papers is supplemented by the

Formatting physical fields and pseudometric manifolds. The dark matter

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It is shown that from the equations of conservation laws for energy, linear momentum, angular momentum, and mass, which are conservation laws for material media (such as thermodynamic, gas dynamical, cosmological systems, systems of charged particles, systems of elementary particles and others), it follows the evolutionary relation. This relation, which appears to be nonidentical due to the noncommutativity of conservation laws, describes the evolutionary processes proceeded in material media and accompanied by the origination of physical structures. The physical fields and relevant manifolds are formed by such physical structures. Since, due to the noncommutativity of the conservation laws, the nonpotential inconsistent external actions upon material medium do not converge into the quantities of the material medium itself, this leads to the appearance of immeasurable quantities in the material medium. As it is shown, under realization of any degrees of freedom of material medium (to what the degenerate tansformation corresponds) the nonmeasurable quantity locally partly converts into observable and measurable formations and physical structures forming physical fields and corresponding manifolds. However, since this occurs only locally, only a part of measurable quantity converts into physical structures. This means that a certain

nonmeasurable quantity remains in material medium. The dark energy and dark matter are such nonmeasurable and nonobservable quantity (essence) that emerges due to various nonpotential actions and, because of the noncommuativity of conservation laws, cannot directly convert into own quantities of material medium.

Reducing Optical Coating Thermal Noise in Interferometric Detectors of Gravitational Waves

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The relevance of thermal noise in the high-reflectance optical coatings of interferometric detectors of gravitational waves is discussed. The milestones of coating thermal noise physics are highlighted, in a historical perspective. The status of optical coating technology for gravitational wave detectors is presented, and current research trends are summarised, including yet unanswered questions, and possible/proposed mid- and far-term options.

Stable Compact Objects from Dark Matter in Planetary Systems

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Within the framework of the standard cosmological model, the dynamics of the Universe are essentially determined by the gravitational interaction of the Dark Matter (DM). However, it has not yet been possible to detect individual particles of DM in experiments. In this paper, possible values of the masses and radii of stable compact objects from DM particles are estimated and discussed. It is shown that as a result of some specific interactions of such objects with the planets or the central star, these DM objects could manifest themselves in astrophysical data.

High frequency gravitational waves generation by optical method

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The task of establishing the conditions for the generation and detection of high-frequency gravitational waves in material media under laboratory conditions is considered. An important advantage of the high-frequency parametric process of detecting gravitational waves, compared with the known method based on detection of low-frequency (10-100 Hz) mechanical oscillations of stars, is the factor of the sixth degree of frequency in the formula for the intensity of gravitational radiation.

The possibility of detecting high-frequency gravitational waves in the laboratory, planned for research, is based on the use of intense pulsed laser light sources as excitation radiation. The sources make it possible to record the radiation at the tripled frequency in dielectric media and in photonic crystals. It is supposed to use lasers that provide the possibility of generating ultra short, i.e. picosend and femtosecond, pulses of light radiation with wavelengths in the region of one micron or 0.5 micron, for which the third optical harmonic corresponds to the visible or ultraviolet range suitable for detection by sensitive radiation receivers. The conditions for the observation of two-photon-excited photoluminescence in condensed dielectrics are analyzed, during which at the first stage two-photon absorption occurs in a dielectric medium with the formation of real states in crystals whose symmetry coincides with the symmetry of gravitational waves. At the second stage, the process of adding the frequencies of the exciting radiation and the two-photon state with the generation of radiation at the frequency of the third optical harmonic is carried out.

Stability of mix fluid cosmological models with dark energy anisotropy and an advanced diagnostic analysis

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This work aims to give an insight to the role of anisotropic components on dark energy (DE) and dynamics of the universes in different two-fluid environments. We have constructed the Bianchi type-V model of universe with a newly developed mathematical formalism in various two-fluid situations, such as: usual DE fluid +

bulk viscous fluid, DE fluid + one dimensional string fluid and DE fluid + electromagnetic fluid. In each case, the DE fluid is assumed with different pressure along orthogonal spatial directions to incorporate the effect of anisotropy. A small amount of anisotropy is also contributed by the three matter sources (viscous, string and electromagnetic fluid) either in each case. We have considered a hybrid scale factor that simulates the cosmic transition and based on the coefficient values of these three different sources of matter. The physical parameters (DE density, equation of state parameter, skewness parameters etc.) are derived, analysed and found to be in agreement with recent observational data. In order to yield a healthy comparison among these two-fluid situations, a brief stability analysis is carried out w.r.t situation followed by DE fluid. For each case, we found, there is instability in early time and stability at late epoch. Also, this work clearly compares the effect of magnetized fluid w.r.t other two fluids according to cosmic evolution, along with DE fluid. We observe that at early phase of evolution, the anisotropic effect due to the sources of matter substantially dominate the dynamics of the universe, whereas, the late epoch is completely filled and driven by DE fluid. Also, the electromagnetic fluid has found to be more dominant among other two during early epoch. Finally the geometrical nature and physical acceptability of the model is confirmed by *Om* diagnosis. This diagnostic is used to distinguish the Λ - CDM model from our DE model. We also demonstrate that *Om* is a useful diagnostic to apply observational data.

