KAZAN FEDERAL UNIVERSITY

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5-100 Russian Academic Excellence Project

3rd Symposium of the BRICS Association on Gravity, Astrophysics and Cosmology
August, 29 – September, 3 2019

Program and Abstracts

Kazan, 2019

УДК 530.12+521

3-й Симпозиум Ассоциации стран БРИКС по гравитации, астрофизике и космологии. 29 августа – 3 сентября. Программа и тезисы докладов Симпозиума. — Казань: Изд-во КФУ, 2019. – 68 с.

Сборник содержит программу и тезисы докладов участников 3-й Симпозиум Ассоциации стран БРИКС по гравитации, астрофизике и космологии. В материалах представлены работы ведущих специалистов и начинающих исследователей из научных центров России, ближнего и дальнего зарубежья, посвящённые исследованиям в ОТО и модифицированных теориях гравитации, теоретической и наблюдательной космологии, релятивистской астрофизике. Симпозиум проходил в Казанском университете с 29 августа по 3 сентября 2019 года.

Сборник адресован научным работникам, аспирантам и молодым ученым, специализирующихся в области теории гравитации, космологии и астрофизики, а также для студентов старших курсов естественнонаучных направлений.

3-й Симпозиум Ассоциации стран БРИКС по гравитации, астрофизике и космологии проводится за счет средств субсидии, выделенной в рамках государственной поддержки Казанского (Приволжского) федерального университета в целях повышения его конкурентоспособности среди ведущих мировых научно-образовательных центров. Проведение Симпозиума нацелено на реализацию научно-образовательных задач в рамках стратегической академической единицы «Астровызов».

УДК 530.12+521

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3rd Symposium of the BRICS Association,
on Gravity, Astrophysics and Cosmology
August, 29 – September, 3 2019

PROGRAM

of the Third Symposium of the BRICS Association on Gravity, Astrophysics and Cosmology August, 29 – September, 3 2019

	Aug, 29	Aug, 30	Aug, 31	Sept, 1	Sept, 2	Sept, 3
8.00-9.00	Arrival Day	**Registration**			Excursion & Departure Day	Departure Day
9.00-10.00			**Plenary Session**	**Plenary Session**		
10.00-10.30		**Opening Ceremony**				
10.30-11.00		**Plenary Session**				
11.00-11.20			Coffee-break	Coffee-break		
11.20-12.40			**Plenary Session**	**Morning Session** *Sections A,C*		
12.40-14.00		Lunch	Lunch	Lunch		
14.00-16.00		**Afternoon Session** *Sections A,B*	**Afternoon Session** *Sections A,D*	**Afternoon Session** *Sections D,E*		
16.00-16.20		Coffee-break	Coffee-break	Coffee-break		
16.20-17.40		**Evening Session** *Sections A,B*	**Evening Session** *Sections A,E*	**Evening Session** *Sections D,C*		
18.00		**Welcome Party**				
19.00				**Banquet**		

Plenary talks are of 30-35 min long.

Section talks are of 15-20 min long.

The sections are the following:

- **Section A.** Cosmology, Dark Energy
- **Section B.** Astronomy and Astrophysics
- **Section C.** Black Holes, Wormholes
- **Section D.** General Relativity and Extensions
- **Section E.** Experiments and Observations

30th AUGUST, FRIDAY

8.00-10.00	Registration of participants

10.00-10.30	**Opening Ceremony**

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30th AUGUST, FRIDAY

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14.40-15.00	**Alexey Toporensky** and Daniel Muller *Initial conditions for Starobinsky inflation in Einstein and Jordan frames*
15.00-15.20	Salvatore Capozziello, **Anjan A. Sen** *Model independent constraints on dark energy evolution from low-redshift observations*
15.20-15.40	**Bijan Saha** *Spinor field in cosmology: non-minimal coupling*
15.40-16.00	**R.K. Muharlyamov** *The anisotropic distribution of the dark energy within the scope of LRS Bianchi type I model*

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14.20-14.40	**Charissa Bronwyn Button** *The application of the adiabatic scenario to the radio relic hosted in the galaxy cluster Abell 3411-3412*
14.40-15.00	**Bin Chen**, Geoffrey Compere, Yan Liu, Jiang Long and Xuao Zhang *Spin and Quadrupole Couplings of IMRACs*
15.00-15.20	**Byron P. Brassel** *Dynamics and collapse of radiating stars with a Vaidya geometry*
15.20-15.40	**Charles Takalana** & Paolo Marchegiani *Simulated differential observations: Probing the DA and EoR with the Sunyaev-Zel'dovich Effect*
15.40-16.00	**Ahmed Ayad Mohamed Ali** *Phenomenology of axion-photon coupling in the jets of AGNs*

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30th AUGUST, FRIDAY

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17.00-17.20	**K.A. Bolshakova**, S.V. Chervon *Cosmological solutions with the Higgs potential in tensor-multi-scalar gravity*
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SECTION B. ASTRONOMY AND ASTROPHYSICS

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31st AUGUST, SATURDAY

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31st AUGUST, SATURDAY

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17.30-17.50	**Ildus Nurgaliev** *Nonsingular Cosmology*
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31st AUGUST, SATURDAY

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1st SEPTEMBER, SUNDAY

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10.00-10.30	**V.S. Gorelik** *Excitation and detection of paraphotons and axions during laser action on dielectric media*
10.30-11.00	**S.D. Maharaj** *The generalized Vaidya spacetime and relativistic stars*

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11.40-12.00	**S.Yu. Vernov** *Exact spherically symmetric static solutions and Kantowski-Sachs universes in models with non-minimally coupled scalar fields*
12.00-12.20	**S.V. Sushkov** *Cosmological perturbations during the kinetic ination in the Horndeski theory*
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1st SEPTEMBER, SUNDAY

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15.00-15.20	Artyom V. Yurov, **Valerian A. Yurov** *The Hawking radiation and the horizon of a De Sitter Universe*
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15.40-16.00	**P. Tretyakov** *Cosmological perturbations in teleparallel gravity*

SECTION E. EXPERIMENTS AND OBSERVATIONS

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15.00-15.20	**Ivan Karpikov** *The problem of excessive density of muons in extensive air showers*
15.20-15.40	**E. Shlepkina** *Calculation of dark matter particle decays using various software packages*
15.40-16.00	V.A. Sokolov, **B.D. Garmaev** *Astrophysical effects in conformal nonlinear electrodynamics*

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1st SEPTEMBER, SUNDAY

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17.20-17.40	**Yan Ryazantsev** *The analytical Bekenstein limit and a new relation between fundamental constants*
17.40-18.00	**M. Lulinsky** *Geodesics in superspace*

SECTION C. BLACK HOLES, WORMHOLES

16.20-16.40	**A.V. Aminova** *On Kaluza-Klein cylindrically symmetric wormholes*
16.40-17.00	D.V. Galtsov and **I.A. Bogush** *Rotating Fisher-Janis-Newman-Winicour spacetimes*
17.00-17.20	**O.B. Zaslavskii** *Super-Penrose process*
17.20-17.40	**D. Lisenkov**, N.R. Khusnutdinov, A.A. Popov *Vacuum polarization of a quantized scalar field in the thermal state in wormhole spacetime with infinitly short throat*
17.40-18.00	A. Popov, **A. Osman** *Self-force of a static charge in spacetime of a wormhole with an infinitly short throat*