One Hundred Years of Weyl's (unfinished) unified field theory

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In 1918, H. Weyl proposed a unified theory of gravity and electromagnetism based on a generalization of Riemannian geometry. In spite of its elegance and beauty, a serious objection was raised by Einstein, who argued that Weyl's theory was not suitable as a physical theory. According to Einstein, the theory led to the prediction of a "second clock effect", which has not been observed by experiments as yet. We briefly revisit this point and argue that a preliminary discussion on the very notion of proper time is needed in order to consider Einstein's critical point of view. We also point out that Weyl theory is basically incomplete in its original version and its completion may lead to a rich and interesting new approach to gravity.

Gravity: Local or Nonlocal

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Gravity is generally assumed to be a local gauge theory like the other three fundamental forces but no one has been successful so far in creating the quantum version that this would imply. The main difficulty seems to lie in the fact that gravity requires an attractive force between identical particles with corresponding spin 2 boson, where the other gauge theories require a repulsive force with spin 1 boson. Gauge theories with spin 1 bosons are renormalizable, whereas those with spin 2 bosons are not, leading to unrenormalizable infinities in the quantum field integrals. The assumption that gravity is intrinsically a local theory arises from the success of general relativity in predicting a whole series of relativistic consequences, including perihelion precession, light deflection, time delay, redshift, gravitomagnetic effects and gravitational waves. Local and nonlocal are not separate concepts, however. Each implies the other. Quantum theories may start off using a local description, for instance, but they end up predicting a series of nonlocal consequences. And some phenomena with a clearly nonlocal origin can have massive local consequences, as Pauli exclusion does in the case of the structure of matter and the lifetime of stars. The clear relationship between local and nonlocal interpretations is evident in the author's own nilpotent representation of relativistic quantum mechanics. It is also clear from this representation that the kind of negative energy and attractive forces associated with gravity are aspects of vacuum nonlocality rather than of discrete locally described particle states. In addition, there is a strong indication of gravity / gauge theory correspondence between the four interactions, and a local / nonlocal connection between gravity and inertia. All these indications suggest that gravity might be considered initially using a nonlocal description leading to a localised (repulsive) force of inertia in contrast to the local description leading to nonlocal vacuum effects which we find in the three known gauge forces. In this description, the experimental consequences of the general relativistic field equations will exactly as predicted, but the equations will not break down in strong fields, as many theorists currently imagine. Among other effects (as already predicted) there will be an inertial 'dark energy' making up 67 % of the total energy of the universe.

Space gravitational experiments with quantum standards of frequency and time

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Space-based experiments with quantum standards of frequency and time offer an interesting opportunity to test various aspects of the Einstein Equivalence Principle (EEP). One of the cornerstones of general relativity and the EEP is the gravitational time dilation effect, or the gravitational redshift. The most accurate redshift tests to date were performed by the NASA/SAO Gravity Probe A rocket mission and the European GREAT experiment with the Galileo 5 & 6 satellites. A similar experiment was performed with the RadioAstron satellite of the RadioAstron space very-long baseline radio astronomy mission. The results obtained so far are consistent with the EEP at the level of accuracy of $\sim 10^{-4}$.

Космические гравитационные эксперименты с квантовыми стандартами частоты и времени

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Космические эксперименты с квантовыми стандартами частоты и времени предлагают интересную возможность проверить различные аспекты принципа эквивалентности Эйнштейна (ЭПЭ). Одним из краеугольных камней общей теории относительности и ЭПЭ является эффект гравитационного замедления времени или гравитационного красного смещения. Наиболее точные тесты эффекта на сегодняшний день были выполнены с помощью ракетной миссии “Gravity Probe A” и европейского эксперимента GREAT со спутниками Galileo 5 и 6. Аналогичный эксперимент был проведен со спутником РадиоАстрон. В докладе будет представлена схема эксперимента и текущее состояние обработки данных. Полученные результаты согласуются с ЭПЭ на уровне точности $\sim 10^{-4}$.

The redshift function of traversable wormholes in f(R;T) gravity

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We propose, as a novelty in the literature, the modelling of wormholes within the particular case of the $f(R,T)$ gravity, namely $f(R,T)=R+\lambda T$, with R and T being the Ricci scalar and trace of the energy-momentum tensor, respectively, while α and λ are constants. Although such a functional form application can be found in the literature, those concern to compact astrophysical objects, such that no wormhole analysis has been done so far. The linear geometric and material corrections of this theory make the matter content of the wormhole to remarkably be able to obey the energy conditions.

Nano Hertz Gravitational Waves: Detectors and Sources

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The complexity of the cosmological scenario regarding cosmic strings (CSs) stands still in the way of a complete understanding. I describe here a promising strategy for the possible detection of these elusive physical entities. It is based on the search of strong gravitational lensing events in the location area of the CS candidate (CSc-1), which was found in the CMB data by step-like function filtration procedure. Using photometric and geometric criteria, there were identified pairs of candidates of lensed galaxies (LGCs) in the 'string field' (SF), which were then compared with the average density of background galaxy pairs in a set of 'control fields'. It was found an excess of 22 per cent (per deg2) of the LGCs in SF, which exceeds the estimated cosmic dispersion. It was also found that the number of LGCs is in excess of 29.2 per cent in the angular separation bin [8, 9 arcsec]. It was analysed the possibility of a preferred orientation of the line connecting the centres of the LGCs. The orientation is statistically significant for an angular separation bin [4, 6 arcsec]. Therefore, it was found two 'windows' for the preferred angular separation for LGCs along the possible CS. However, the confirmation of the gravitational lensing origin of our LGCs requires spectroscopic observations that seem to be justified by the present results. It was planned to acquire their spectra and to continue the study of the spectral and morphological features of the LGCs in the CSc-1 field and to analyse the

other CS candidates using the same strategy. Finally, it was estimated the gravitational waves' radiation from CS-candidates similar to CSc-1 and their possible contribution into generation of the B-mode polarization of the CMB.