19.00	***Banquet***

ABSTRACTS

THE EXACT SOLVABILITY MODEL OF THE EULER-POISSON EQUATIONS IN THE STANDART LOBACHEVSKY FUNCTION SPACE

D.L. Abrarov[1]

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The Euler-Poisson equations describing a dynamics of three-dimensional heavy tops in a plane-parallel gravitational field have the form:

$$\frac{d\overline{M}}{dt} = \left[\overline{M}, \overline{\omega}\right] + k\left[\overline{\gamma}, \overline{c}\right], \tag{1}$$

$$\frac{d\overline{\gamma}}{dt} = \left[\overline{\gamma}, \overline{\omega}\right], \tag{2}$$

where the corresponding vectors are: $\overline{M}$ - angular moment of the body; $\overline{\omega}$ - angular velocity of the body; $\overline{c}$ - displacement of the fixing point of the body from its center mass; $\overline{\gamma}$ - projections of the vertical unit vector on the axis of the of the moving coordinate system, rigidly connected with the body; I - diagonalized inertia tensor of the body at its fixed point; $k = mg|r_c|$ - coefficient equal to the product of body weight by the distance from a fixed point to the center of mass.

Equations (1,2) have classical integrals: $\{S =< \overline{\gamma}, \overline{\gamma} >= 1\}, \{G =< I \cdot \overline{\omega}, \overline{\gamma} >= g\}, \{H_{\text{ob}} =< \frac{1}{2} I \cdot \overline{\omega}, \overline{\omega} > -k < \overline{c}, \overline{\gamma} >= h\}$.

Theorem 1. The function $F = \exp(\gamma_3^2 - \gamma_2^2 - \gamma_1^2)$, where $(\gamma_1, \gamma_2, \gamma_3) = \overline{\gamma}$, is the 4th integral of equations (1,2) independent with the integrals S, G, H. The functions S, G, H, F form a complete set of integrals of equations (1,2).

Theorem 2. The general solution of differential equations (1,2) has an analytical form:

$$\overline{M}(t) = \exp(\exp(F)) = \exp(\zeta(s, \Delta_{12}(q) \otimes_{SL_2(\mathbb{Z})} PGL_2(\mathbb{Q}(t))), \tag{3}$$

where $\Delta_{12}(q)$ - is the uniqe parabolic form of weight 12 with respect to the group $SL_2(\mathbb{Z})$ (Dedekind function):

$$q \prod_{n=1}^{n=\infty} (1 - q^n)^{24}, \quad q = e^{2\pi i z}, \quad \{z \in \mathbb{C}, Imz > 0\};$$

- $a, b, c, d \in \mathbb{Z}$ and $ad - bc = 1$ is the condition defining the function $\Delta_{12}(q)$ as modular form of weight 12; $\zeta(\Delta_{12}(q))$ - zeta-function of the form $\Delta_{12}(q)$; $PGL_2(\mathbb{Q}(t)$ is the functional expansion of $PGL_2(\mathbb{Q})$, which is the group of matrices of projective linear transomations of the affine plane over the field $\mathbb{Q}$.

Theorem 3. The function $\exp F$ represents the metric in the function space $\Lambda^3_{C^0}(\mathbb{C})$ that is the canonical continuos expansion of the standart three-dimensional Lobachevsky complex space $\Lambda^3(\mathbb{C})$ and has the form $\exp F = \exp(t^2 - \omega_3^2 - \omega_2^2 - \omega_1^2 - \gamma_3^2 - \gamma_2^2 - \gamma_1^2)$, when $(\omega_1, \omega_2, \omega_3) = \overline{\omega}$, $(\gamma_1, \gamma_2, \gamma_3) = \overline{\gamma}$. The function F represents the metric on the absolute of the space $\Lambda^3_{C^0}(\mathbb{C})$.

References

1. Abrarov D. L. The exact solvability and global dynamics of the Euler-Poisson equations. Monograph. Preparing for print.

2. Abrarov D. L. The exact solvability of the heavy top problem. M.: Computer Center of RAS, 2007. 194 p.

GLOBAL PROPERTIES OF WARPED SOLUTIONS IN GENERAL RELATIVITY WITH AN ELECTROMAGNETIC FIELD AND A COSMOLOGICAL CONSTANT

D.E. Afanasev[1], M.O. Katanaev[2]

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We consider general relativity with a cosmological constant minimally coupled to an electromagnetic field and assume that four-dimensional space-time manifold is the warped product of two surfaces with Lorentzian and Euclidean signature metrics. Einstein's equations imply that at least one of the surfaces must be of constant curvature. It means that the symmetry of the metric arises as the consequence of the equations of motion ("spontaneous symmetry emergence"). We give classification of global solutions in two cases: (i) both surfaces are of constant curvature and (ii) the Riemannian surface is of constant curvature. The latter case includes spherically symmetric solutions (sphere S^2 with $SO(3)$-symmetry group), planar solutions (two-dimensional Euclidean space R^2 with $IO(2)$-symmetry group), and hyperbolic solutions (two-sheeted hyperboloid H^2 with $SO(1,2)$-symmetry). Totally, we get 37 topologically different solutions. There is a new one among them, which describes changing topology of space in time already at the classical level.

THE PECULIARITIES OF THE COSMOLOGICAL MODELS BASED ON SCALAR SINGLET WITH HIGGS POTENTIAL

A.A. Agathonov[1], Yu.G. Ignat'ev[2]

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A detailed qualitative analysis and numerical modeling of the evolution of cosmological models based on nonlinear classical and phantom scalar fields with self-action are performed. Complete phase portraits of the corresponding dynamical systems and their projections onto the Poincaré sphere are constructed. It is shown that the phase trajectories of the corresponding dynamical systems can, depending on the parameters of the model of the scalar field, split into bifurcation trajectories along 2, 4, or 6 different dynamic streams. In the phase space of such systems, regions can appear which are inaccessible for motion. Here phase trajectories of the phantom scalar field wind onto one of the symmetric foci (centers) while the phase trajectories of the classical scalar field can have a limit cycle determined by the zero effective energy corresponding to a Euclidean Universe.

PHENOMENOLOGY OF AXION-PHOTON COUPLING IN THE JETS OF AGNS

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An outstanding result of modern cosmology is that only a small fraction of the total matter content of the universe is made of baryonic matter, while the vast majority is constituted by dark matter (DM). However, the nature of such component is still unknown and might be a matter of long standing controversies. In principle, the nature of DM can be understood through looking for light scalar candidates of DM such as axion and axion-like particles. The axion is a pseudo-Nambu-Goldstone boson that appears after the spontaneous breaking of the Peccei-Quinn symmetry and it was introduced to solve the CP-violation problem of the strong interactions. On the other hand, there are other axion-like particles (ALPs) predicted by many extensions of the standard model of particle physics (SM) and they postulated to share the same phenomenology of the axion. The theory, together with observational and experimental bounds, predicts that such axions or more generally ALPs are very light and weakly interacting with the SM particles. Therefore, we strongly believe that ALPs are highly viable candidate for cold DM in the universe. If they really exist in nature, they are expected to couple with photons in the present of an external magnetic field through the Primakoff effect. We will examine the detectability of signals produced by ALP-photon coupling in the highly magnetized environment of the relativistic jets produced by active galactic nuclei (AGNs).