Emergency seismic sensing method of asteroid structure

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The problem of emergency choice of measures in order to protect the Earth from a large celestial body with high kinetic energy is considered. The asteroids of the Solar System are moving at a speeds of 10 - 20 km/s relative to the Earth. The speed of asteroids and comets that enter the Solar System from other star systems and neighboring galaxies is determined by their origin and reaches 300 km/s. A direct hit of a body with size from kilometer across is fatal threat to life on Earth. Larger space objects can provoke disasters at a distance.

Information on the internal structure of a dangerous space object is necessary for choosing the means of preventing a catastrophe. It can be an ice or rock block, a composite of stones and ice, a metal asteroid, etc. The problem is enhanced by the identification difficulty of such objects; especially when they approach the Earth from the side of the Sun. As a result, there is a severe time limit for studying the structure of the body and determining the associated danger, choosing the method for eliminating the threat and its implementation. Therefore, an urgent sounding of a celestial body is necessary.

The paper proposes a method of emergency seismic sensing of the structure of a space body by a high-speed drummer. The shell includes a drummer, a set of sensors and a seismic trace analyzer. A high-speed drummer excites seismic waves in a space body, recorded through a sensor system by a puller - an analyzer that processes information on a span. The structure of the investigated body is restored on the basis of the information obtained by computed tomography methods.

Метод экстренного сейсмического зондирования структуры астероида

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В докладе рассмотрена проблема экстренного выбора мер по защите Земли от крупного небесного тела, обладающего высокой кинетической энергией. Астероиды Солнечной системы движутся со скоростью 10 – 20 км/с относительно Земли. Скорость небесных тел – астероидов и комет – попадающих в Солнечную систему из других звездных систем и соседних галактик определяется их происхождением и достигает 300 км/с. Фатальную угрозу жизни на Земле несут плотные небесные тела размером от километра в поперечнике – при прямом попадании. Более крупные космические объекты способны спровоцировать катаклизмы на расстоянии.

Для выбора средств предотвращения катастрофы необходима информация о внутреннем строении опасного космического объекта. Это может быть ледяная или каменная глыба, композит из булыжников и льда, металлический астероид и т.д. Проблема усугубляется сложностью выявления таких объектов; особенно – при их подлете к Земле со стороны Солнца. Как следствие – жесткое ограничение времени для исследования структуры тела и определения связанной с ним опасности, выбора метода устранения угрозы и его реализации. Поэтому необходимо экстренное зондирование небесного тела.

В работе предлагается метод экстренного сейсмического зондирования структуры космического тела высокоскоростным ударником. Снаряд включает ударник, комплект датчиков и съёмник – анализатор сейсмической трассы. Высокоскоростной ударник возбуждает в космическом теле сейсмические волны, регистрируемые через систему датчиков съёмником – анализатором, обрабатывающим информацию на пролете. Структура исследуемого тела восстанавливается на основе полученной информации методами компьютерной томографии.

Anisotropic Solutions and Minimal Geometric Deformation

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This paper investigates exact models for spherically symmetric anisotropic matter distribution in 2+1-dimensions via gravitational decoupling approach. For this purpose, we choose known spherical solutions with perfect fluid in the absence as well as the presence of cosmological constant and extend them to anisotropic models by imposing a constraint on matter components. The physical viability and stability of our developed solutions are investigated through graphical analysis of density, radial/tangential pressure, energy conditions, and causality criterion. It is found that both solutions are stableand satisfy all the physical requirements for the feasible choice of the model parameters.

LCFT and Liouville theory

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Logarithmic conformal field theories LCFT are two-dimensional conformal field theories with logarithmic terms in operator product expansion OPE [1]. Logarithmic terms appear because of some primary operators have degeneration for conformal dimensions. Most famous example of such theory is $c=-2$ model. This model describes the system of ghosts with conformal dimensions 0 and 1. Also LCFT appear at WZWN model for some (super)groups and some levels k. Caux, Kogan and Tsvelik [2] had remarked that in Liouville model some primary operators consist LCFT. We will discuss LCFT for some generalizations of Liouville model: Super-Liouville theory and Sine-Liouville theory. Remarkable that Sine-Liouville theory describes two-dimensional black hole (the Witten cigar) [3].

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Non-local imprints of gravity on quantum theory

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The implementation of minimum length in quantum mechanics (QM) can be done either by modification of position and momentum operators or by restriction of their domains. In the former case the resulting classical dynamics is drastically different from the usual one. Starting with the latter possibility, we propose a non-local modification of QM. It has close ties to the band-limited QM, but in contrast to it one can easily work out the corrections to various processes and discuss further the semi-classical limit of the theory. Surprisingly enough, the classical limit proves again to be unacceptably altered. In the last section a further modification is suggested to alleviate this problem.

Exact solutions of some anisotropic models

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We obtain the general solutions of the field equations of some anisotropic cosmological models including LRS Bianchi I model, Bianchi V model and five-dimensional Kaluza-Klein model with perfect fluid equation of state. We present a unified and systematic treatment by solving the field equations in a straight forward manner. The models filled with dust, vacuum energy and Zel'dovich stiff matter are studied in detail. The models describe early decelerated phase and late-time accelerated phase as well with suitable values of equation of state parameter.

Registration of gravitational waves emitted by periodic astrophysical sources and the prospects for GW-astronomy

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All the efforts to directly detect GW, including the recent successes of the LISA and VIRGO teams, are focused on registering the catastrophic events in deep space. The two main features of this activity are the unpredictability of these events and the extreme sensitivity of the necessary equipment.

The principally new method of the GW detection is based on the effect of optic-metrical parametric resonance (OMPR) and does not require catastrophic events and supersensitive equipment. A close binary star emits periodic GW that act on a distant astrophysical maser. When certain conditions are met, the maser radiation acquires a specific non-stationary component. Therefore, the effect of GW can be recorded by a conventional radio telescope. The effect of OMPR was predicted theoretically [1,2] and constitutes the following. When a strong resonant electromagnetic wave acts on a gas consisting of "two-level atoms," (TLA) their population changes with the Rabi frequency, which is proportional to the field intensity. If the atoms oscillate mechanically with a frequency proportional to the Rabi frequency, a parametric resonance occurs, and the scattered radiation contains a non-stationary component, corresponding to periodic amplification and attenuation of the signal. Its amplitude does not depend on the amplitude of atomic vibrations and has the same order as the amplitude of the main maser signal. The TLA model is perfect for describing the dynamics of the atoms and molecules of astrophysical masers. Oscillations mean a change in the distance between the atoms and the receiver. This happens when a periodic GW emitted by a close binary star system passes through a maser. The conditions imposed on the astrophysical system are analyzed in [3]. Fluctuations of masers' intensity have various characteristic times and are usually interpreted in connection with the activity of the maser host star. However, if only one component in the observed maser spectrum varies periodically with a period of the order of tens of minutes, no other interpretation than the OMPR effect associated with the GW action is possible to suggest. The first results of such observations were presented in [4]. 149 observation sessions of 49 radio sources were conducted on the RT-22 radio telescope in the Pushchino Observatory of the RAS. The program of signal processing includes the identification of periodic components in the maser spectrum, the elimination of artifacts associated with the observation procedure, and the determination of the frequencies of periodic components [5]. The results of maser sources observations in which the OMPR effect associated with the GW action is manifested, are presented in [6], the corresponding binary stellar systems are also identified and given there. Thus, close binaries become a kind of GW-beacons,

distributed in the sky. This gives rise to the GW-astronomy, provides obvious applications for stellar navigation and gives a clue to the study of the geometric structure of our galaxy.

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Inflation: the present status and future perspectives

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Outlined are the two simplest classes of phenomenological models of slow-roll inflation in the early Universe based either on scalar fields in General Relativity or on modified $f(R)$ gravity, their relation and basic assumptions necessary for their realization. At the present state-of-the-art, the simplest inflationary models from these classes producing the best fit to all existing astronomical data requires one, maximum two dimensionless parameters taken from observations only. It is shown that inflation in $f(R)$ gravity represents an intermediate dynamical attractor for slow-rolling scalar fields strongly coupled to gravity. The main discoveries expected for these models in future are discussed, too. Among them the most fundamental are primordial quantum gravitational waves generated during inflation. It is argued that the measured value of the slope $n_s - 1$ of the primordial scalar power spectrum, under the additional assumption of the absence of new fundamental scales both during and after inflation, implies small, but not too small tensor-to-scalar ratio $r \sim 3(1-n_s)^2 \sim 0.004$ or even more, similar to that in the original $R + R^2$ inflationary model (Starobinsky, 1980). Another possible discovery is related to small local features in the CMB temperature anisotropy power spectrum in the multipole range $l = (20-40)$ beyond which new physics during inflation may be hidden. Also considered is the onset of inflation from generic anisotropic curvature singularity preceding it in GR and $f(R)$ gravity, and which conditions are needed for it. Since this process is generic, too, for inflation to begin inside a patch including the observable part of the Universe, causal connection inside the whole patch is not

necessary. However, it becomes obligatory for a graceful exit from inflation in order to have practically the same number of e-folds during inflation inside this patch.

Cosmological perturbations during the kinetic inflation in the Horndeski theory

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The Horndeski theory is the most general scalar-tensor theory of gravity with second-order field equations. A particularly interesting subclass of Horndeski models is that with the scalar field φ possessing the nonminimal kinetic coupling to curvature given as $\eta G^{\mu\nu}\varphi_{,\mu}\varphi_{,\nu}$. A very important feature of the model is that it provides an essentially new inflationary mechanism without any fine-tuned scalar potential. Namely, at early cosmological times the domination of coupling terms in the field equations guarantees the quasi-De Sitter behavior of the scale factor: $a(t)\propto e^{H_\eta t}$ with $H_\eta = 1/\sqrt{9\zeta}$. This type of cosmological evolution is called a kinetic inflation. We present a systematic analysis of cosmological perturbations during the kinetic inflation.