ON KALUZA-KLEIN CYLINDRICALLY SYMMETRIC WORMHOLES

A.V. Aminova[1], D.R. Brill, P.I. Chumarov

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We study the radial and non-radial motion of test particles for cylindrically symmetric wormholes of type WhCR^e found earlier [A. V. Aminova and P. I. Chumarov, Phys. Rev. D **88**, 044005 (2013)] in the 6-dimensional reduced Kaluza–Klein theory with the radial Abelian gauge field and two dilaton fields. We show that space–time

$$ds^2 = \frac{dt^2}{\sqrt{2|q_e|\cosh(hu)}} - \sqrt{2|q_e|\cosh(hu)}\left(e^{2(a+b)u}du^2 + e^{2bu}dz^2 + e^{2au}d\phi^2\right)$$

has a regular wormhole region and has a physical singularity at $u = -\infty$ (for $a, b > 0$). The motion of test particles in the ϕ and z-direction is governed by two conserved canonical momenta L and M, and the radial motion is described by an effective potential. This potential is repulsive away from the wormhole throat region. This difference from the typically attractive nature of spherically symmetric wormholes is related to the collapse of the latter, which allows a particle at the throat to move to a smaller circle radius, whereas in our example the size of the throat does not change. Thus, for a radially moving particle with energy $E < 1/\sqrt[4]{2|q_e|}$ there is a potential barrier at $u_- < u < u_+$. Equating

u_- and u_+ gives $u = 0$, $E = 1/\sqrt[4]{2|q_e|} \equiv E_0$, so the particle located at $u = u_- = u_+ = 0$ will be at a point of (unstable) equilibrium. The energy E_0 divides motions of qualitatively different behavior. The particle with energy $E < E_0$ starting from rest at $u_+ > 0$ is separated by the potential barrier from the singularity at $u = -\infty$. It moves away from the singularity and reaches infinity in infinite proper time $\tau = +\infty$. In order that a radially moving particle with energy $E < E_0$ could traverse or touch the wormhole throat $u = u_0 < 0$ it must have $u_- \geq u_0$. From this follows the existence of a (lower) energy threshold $E_{thr} \equiv E_0 \sqrt[8]{1 - 16a^2/h^2}$ of traversability of the wormhole throat for a radially moving massive test particle. Particles starting from rest at $u_- > u_0$ with energy E satisfying $E_{thr} < E < E_0$ pass through the throat and fall to the singularity in a finite proper time.

Radial trajectories of massive particles starting from rest at $u_- < u_0$ with energy $E < E_{thr}$ do not pass through the wormhole throat. Massive particles with energy $E = E_{thr}$ start at the point of rest $u_- = u_0$ on the wormhole throat and fall toward the singularity in a finite proper time. Radially moving particles with energy $E < E_0$ that start from rest at u_+ do not traverse the wormhole throat; they move away from the throat and reach infinity in infinite proper time. For $E > E_0$ the wormhole is traversable for radially moving test particles with non-zero rest masses.

A particle with energy E_0 and initial values $u_i < 0, \dot{u}_i < 0$ of radial coordinate and velocity moves toward the singularity, crosses the wormhole throat (only if $u_i > u_0$) and falls to the singularity in a finite proper time. If $u_i < 0$, but $\dot{u}_i > 0$, the particle moves to the hypersurface $u = 0$ and reaches it in infinite proper time. When $u_i > 0, \dot{u}_i > 0$ a particle moves away from the singularity and reaches infinity in infinite proper time. In the case $u_i > 0,\ \dot{u}_i < 0$ the particle moves toward the hypersurface $u = 0$ and reaches it in infinite proper time, so the particle does not cross the throat (the hypersurface $u = 0$ traps out particles with energy E_0). Photons, being scale (conformally) invariant, cannot have a critical energy E_0, and in fact we found that each radial photon trajectory crosses the throat.

In the case of non-radial motion the effective potential has a "centrifugal potential" contribution due to the conserved canonical momenta M_z and L of the z- and ϕ-motion. As shown, this contribution is always positive, and therefore increases the potential barrier compared to that for pure radial motion. For motion in the hypersurface $z = \text{const}$ ("planar orbits", $M = 0$, $L \neq 0$) the ability of a particle to overcome this barrier can be stated in terms of its impact parameter D. As in the Kerr and Schwarzschild geometries we should then distinguish, between orbits with impact parameters greater and/or less than a certain critical value D_c of the impact parameter, which corresponds to the unstable circular orbit of radius u_c. For $D^2 > D_c^2$ there are two kinds of orbits: orbits of the first kind arrive from infinity and turn around at the orbit's minimum radial coordinate u (pericenter) greater than u_c, whereas orbits of the second kind turn around at maximum radial coordinate u (apocenter) less than u_c and terminate at the singularity at $u = -\infty$. For $D = D_c$ orbits of the first and second kinds spiral infinite number of times on the unstable circular orbit $u = u_c$. For $D^2 < D_c^2$ we have only orbits of one kind: starting at infinity, they cross the wormhole throat and terminate at the singularity. Thus, to penetrate the wormhole, improperly (non-radially) aimed planar orbits need more energy and time to traverse the wormhole, but they still do not avoid the central singularity.

In the case of non-radial motion with zero angular momentum ($L = 0$) the effect of the corresponding "centrifugal potential" due to M is similar to that due to L except that V_{eff} always diverges at $u = -\infty$, shielding the singularity: all orbits have the finite lowest values of the orbit's radial coordinate u. All null orbits terminate at radial infinity. For massive particles we have to distinguish between the four cases (a, b, c, d). In case (a) there exist two kinds of orbits: an orbit of the first kind oscillates between two values $u_1 < u_2$ of radial coordinate u, an orbit of the second kind arrives from infinity and has the minimal radial coordinate $u_3 > u_2 > u_1$. In case (b) we have the unstable orbit $u = u_2$; the orbit of the first kind starts at $u_1 < u_2$ and approaches the orbit $u = u_2$ asymptotically in the infinite proper time, and the orbit of the second kind arrives from infinity and has the minimal radial coordinate u_2. In case (c) we have the stable orbit at $u = u_1$ and an orbit that arrives from infinity and terminates at $u_2 > u_1$. In case (d) orbits arrive from infinity and terminate at u_1. This type of orbit allows traversing the wormhole from V_+, spending a finite time on the "other side" V_- without encountering the singularity, and reemerging in the original space V_+.