Space-Frame Periodic Table Representation System Testing Relativity in Nucleosynthesis of the Elements

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The geometric Lie algebra $SO(3)$ isotropic vector matrix realization of the periodic table octet truss space-frame reported at PIRT 2017 has now been broken up to a disjoint-set modular $R3\times SO(3)$ building kit of its lattice elements, exactly sufficing to stage the Big Bang and ensuing nucleosynthesis events: First erupts the ultrashort radiation/plasma inflation of the Big Bang phase transition moment with release of photons, neutrinos and module precursors, which in next seconds can recombine to the Protium proton/electron β particle compound and its neutron conversion to continue separately or in fusion of the two get on to Deuterium and from there completing the chain to Tritium, Helium in isotope and α form, and traces of Lithium plus possibly Beryllium. That is, literally the whole primordial start-gas

delivered within a few minutes to billion-year wait for sufficiently energetic perturbations with itself for astrophysical/cosmogenic/experimental nucleosynthesis of the full periodic table as now going on in the universe and likewise replicable by systematic space-filling assembly/disassembly of the here disclosed neutrino and photon lattice vector, β particle, α wave-packet and neutron building bricks, providing distinct clues also on isotope/neutron excess, shell/subshell, spectroscopy, and chemical bond structural make-up and disposition, and well suited for direct material, graphical and computer implementation. Furthermore, the absolute trigonometric sharpness of the nucleosynthesis phase transition burst and expansion is reciprocal to the absolute speed of light and hence a specific test and verification of the relativity theory.

Bouncing Models in Extended Gravity Theory

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Some bouncing models are investigated in the frame work of an extended theory of Gravity. The extended gravity model is a simple extension of the General Relativity where an additional matter geometry coupling is introduced to account for the late time cosmic speed up phenomena. The dynamics of the models are discussed in the background of a flat FRW universe. Some viable models are reconstructed for some assumed bouncing scale factors. The behavior of the models is found to be decided mostly by the parameters of the respective models.

Approach to the gauge theories for massive fields in the extended space model

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One of the most effective methods of constructing theories of interaction of elementary particles is the theory of gauge fields. With its help, it was possible to construct quantum electrodynamics, as well as the theory of electroweak interactions. An important point in the construction of quantum electrodynamics is that the gauge field (photon) has a zero mass.

In the case of weak interactions vector bosons with non-zero mass serve as a carrier of interaction. In order to use gauge formalism, it is assumed that initially these bosons have zero mass, and then acquire it due to a spontaneous violation of the symmetry of the vacuum state.

In the 5-dimensional Extended space model (ESM) [1-5] particles that have zero mass in empty space acquire nonzero mass due to interaction. In the ESM the formalism of such process of nonzero mass origin is described by means of symmetry transformations of the Extended space E(4,1). This allows us to develop a gauge theory of interactions for massive gauge fields. Also in the ESM one can formulate a physical approach to understanding the process of localization of elementary particles, the reduction of the wave packet and renormalization procedure. In the empty of Minkowski space a plane wave with infinite dimensions meets the photon. If the photon begins to interact with some external object, particle, or field, the infinite plane wave is reduced to a finite size, and it has a nonzero mass. The values of these dimensions and masses are determined by the magnitude and nature of the interaction. In this case, both the cutting parameter and the particle masses obtain an invariant interpretation, which is not the case in the usual Lorentz invariant theory. Also in the ESM “virtual” particles acquire real physical meaning.

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The analysis of CMB anisotropy in temporary domain according to databases of the probes WMAP and PLANCK

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The temporary jumps of temperature anisotropy of CMB found in data of the probe "PLANCK" are described in [1]. These data are distributed on $n = 12582912$ to the directions of the celestial sphere. Data are integrated on eight semi-annual measuring cycles. The differences between values of anisotropy of adjacent measuring cycles form the jumps reaching 6% of swing of anisotropy. Jumps can be as positive that corresponds to growth of temperature anisotropy, and negative that corresponds to its decrease. Jumps observed in the same directions of the celestial sphere at various frequencies of CMB of 30, 44 and 70 GHz. Statistical probability that the revealed jumps will arise at all three frequencies in a random way appeared the significantly smaller of probability of detection of these jumps in experimental data. Frequency independence of jumps allows assuming that jumps are caused by a gravitational lensing of CMB.

This research considers jumps of anisotropy of CMB for probes "WMAP" and "PLANCK" from common positions. Angular permission of the database of the probe "WMAP" corresponds to angular permission analyzed earlier for the probe "PLANCK". Data of the probe "WMAP" also are integrated. They correspond to nine year measuring cycles, executed at frequencies of 23; 33; 41; 61 and 94 GHz.

The general statistical criterion of identification of frequency-independent jumps is developed. Let probabilities of presence of jump at any direction of the heavenly sphere in the tail of statistical distribution of temperature anisotropy is equal by P_1 for any frequency of measurement of any space probe. Let similar probabilities for two other frequencies are equal P_2 and P_3. Then the probability of presence of jump at tails of distributions at all three frequencies is $P_1 \cdot P_2 \cdot P_3$. If this multiplication exceeds size $1/n$, then such jump should be considered statistically significant.