ABOUT GEODESIC LINE IN SUPERSPACE

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The present work is devoted to the construction of supersymmetric cosmological models in the framework of a consistent supersymmetric approach developed in the works of Aminova and Mochalov. The consistent approach to the supersymmetric theory of gravity means that the supergeometry is defined by supersymmetry properties. This approach requires the development of group-invariant methods of supergravity. We regard supersymmetry as an automorphism of a supergeometric structure, in particular, as infinitesimal supertransformation preserving a metric of a superspace. The metric is defined as an invariant of a Lie supergroup of supertransformations. In this paper we consider the important case of supersymmetric de‘Sitter space. We write Hamilton-Jacoby equation and obtain supersymmetric terms. We derive motion equations and find supersymmetric velosity.

SELF-ACTION OF A STATIC CHARGE IN THE WORMHOLE WITH AN INFINITELY SHORT THROAT

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The motion of a charged point-like object in a fixed background spacetime, is affected by the coupling between the object's own charge, and the field that this charge induces. This coupling results in a self-force acting on the object. At leading order, the object's acceleration due to this self-force (in the absence of non-gravitational external interactions) is proportional to e^2/M, where e and M denotes the object's charge and mass, respectively. This leading order is obtained by treating the particle's field as a linear perturbation over a fixed curved background spacetime. Analysis of the self-force in curved spacetime also has a practical motivation: one possible source for LISA - the planned spacebased gravitational wave detector, is a binary system with an extreme mass ratio, which inspirals toward coalescence. Here, the self-force is required for the calculation of the accurate orbital evolution of such systems. These orbits are needed in order to design templates for the gravitational waveforms of the emitted gravitational radiation.

In this work a method is presented which allows for the computation of the self-force for a static charge on the background of the wormhole with an infinitely short throat

$$ds^2 = -dt^2 + dr^2 + (|r| + a)^2 \left(d\theta^2 + \sin^2\theta d\varphi^2\right). \tag{1}$$

The effect of self-action is described in the frame of non-minimal coupling Einstein-Maxweel theory, with the coupling linear in the curvature

$$S = \int d^4x\sqrt{-g}\mathscr{L} = \int d^4x\sqrt{-g}\left(-\frac{R}{\kappa} + \frac{1}{2}F_{mn}F^{mn} - \frac{1}{2}\chi^{ikmn}F_{ik}F_{mn}\right), \tag{2}$$

where the quantity

$$\chi^{ikmn} \equiv \frac{q_1 R}{2}(g^{im}g^{kn} - g^{in}g^{km}) + \frac{q_2}{2}(R^{im}g^{kn} - R^{in}g^{km} + R^{kn}g^{im} - R^{km}g^{in}) + q_3 R^{ikmn}. \tag{3}$$

is the susceptibility tensor, and the parameters q_1, q_2, and q_3 are in general arbitrary.

The result for the tetrad component of the self-force have the form

$$F^{(r)} = -\frac{e^2}{2a^2}\sum_{l=0}^{\infty}\frac{\left(1 - 2l(l+1)(4q_1 + q_2)/a^2\right)}{\left(1 - l(4q_1 + q_2)/a^2\right)}(1 + r/a)^{-2l-3} \tag{4}$$

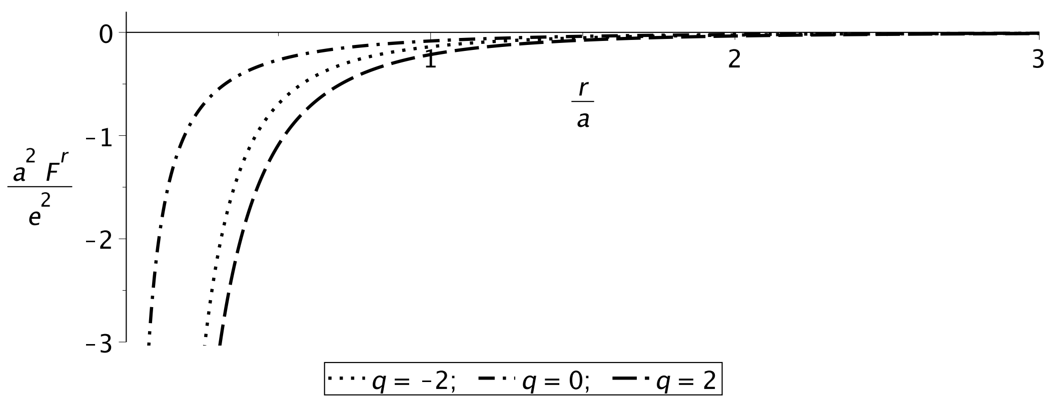

Fig. 1. Plot of function (4) for different values of $q = \frac{4q_1 + q_2}{a^2}$ vs $\frac{r}{a}$.

TRI-VECTOR DEFORMATIONS OF $D = 11$ SUPERGRAVITY

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We construct a $d = 11$ supergravity analogue of the open-closed string map in the context of SL(5) Exceptional Field Theory (ExFT). The deformation parameter tri-vector Ω generalizes the non-commutativity bi-vector parameter Θ of the open string. When applied to solutions in $d = 11$, this map provides an economical way of performing TsT deformations, and may be used to recover $d = 10$ Yang-Baxter deformations after dimensional reduction. We present a generalization of the Classical Yang-Baxter Equation (CYBE) for rank 3 objects, which emerges from $d = 11$ supergravity and the SL(5) ExFT. This equation is shown to reduce to the $d = 10$ CYBE upon dimensional reduction.

ONE GENERALIZATION OF THE INTERIOR SCHWARZSCHILD SOLUTION

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The static generalization of the interior Schwarzschild solution [1] is considered with a metric $ds^2 = G(x)^2dt^2 - 2L(x)dtdx - x^2(d\theta^2 + \sin^2\theta d\varphi)$ for an interior gravitation field of a ball, which is filled by the perfect fluid. Here $x = r/R$, r,θ,φ are a radial and the angle coordinates; R is a ball radius. The Einstein equations can be reduced to the equation $G''_{\zeta\zeta} + \Omega^2(\zeta)G = 0$, where $d\zeta = dy/(2\sqrt{\varepsilon(y)}) = dy/(2\sqrt{1-\Phi(y)})$; $y = x^2$; $\varepsilon(y) = (G(y)/L(y))^2$; $\Phi(y) = 1-\varepsilon(y) = (\chi/x)\int\mu(x)x^2dx$ is an analog of the Newton potential; $\chi = \kappa\cdot R^2$; $\mu(x)$ is a mass density; $\Omega^2(\zeta(y)) = -d(\Phi(y)/y)/dy$.

When $\Omega^2 = 0$, we have the interior solution of Schwazschild [1]. For $\Omega^2 \equiv k^2 = const$ we have the interior solution with a parabolic mass density ([2]- [3]). For $\Omega^2 = k^2 + W(\zeta)$ we can find solution if will take $G(\zeta) = A(\sin(k\zeta+\alpha_0)/\zeta - \cos(k\zeta+\alpha_0))$ and $W(\zeta) = -2/\zeta^2$. In this case we have a regular solution in the centre, if $\zeta(y=0) = \zeta_0 \geq 0$ and $\alpha_0 = 0$.