It is established that statistically significant jumps of anisotropy are present in number of several hundred at databases of the probes "PLANCK" and "WMAP" in each of couples of adjacent measuring cycles. Statistical distributions of amplitudes of frequency-independent jumps of CMB for the probes "PLANCK" and "WMAP" can be considered two selections of the same distribution.

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Анализ анизотропии микроволнового реликтового излучения во временной области по данным зондов “Planck” и “WMAP”

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В [1] описаны временные скачки анизотропии температуры микроволнового реликтового излучения, выявленные в данных зонда “PLANCK”. Эти данные распределены по $n = 12582912$ направлениям небесной сферы. Данные являются интегральными по восьми полугодичным измерительным циклам. Разности между значениями анизотропии в пределах смежных измерительных циклов образуют скачки, достигающие 6 % от размаха анизотропии. Скачки могут быть как положительными, что соответствует росту температурной анизотропии, так и отрицательными, что соответствует ее снижению. Скачки наблюдается в одних и тех же направлениях небесной сферы на различных частотах излучения 30, 44 и 70 ГГц. Статистическая вероятность того, что выявленные скачки возникнут на всех трех частотах случайным образом, оказалась существенно меньшей вероятности обнаружения этих скачков в экспериментальных данных. Частотная независимость скачков позволяет предположить, что скачки обусловлены гравитационным линзированием излучения.

Настоящее исследование рассматривает скачки анизотропии микроволнового реликтового излучения применительно к данным зондов “WMAP” и “PLANCK” с единых позиций. Угловое разрешение базы данных зонда “WMAP” соответствует угловому разрешению проанализированных ранее данных зонда “PLANCK”. Данные зонда “WMAP” также являются интегральными. Они соответствуют девяти годичным измерительным циклам, выполненных на частотах 23; 33; 41; 61 и 94 ГГц.

При этом разработан единый статистический критерий выявления частотно-независимых скачков. Пусть вероятности присутствия скачка в каком-либо направлении небесной сферы в хвосте статистического распределения температурной анизотропии составляет P_1 для какой-либо частоты измерения какого-либо космического зонда. Пусть аналогичные вероятности для двух других частот составляют P_2 и P_3. Тогда вероятность присутствия скачка в хвостах распределений на всех трех частотах составляет $P_1 \cdot P_2 \cdot P_3$. Если это произведение превышает величину $1/n$, то такой скачок следует считать

статистически значимым. Установлено, что статистически значимые скачки анизотропии присутствуют в количестве нескольких сотен штук в базах данных зондов “PLANCK” и “WMAP” в каждой из пар смежных измерительных циклов.

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The Noether's theorems and the Foundations of Physics

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The problem of the foundations and the axiomatization of physics has been put forth by D. Hilbert in 1900. In his opinion the real prerequisites for this axiomatization appeared after G.Mie had created his relativity invariant nonlinear electrodynamics, A.Einstein and M.Grossmann had created the tensor-geometrical theory of gravitation, and thus the first version of the general theory of relativity (GTR) with non – general covariant equations of gravitation (1913), emerged. He built a unified theory of gravitational and electromagnetic fields which was based on general covariant variational principle of action, and described it in a paper “Foundations of Physics” (1915). In this theory the generalized nonlinear equations of the electromagnetic field were deduced from the gravitational equations and also contained solutions, which were to be interpreted as charged particles, for instance, electrons. This unification of fields was based on a “Hilbert’s assertion”. Emmy Noether, a young mathematician at time, was invited by Hilbert to Goettingen to prove the assertion.

In 1918, using calculus of variations and the theory of Lie’s groups, E.Noether proved two wonderful theorems on invariant variational problems. They still form the basis of modern theoretical physics and permit us to talk in terms of “Noether’s structure” of the theory of the four fundamental interactions. The second Noether's theorem contained “Hilbert’s assertion” as a special case and explained the difficulties with the law of energy-momentum conservation in general relativity. The first Noether's theorem connected continuous symmetries with conservation laws, and it turned out to be a kind of the fundament for the theories of electromagnetic, weak and strong interactions, and thus, the standard model in physics of the elementary

particles. The transition from global internal symmetry to their local analogues allows us to describe fundamental interactions as gauge Yang–Mills fields.

Conception of the "Noether's structure" of fundamental physics corresponds well with two notable philosophical-methodological models of physical cognition: with Einstein's three-layer model as well as with E.Wigner's three-layer model. In the first model a non-logical path from the empirical to the axioms, in particular the principles of symmetry would appear as a curved line ("Arc of Einstein"). The second model (of Wigner) has also three levels: symmetries, the laws of nature and natural phenomena (events). Events are being govern by the laws of nature, although the laws of nature themselves are defined almost entirely by the principles of symmetry.

Physical interactions in three metaphysical paradigms

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It is shown that the known types of physical interactions – gravitational, electromagnetic, electroweak and strong – are described in fundamentally different ways in three metaphysical paradigms: geometric, field-theoretic and relational. In the geometric paradigm, this is performed by using geometries of using different dimensions, including additional (hidden) dimensions (in 5-dimensional and larger dimensions, models of the Kaluza theory type). In the field-theoretic paradigm a gauge field approach (based on localization of internal symmetries) is used. In the relational paradigm, based on the works of G. Leibniz and E. Mach, this is carried out within the framework of binary pregeometry. The latter is constructed using the mathematical apparatus of binary systems of complex relations of minimal ranks (2.2), (3.3), (4.4). The principles of the theory of relativity are preserved in all three metaphysical paradigms.