New variable $\zeta(y)$ we must find from $\zeta(y) = (1/2)\int dy/(\sqrt{1-(1/\sqrt{y})\int\chi\mu(y)\sqrt{y}dy}$.

We can take $\chi\mu$ as an approtimation $\chi\mu \approx \chi\mu_0(1-ay-by^2)$, where $\chi\mu_0$ is the mass density for the interior Schwarzschild solution and $\chi\mu_0(1-ay)$ is a parabolic distribution. Then $\Phi(y) = -(2/105)\chi\mu_0 y(15by^2+21ay-35)$. If $\Phi(y) < 1$ for all $y \in (0,1)$, we will have $\zeta(y) \approx (1/2)y - (1/210)\chi\mu_0((15/4)by^4 + 7ay^3 - (35/2)y^2)$.

If $a = 0.01, b = 0.95, k^2 = 1$ we find a graph of the mass distribution (Fig1) and graph of the function $G(x) = \sqrt{g_{00}}$ (Fig2). There is the graph of the function $\sqrt{g_{00}}$ of the interior Schwarzschild solution as a comparison.

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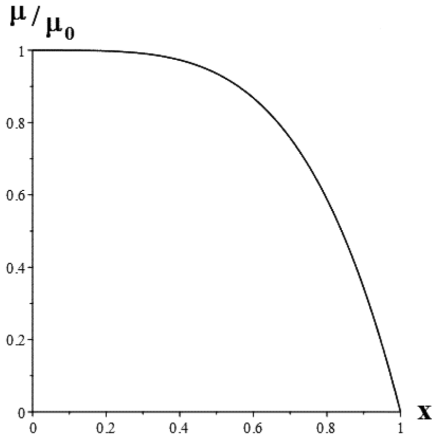

Fig.1

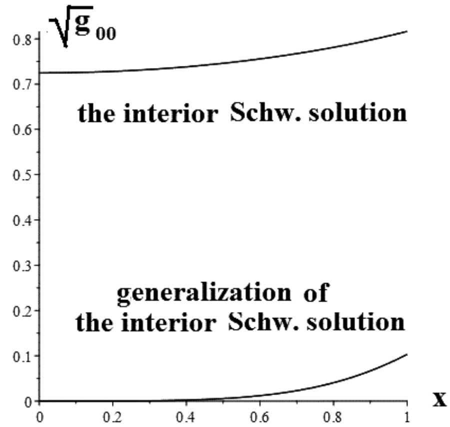

Fig.2

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LEAST ACTION PRINCIPLE AND GRAVITATIONAL DOUBLE LAYER

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Everybody knows that the field equations for any relativistic gravitational theory are highly nonlinear. In the simplest case of Einstein's General Relativity the differential equations are of the second order. The merely solving these equations and giving them the physical interpretation is extremely difficult task. Therefore, it is important to find some special distributions of matter source that allow obtaining more or less easily the exact solutions in order to develop our physical intuition. It appears that the simplest source of this kind is the so called thin shell, when the matter energy-momentum tensor is concentrated on the singular hypersurface in the form of the Dirac's delta-function. The thin shell formalism in General Relativity was elaborated by W.Israel long ago. It was and are still being used successfully in cosmology and black hole physics. The corresponding equations of motion are usually obtained simply by integrating the Einstein equations across the singular hypersurface. Here we demonstrate how they can be derived straight from the least action principle.

But, most of the modifications of General Relativity which are using metric formalism, give rise to the differential equations of the fourth order. It appears that in this case there exists one more type of the singular hypersurface – the double layer described by the derivative of the Dirac's delta-function, that is, by delta-prime. Since there exists no mass-dipole distribution (unlike the charge-dipole one in classical electrodynamics), such a double layer is a pure gravitational phenomenon. The general formalism for the quadratic gravity was elaborated by J.Senovilla some time ago. We applied it in the rather simple case of the spherically symmetric Weyl+Einstein gravity and discovered two very interesting and unusual features. First, the appearance of the completely arbitrary function in the junction conditions. This is due to the fact that the delta-prime function is not concentrated on the singular hypersurface contrary to the “usual” Dirac’s delta-function). Second, the extrinsic curvature tensor (in the considered case it has only one component) of the singular hypersurface must be zero, what is very important because it imposes some restrictions prior to solving the equations of motion. Here we show how these two features emerge naturally in the general case already in the framework of the least action principle. It is interesting to note that the delta-prime function does not appear explicitly in our approach.

ASTRONOMY IN KAZAN: FROM IVAN SIMONOV TO SPACE OBSERVATORIES

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Astronomy at Kazan University dates back to 1810, when a visiting Professor of astronomy from Austria Johann littrov arrived in Kazan. Among the first students of his lectures on astronomy were Nikolai Lobachevsky and Ivan Simonov, who later became famous scientists and rectors of the Imperial Kazan University. In 1838, with the direct participation of N. I. Lobachevsky and I. M. Simonov, the building of the city astronomical Observatory was built, which was equipped with the best astronomical instruments at that time.

Currently, the experimental base of Kazan astronomy has competitive advantages among other classical universities of the Russian Federation (Moscow, St. Petersburg, Yekaterinburg), where education of MS and PhD students in Astronomy is conducted. In particular, on the territory of the Engelhardt Astronomical Observatory the Planetarium of Kazan Federal University was built in 2013, equipped with telescopes with diameters of mirrors from 10 cm to 50 cm. In the North Caucasus (near the 6-meter BTA telescope of the Special astrophysical Observatory of the Russian Academy of Sciences) the North Caucasus astronomical station was established, which is currently held student practices and the first scientific researches are performed by undergraduate students. In 1995-2000, an optical telescope of Kazan University with a diameter of the main mirror of 150 cm was installed in the mountains in the South of Turkey on the territory of the TUBITAK National Observatory. Telescope is equipped with modern research equipment and being included in the international project RTT-150 with the participations of Kazan University, the Tatarstan Academy of Sciences, Space research Institute of Russian Academy of Sciences, TUBITAK National Observatory. With the help of the RTT-150 telescope Kazan University has an opportunity to participate in programs for ground support of space orbital observatories (INTEGRAL, SWIFT, Chandra, Planck).

Since 2019, KFU astronomers will take part in the project of the Russian orbital Observatory (with the participation of Germany) “Spectrum-X-Ray-Gamma” which was launched into space from the Baikonur cosmodrome on July 13, 2019. With the help of two X-ray telescopes - eRosita (Germany) and ART-XC(Russia), this space Observatory will be able to detect in the coming years a huge number of new X-ray sources in the Universe - accreting neutron stars, supermassive black holes, massive clusters of galaxies. Using the RTT-150 telescope, KFU astronomers will carry out work on optical identification and investigate of new X-ray sources of the SRG satellite.

OPTICAL IDENTIFICATIONS OF PLANCK CLUSTER OF GALAXIES BY USING RTT-150

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The project proposes to carry out a large observational program on RTT-150 telescope aimed at finding and measuring the redshifts of the most massive clusters in the observed part of the Universe among the objects selected from the survey of the entire sky by the Planck space Observatory.

The proposed observations will allow to start a program of optical identifications of cluster of galaxies based of the entire sky survey by the “Spectrum-X-Ray-Gamma” Observatory.

In particular, among the sources of the Syunyaev-Zeldovich signal from the survey of Planck Observatory mission, we expect to find for the first time the most massive clusters located on the redshifts $z = 0.5 - 1.0$. As the data of the future X-ray survey of the SRG Observatory appear, we propose to search for the most massive clusters of galaxies among X-ray sources from this survey.

As part of our project, we also propose to carry out a number of works, the results of which will allow to clarify restrictions on various cosmological parameters according to the data on galaxy clusters and other cosmological data that have been obtained recently.

ROTATING FISHER-JANIS-NEWMAN-WINICOUR SPACETIMES

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General relativity, minimally coupled to a scalar field, is known to admit a spherically symmetric solution with a singular horizon which was initially found by Fisher [1] and rediscovered by Janis, Newman and Winicour [2]. The Fisher-Janis-Newman-Winicour solution (FJNW) has independent mass and scalar charge, whereas equating scalar charge to zero brings Schwarzschild solution with regular horizon back. Attempts to generate a rotating generalisation of FJNW with Janis-Newman algorithm failed due to the presence of the scalar field. Although in Einstein-Maxwell-dilaton model certain examples of exact rotating solutions are known [3], they have Schwarzschild limit for zero angular momentum and zero electric/magnetic charge. The problem of rotating generalisation with an independent scalar charge without other fields remains unsolved until now. Here we present a new rotating Kerr-like solution which shares properties of FJNW and axisymmetric Zipoy-Voorhees solutions in the static limit. To generate the new solution, we

developed a technique, which combines other known techniques, and it takes advantage of the σ-model representation and the Geroch group.

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ON GENERALIZED MELVIN SOLUTIONS FOR LIE ALGEBRAS OF RANK 4

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We consider generalized Melvin-like solutions associated with Lie algebras of rank 4 (namely, A_4, B_4, C_4, D_4, and the exceptional algebra F_4) corresponding to certain internal symmetries of the solutions. The system under consideration is a static cylindrically-symmetric gravitational configuration in D dimensions in presence of four Abelian 2-forms and four scalar fields. The solution is governed by four moduli functions $H_s(z)$ $(s = 1,...,4)$ of squared radial coordinate $z = \rho^2$ obeying four differential equations of the Toda chain type. These functions turn out to be polynomials of powers $(n_1, n_2, n_3, n_4) = (4,6,6,4), (8,14,18,10), (7,12,15,16), (6,10,6,6), (22,42,30,16)$ for Lie algebras A_4, B_4, C_4, D_4, F_4, respectively. The asymptotic behaviour for the polynomials at large distances is governed by some integer-valued 4×4 matrix ν connected in a certain way with the inverse Cartan matrix of the Lie algebra and (in A_4 case) the matrix representing a generator of the $\mathbb{Z}_2$-group of symmetry of the Dynkin diagram. The symmetry properties and duality identities for polynomials are obtained, as well as asymptotic relations for solutions at large distances. We also calculate 2-form flux integrals over 2-dimensional discs and corresponding Wilson loop factors over their boundaries.

COSMOLOGICAL SOLUTIONS WITH HIGGS POTENTIAL IN TENSOR-MULTI-SCALAR GRAVITY THEORY

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Following by the method proposed in [1] we extend the tensor-multi-scalar gravity model

$$S = \frac{1}{\kappa_*}\int d^4x\sqrt{-g_*}\left[\frac{R_*}{2} - \frac{1}{2}g_*^{\mu\nu}h_{AB}\varphi^A_{,\mu}\varphi^B_{,\nu} - W(\varphi^C)\right] + S_m[\psi_m, \Omega^2(\varphi)g^*_{\mu\nu}]. \qquad (1)$$

for the case of Higgs potential. Namely, as the source of gravity, we define the material part of the action S_m as a scalar Higgs field χ with the potential $U(\chi)$ [2]

$$U(\chi) = \frac{1}{\omega^4}\frac{\lambda}{4}(h(\chi)^2 - v^2)^2 \qquad (2)$$

The analysis of theoretical predictions and their comparison with observational data is carried out in the slow rolling mode for the Higgs field. Higgs inflation with the potential (2) is considered in three main ranges described in [3], and these limits we took to find the solutions in tensor-multi-scalar gravity theory with the action (1).

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DYNAMICS AND COLLAPSE OF RADIATING STARS WITH A VAIDYA GEOMETRY

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We model the dynamics of a spherically symmetric radiating dynamical star with three spacetime regions. The local internal atmosphere is a two-component system consisting of standard pressure-free, null radiation and an additional string fluid with energy density and nonzero pressure obeying all physically realistic energy conditions. The middle region is purely radiative which matches to a third region which is the Schwarzschild exterior. A large family of solutions to the field equations are presented for various realistic equations of state. We demonstrate that it is possible to obtain solutions via a direct integration of the second order equations resulting from the assumption of an equation of state. A comparison of our solutions with earlier well known results is undertaken and we show that all these solutions, including those of Husain, are contained in our family.

POTENTIALLY OBSERVABLE CYLINDRICAL WORMHOLES AND ENERGY CONDITIONS

K.A. Bronnikov, S.V. Bolokhov, M.V. Skvortsova

All known solutions in GR describing rotating cylindrical wormholes lack asymptotic flatness in the radial directions and thus cannot describe wormhole entrances as local objects in our Universe. To overcome this difficulty, wormhole solutions are joined to flat asymptotic regions at some cylindrical surfaces on both sides of the throat. The whole configuration thus consists of three regions, the internal one containing a wormhole throat, and two flat external ones. It remains to find such solutions where the matter content of the internal region and both junction surfaces respect the weak energy condition. Two examples of such configurations have been found, in one of which the internal matter is represented by a stiff perfect fluid and another one with a special kind of anisotropic fluid. In both examples, the resulting configurations do not contain closed timelike curves.

THE APPLICATION OF THE ADIABATIC SCENARIO TO THE RADIO RELIC HOSTED IN THE GALAXY CLUSTER ABELL 3411-3412

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Radio relics are non-thermal, steep-spectrum ($\alpha < -1$) diffuse radio sources found in the peripheral regions of galaxy clusters. The emission is produced through synchrotron radiation as relativistic electrons ($\gamma \gg 1000$) move in helical paths through the magnetic fields of the intracluster medium (ICM). As the time it would take for the electrons to diffuse over a distance greater than 50 kpc from any compact source is longer than their radiative lifetime of approximately 0.1 Gyr, the electrons have probably been injected or (re)accelerated close to where the emission is observed. Radio relics are widely considered to have originated in intracluster shock waves, since studies have shown that relics seem to trace shock fronts. Although diffusive shock acceleration (DSA) has been widely used to explain the origin of relics, it is inefficient at low Mach numbers and other mechanisms such as adiabatic compression of fossil relativistic electrons are also present in these structures. In this project we apply the adiabatic compression model in an attempt to explain the spatial structure of the spectral index that is observed in the relic hosted in the merging galaxy cluster Abell 3411-3412.