Физические взаимодействия в трех метафизических парадигмах

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Показано, что известные виды физических взаимодействий – гравитационные, электромагнитные, электрослабые и сильные – описываются

принципиально различным образом в трех метафизических парадигмах: геометрической, теоретико-полевой и реляционной. В геометрической парадигме это осуществляется посредством использования геометрий разной размерности, включая дополнительные (скрытые) размерности (в 5-мерной и больших размерностей моделях типа теории Калуцы). В теоретико-полевой парадигме это делается посредством калибровочного метода (локализацией групп внутренних симметрий), а в реляционной парадигме, основы которой заложены в трудах Г. Лейбница и Э. Маха, это осуществляется в рамках бинарной предгеометрии. Последняя строится с помощью математического аппарата бинарных систем комплексных отношений минимальных рангов (2,2), (3,3) и (4,4). Во всех трех метафизических парадигмах сохраняются принципы теории относительности.

Calculation of thermal noise of beam splitters in laser gravitational wave detectors from first principles

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We present the calculation of thermal noise in interferometric gravitational-wave detectors due to the thermal fluctuations of the beam splitter (BS). This work makes use of a recently developed method of analysis of thermal noise in mirrors from first principles, based on the fluctuation dissipation theorem. The evaluation of BS thermal noise is carried out for the two different gravitational wave observatories, GEO600 and the Advanced Laser Interferometer Gravitational Wave Observatory (aLIGO). The analysis evaluates thermal noise from both the substrate and the optical reflective and antireflective stacks located on the BS surface. We demonstrate that the fluctuations of both reflecting and antireflecting surfaces significantly contribute to the total thermal noise of the BS. The oscillating intensity pattern couples small-scale distortions of the surface to the overall phase readout, and therefore increases the overall thermal noise. In the case of aLIGO, the BS contribution is with 0.3% negligibly small. At a frequency of 500 Hz, the BS causes about 10% of GEO600's sensitivity limit. BS noise impairs the feasible sensitivity of the GEO-HF design proposal by about 50%.

On the nature of a particle spin in the standard model

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The problem of the spin moment and dynamical structure of a particle were investigated. Zero oscillations and some features of the wave nature of a particle were taken account. The Borh's quantization rule was used. The trajectory of propagation of zero oscillations was ring so spin moment is axis vector. It was found equation for the spin quantum number. Solutions of this equation were integer and half-integer numbers. These results were produced for particle of standard model with zero mass and a massive particle in the Minkovsky's space. Concerning with results of other authors was made. Original dynamic model of a particle of standard model was built.

О природе спина частицы в стандартной модели

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Были исследованы проблема спинового момента и динамической структуры частицы. Были учтены нулевые колебания и некоторые черты волновой природы частицы. Было использовано правило квантования Бора. Траекторией распространения нулевых колебаний было кольцо, так как спиновый момент является осевым вектором. Для спинового квантового числа было найдено уравнение. Целые и полуцелые числа были решениями этого уравнения. В пространстве Минковского эти результаты были получены для частицы стандартной модели с нулевой массой и массивной частицы. Было сделано сравнение с результатами других авторов. Построена оригинальная динамическая модель частицы стандартной модели.

On the temperature distribution in a black hole

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We have considered flux of the Howking's thermal radiation in a black hole. We have supposed a spherical form of a black hole. Now the radius temperature dependence has the degree character. This result is true if ratio of this radius to the Plank's length is very large. Also we have found solution for temperature of quantum gas in a black hole. We have supposed existence relativistic gas. The gas may be system of photons or gravitons. We have found number of an energy levels of this system and. We discuss problem of temperature in black hole. We have concerned our results with other results and have showed existence of the problem. We have supposed original path to solving of this problem. Our results may be used to the Schwartzshild's black holes and may be useful for analyze of other types of black holes.

Pseudogravitational waves

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More and more human and material resources are being involved in the development of methods to detect gravitational waves (GWs). This fact reflects the importance and complexity of GW phenomena investigations.

Description of a wide class of GW-detectors, including laser interferometers, and their response to GWs, is based on calculations of the time of flight (or its Doppler derivative) of a light beam sending from one observer, a "phase source" (a clock), to another (a detector). The main GW response is expressed as an integral over the (unperturbed) light path of a contraction of the Riemannian curvature tensor with the light vector and the phase gradient [1-2].

The curvature tensor can be decomposed into the Weyl tensor (the contribution of mere GWs) and the Ricci tensor (responsible for the Shapiro effect). In GR, the Ricci (or Einstein's) tensor is rigidly defined (equal to the energy-momentum tensor), and has no "its own" waves, or polarization degrees of freedom, polarizations (except for the link with electromagnetic waves squared).

The situation is some different in the alternative theory of gravity, the unique variant (no singularities of solutions) of absolute parallelism [3-4], where $D = 5$, only three of 15 polarizations carry D-momentum (and also cause linear instability, i.e.

linear resonance growth, of three “weightless” polarizations), and finally, localized field configurations can carry topological charges and/or (for symmetric configurations) quasi-charges (and serve as new “actors”, a sort of quasi-particles).

In this theory, the Einstein's tensor is linked linearly with the longitudinal polarization (so nonstationary O^4-symmetric solutions are possible that look as a single wave moving along the radius and forming a shallow and thick S^3-shell waveguide), and with unstable (“giant”) polarizations squared. The energy-momentum tensor appears in a prolonged 4th order equation, but the second order equation restricts the set of solutions (and corrections to the Newton’s $1/r^2$ law).

Thus, the curvature perturbation can occur not only through GW propagation, but also through these “new” polarizations which (do not carry D-momentum and) can be called pseudo-gravitational waves (PGWs). Perhaps, the so-called Biefeld-Brown effect [5] can be explained as a manifestation of PGWs.

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Псевдогравитационные волны

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В развитие методов регистрации гравитационных волн вовлекается все больше людских и материальных ресурсов. Это отражает важность и сложность исследований гравитационно-волновых (ГВ) явлений.

Описание широкого класса ГВ-детекторов, в том числе лазерно-интерференционных, и их отклика на ГВ, сводится к определению времени полета света от одного наблюдателя (источник “фазы”, часы) к другому (детектор). Траектория луча может быть ломанной геодезической линией, то есть зависеть от дополнительных объектов – зеркал. Основной ГВ-отклик выражается как интеграл по (невозмущенной) траектории луча от свертки тензора кривизны с вектором луча и градиентом фазы [1-2].

Тензор Римана можно разложить на тензор Вейля (это, в общем, и есть вклад ГВ) и тензор Риччи (отвечает за эффект Шапиро). В ОТО тензор Риччи (тензор Эйнштейна) жестко определен (равен тензору энергии-импульса), и не имеет “своих” волн, или поляризационных степеней свободы, поляризаций (если не считать квадратичной связи с электромагнитными волнами).

Ситуация меняется в альтернативной теории гравитации, варианте абсолютного параллелизма [3-4], где $D=5$, из 15 поляризаций только три переносят энергию-импульс, а кроме того вызывают линейную неустойчивость (линейный резонансный рост) трех других, “невесомых” поляризаций, и, наконец, возможны локализованные конфигурации поля, несущие топологический заряд и/или (симметричные конфигурации) квази-заряд (квазичастицы).

В этой теории тензор Эйнштейна связан линейно с продольной поляризацией (возможны нестационарные O^4-симметричные решения типа одиночной волны бегущей по радиусу и формирующей оболочку-волновод) и квадратично – с растущими (“гигантскими”) поляризациями. Тензор энергии-импульса появляется в продолженном уравнении 4-го порядка, но уравнение второго порядка ограничивает множество решений (поправки к закону $1/r^2$).

Таким образом, возмущение кривизны может происходить не только через ГВ, но и через указанные “новые” поляризации (не несущие энергию-импульс), которые можно назвать псевдогравитационными волнами (ПГВ). Возможно, к проявлениям ПГВ относится т.н. эффект Биффельда-Брауна [5].

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Logarithmic superfluid theory of physical vacuum

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Recently proposed statistical mechanics arguments [1] and previously known Madelung hydrodynamical presentation [2] have revealed that the quantum liquids with logarithmic nonlinearity, often referred as "logarithmic fluids", are very instrumental in describing generic condensate-like matter, including strongly-interacting quantum liquids, one example being He II, a superfluid component of He-4 [3-6]. A large number of applications of the logarithmic fluids can be also found in a theory of physical vacuum, which thus becomes a useful tool for explaining a phenomenon of gravity. Using the logarithmic superfluid model, one can formulate an essentially quantum post-relativistic theory of superfluid vacuum, which successfully recovers special and general relativity in the "phononic" (low-momenta) limit, but otherwise has rather different tenets and foundations. The paradigm of superfluid as a fundamental background opens up an entirely new prospective on the emergence of the Lorentz symmetry and spacetime, quantum quintessence, black holes, cosmological evolution and singularities, and so on [7-12].

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Evolution of Collisional Matter in Modified Teleparallel Theories

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In this article, we discuss the cosmic evolution in the presence of self interacting collisional matter (CM) with and without radiations within $f(T,B)$ theory of gravity where T stands for torsion scalar and B represents the boundary term related to the divergence of torsion $B=2\nabla_{\mu}T^{\mu}$. This $f(T,B)$ theory makes a good connection between $f(R)$ (R for Ricci Scalar) and $f(T)$ (T for torsion) theory under reasonable conditions. We consider flat Friedmann-Lema $\hat{i}$ tre-Robertson-Walker (FLRW) metric for comparison between non-collisional matter (NCM) with radiation, collisional matter (CM) without radiation, and CM with radiation for three significant $f(T,B)$ models, which are constructed by Sebastian et al. \cite{01}. We consider power law model, logarithmic model, and exponential model in $f(T,B)$ gravity to discuss the behavior of deceleration parameter $q(z)$, Hubble parameter $H(z)$, Equation of state (EoS) for dark energy (DE), and effective EoS. We found the great oscillations of EoS for DE across the phantom divide line. Effective EoS also crossed the phantom divide line without any oscillations. The graphs for $H(z)$, $q(z)$, effective EoS are alike for NCM with radiations, CM without radiaitons and CM with radiations.

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