PRIMODIAL BLACK HOLES AND GRAVITATIONAL WAVES INDUCED BY SCALAR PERTURBATIONS

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One of promising candidates of dark matter is primordial black hole, which could be formed in the early universe by large amplitude of small scale perturbations produced during inflation, when they reenter the horizon. While scalar perturbation and tensor perturbation are decoupled at the linear order, the scalar perturbation can act as the source of the tensor perturbation at the nonlinear order. In this talk I will calculate the stochastic gravitational wave energy density produced by the scalar perturbations and show that if the primordial black holes ranging in between 10^20g to 10^22g, constitute all dark matter, the associated stochastic gravitational wave background must be detectable by Lisa-like detectors, no matter how small the scalar perturbation amplitude or the nonlinear parameter is. In addition, I will also show the potential signature for PTA if the black holes observed by LIGO/Virgo are of the primordial origin.

COSMOGRAPHIC RECONSTRUCTION TO DISCRIMINATE BETWEEN MODIFIED GRAVITY AND DARK ENERGY

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Cosmography is a model independent approach, useful todiscriminate among concurring cosmological scenarios. After reviewing themain features and shortcomings of LCDM model, we propose a cosmographicapproach, based on some polynomial series like Pade', Chebyschev, etc. toinvestigate dark energy and modified gravity. The main result is thatseries convergence seems a powerful tool to extend the matching with the Hubble flow up to high redshift and then improve the role of observers in Cosmology.

SPHERICALLY SYMMETRIC SOLUTIONS IN $F(R)$ GRAVITY WITH A KINETIC SCALAR CURVATURE

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In the work [1] it was shown that the $f(R)$ gravity with a kinetic scalar curvature, where

$$f(R,(\nabla R)^2) = f_1(R) + X(R)\nabla_\mu R\nabla^\mu R \tag{1}$$

can be reduced to 2D chiral cosmological model in Einstein frame with the action

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

where $\varphi^1 = \chi$, $\varphi^2 = \phi$, $h_{11} = 1$, $h_{12} = h_{21} = 0$, $h_{22} = -e^{-\sqrt{\frac{2}{3}}\chi}X(\phi)$, $W(\phi,\chi) = \frac{1}{4}e^{-\sqrt{\frac{2}{3}}\chi}\left(\phi - e^{-\sqrt{\frac{2}{3}}\chi}f_1(\phi)\right)$. Cosmological solutions for the model (1) was studied in the work [2]. In given contribution we study spherically symmetric spacetime with the line element $ds^2 = e^{2\alpha}du^2 + e^{2\beta}(d\theta^2 + sin^2(\theta)d\varphi^2) - e^{2\gamma}dt^2$. The system of gravity and scalar fields equations are:

$$-2\beta'' - \gamma'' + 2\alpha'\gamma' - 2(\beta')^2 - (\gamma')^2 = \kappa\left[(\chi')^2 - e^{-\sqrt{\frac{2}{3}}\chi}X(\phi)(\phi')^2 + e^{2\alpha}W\right] \qquad (3)$$

$$1 - e^{2\beta-2\alpha}\left(\beta'' + 2(\beta')^2 - \beta'\alpha'\right) = \kappa e^{2\beta}W \qquad (4)$$

$$e^{-2\alpha}\left((\gamma')^2 - \alpha'\gamma' + 2\beta'\gamma' + \gamma''\right) = -\kappa W \qquad (5)$$

$$[2\beta' + \gamma' - \alpha']\chi' + \chi'' - \frac{1}{2}\sqrt{\frac{2}{3}}e^{-\sqrt{\frac{2}{3}}\chi}X(\phi)(\phi')^2 + \frac{1}{4}\sqrt{\frac{2}{3}}e^{2\alpha-\sqrt{\frac{2}{3}}\chi}\left[-1 + 2e^{-\sqrt{\frac{2}{3}}\chi}f_1(\phi)\right] = 0 \qquad (6)$$

$$-X(\phi)\left([2\beta' + \gamma' - \alpha']\phi' + \phi''\right) + \frac{1}{2}\frac{\partial X(\phi)}{\partial\phi}(\phi')^2 + \frac{1}{4}\left[1 - e^{-\sqrt{\frac{2}{3}}\chi}\frac{\partial f_1(\phi)}{\partial\phi}\right]e^{2\alpha} = 0 \qquad (7)$$

We investigate a connection of GR solutions, including Schwarzschild metric, with a choice of the functional dependence $f_1(\phi)$ and $X(\phi)$.

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CHIRAL COSMOLOGICAL MODELS AS EQUIVALENT OF THEORIES OF GRAVITY WITH HIGHER DERIVATIVES

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The chiral cosmological model (CCM) with the action

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

give possibility to describe various type of f(R) gravity with higher derivatives with respect to scalar curvature. In the given presentation it will be shown two- and three- dimensional CCM with fixed metric of the target space and the potentials that describe the following models with higher derivatives:

$$S_1 = \int d^4x\sqrt{-g}\left[f(R,(\nabla R)^2)\right] \quad (2)$$

$$S_2 = \int d^4x\sqrt{-g}\left[f(R,\Box R)\right] \quad (3)$$

$$S_3 = \int d^4x\sqrt{-g}\left[f(R,(\nabla R)^2,\Box R)\right] \quad (4)$$

Investigation of the model (2) is presented in [1,2].

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CHIRAL COSMOLOGICAL MODEL OF $F(R)$ GRAVITY WITH KINETIC SCALAR CURVATURE

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We consider modified $f(R)$ gravity with a kinetic scalar of curvature $f(R,(\nabla R)^2) = f_1(R) + X(R)R_{,\mu}R^{,\mu}$ [1, 2, 3], reduced to the special type of a chiral cosmological model:

$$S = \int d^4x\sqrt{-g_E}\left(\frac{R_E}{2} - \frac{1}{2}g_E^{\mu\nu}\chi_{,\mu}\chi_{,\nu} + \frac{1}{4}f_1(\phi)e^{-2\sqrt{\frac{2}{3}}\chi} - \frac{1}{4}\phi e^{-\sqrt{\frac{2}{3}}\chi} + \frac{1}{2}Xe^{-\sqrt{\frac{2}{3}}\chi}g_E^{\mu\nu}\phi_{,\mu}\phi_{,\nu}\right). \quad (1)$$

A detailed derivation of the action of the chiral cosmological model as the equivalent of the gravity model with higher derivatives wrt the Ricci scalar is presented. The equations of the model are written in the spatially flat Friedmann-Robertson-Walker metric. Examples of solutions are found that correspond to the special choice of the field $\chi = \chi_* = const$ and its fixed value $\chi_0 = -\sqrt{3/2}\ln 2$ [1]. For the indicated value χ_0, in the case of the canonical form of the kinetic component of the Ricci scalar, a nonlinear differential equation of the second order on H is derived and the exact solution for power-law inflation is obtained. The transition of de Sitter solutions and power-law expansion from the Jordan frame to the Einstein one is analysed. It is proved that there is the conformal Weil transformation that maps the de Sitter and the power-law solutions to the same ones in the other frame. The inclusion of an additional material field leads both to an exit from the stage of accelerated expansion and to a conversion of the initial vacuum state into radiation, which is a necessary condition for the construction of phenomenologically correct models of the early Universe. To match the model with the observational data, a transition was made to the model of a single massive scalar field. The exact inflation parameters were calculated, which consistent with observational data and confirm the influence of the second field.

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THERMODYNAMICS OF BLACK HOLE SPACETIMES WITH LINE SINGULARITIES

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Thermodynamics of black holes with electric and magnetic charges, cosmological constant, possibly endowed with scalar fields, is well understood not only in Einstein theory but also in its various higher-curvature generalizations. However, adding the magnetic mass (NUT parameter) renders the problem more complicated. Nutty solutions have line singularities on the polar axis (Misner strings) which can be eliminated imposing Misner condition of time periodicity, but even in this case no consistent thermodynamics were formulated, not to say that the whole problem becomes academic, since periodic time can hardly be given physical interpretation. Meanwhile, more close inspection shows that Misner string can be tolerated [1] as a mild singularity originating from infinitely thin tube carrying gravimagnetic flux, similarly to treatment of magnetic monopole as an effect of cutting a thin solenoid. Though the corresponding distributional source has features of exotic matter, this possibility deserves to be explored further.

An approach to thermodynamics of Nutty spacetimes based on this point of view was suggested recently in a series of papers [2–5]. Crucial moment is the derivation of a Smarr relation between the mass, angular momentum and charges, including NUT. Traditionally this is done in terms of the Komar conserved quantities associated with Killing two forms related to stationarity and axial symmetry. However, direct use of them in presence of singularities on the poral axis may be problematic. Here we suggest to apply the rod formalism, which treats the horizons and line singularities on equal footing, as timelike and spacelike rods correspondingly. Combining this with the recently corrected Tomimatsu form of the Komar integrals [6] we derive novel Smarr relations both for horizons and line singularities which can consistently describe Misner strings and provide new base for thermodynamics not only of a single black hole with NUT charge, but also of multi-black hole solutions contaning various defects on the polar axis.

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ON EXPONENTIAL COSMOLOGICAL SOLUTIONS WITH THREE DIFFERENT HUBBLE-LIKE PARAMETERS IN $(1+3+K_1+K_2)$-DIMENSIONAL EINSTEIN-GAUSS-BONNET MODEL WITH A Λ-TERM

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A D-dimensional Einstein-Gauss-Bonnet model with a cosmological term Λ, governed by two non-zero constants: α_1 and α_2, is considered. By restricting the metrics to diagonal ones we study a class of solutions with exponential time dependence of three scale factors, governed by three non-coinciding Hubble-like parameters: $H > 0$, h_1 and h_2, obeying to $3H + k_1h_1 + k_2h_2 \neq 0$ and corresponding to factor spaces of dimensions: 3, $k_1 > 1$ and $k_2 > 1$, respectively, with $D = 4 + k_1 + k_2$. Two cases: i) $3 < k_1 < k_2$ and ii) $1 < k_1 = k_2 = k$, $k \neq 3$, are analysed. It is shown that in both cases the solutions exist if $\alpha = \alpha_2/\alpha_1 > 0$ and $\alpha\Lambda > 0$ obeys certain restrictions, e.g. upper an lower bounds. In case ii) explicit relations for exact solutions are found. In both cases the subclasses of stable and non-stable solutions are singled out. The case i) contains a subclass of solutions describing an exponential expansion of $3d$ subspace with Hubble parameter $H > 0$ and zero variation of the effective gravitational constant G.

RECONSTRUCTION OF 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 4D Friedmann universe is considered. The background solutions and 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, the exact solutions for the power-law and exponential power-law inflation are obtained.

RELATIVE TRAPPING SURFACES AND OPTICAL IMAGES OF BUMPY SPACETIMES

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Event horizons are absolutely trapping surfaces, which can not be left by any photon starting on them. One can define relative trapping surfaces outside the horizon which are trapping for geodesics of restricted classes [1], [2]. These may be useful for describing null geodesic structure of strong gravitational field, providing an alternative and concise way to describe lensing and shadows of compact objects field without recurring to complete integration of the geodesic equations. Here we test this construction in the case of the Weyl metrics when geodesic equations are non-separable, and thus can not be integrated analytically (bumpy spacetimes), while the above characteristic surfaces can be described in a closed form. We develop further our formalism for a class of static axially symmetric spacetimes introducing more detailed specification of transversely trapping surfaces in terms of their principal curvatures. Surprisingly, we find in the static case without spherical symmetry certain features, such as photon regions, previously known in the Kerr space. These photon regions can be regarded as photon spheres, "thickened" due to oblateness of the metric.

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RESONANCE EXCITING OF HIGH FREQUENCY GRAVITATIONAL WAVES IN MEDIA BY INTENSE LASER EMISSION

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The opportunity of high frequency gravitational waves emission [1, 2] in stars at the presence of the strong magnetic field was predicted before [3]. In this case, the frequency of generated gravitational emission coincides with the frequency of the star light emission: $\omega_0 = 2\pi f$; $f \sim 10^{14} 1/s$. On the other hand, in works [4] on the base of the common relativity theory considerations for vacuum, there was the prediction of the high frequency gravitational waves emission presence inside of stars as the result of up conversion light parametric processes. In this case the frequency ω_g of gravitational emission should be twice with comparing to the initial frequency of star light emission: $\omega_g = 2\omega_0$.

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 [3–6] generation in laboratory by means of resonance laser exciting of dielectric media is analyzed. Due to the strong photon-photon anharmonicity in media, the bound two-photonic states [7] in Raman active dielectrics may be formed with the frequency $\omega_g \approx 2\omega_0$, where ω_0 is the exciting laser frequency. The most possibility of such type processes observing is realized when the frequency of exciting laser emission ω_0 is close to absorbance band frequencies of the crystals, liquids or salt solutions. Thus, in these up conversion parametric processes the high frequency gravitational waves in media may be generated. The theory of bound two-photonic states forming in 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, should be in electronic spectra of media. After bound two-photonic states creating due to pulsed laser excitation, the corresponding scalar gravitational waves should propagate into spare space. Elemental excitations of such scalar bound two-photonic states is known as paraphotons or hidden photons [8]. For detection of high frequency scalar gravitational waves, the same media, in which bound two-photonic states were excited, may be used. The experimental results of investigations of Comb Parametric Simulated Raman Scattering in various condensed dielectric media ($CaCO_3$, quartz, $NaBrO_3$, $Ba(NO_3)_2$, water, ethanol, salt solutions and others), excited by laser pulses are presented. The first (λ = 1064 nm) and second (λ = 532 nm) optical harmonics of a YAG: Nd^{3+} laser emission seemed to be very effective for the excitation of the Comb Parametric Simulated Raman Scattering Raman spectra in discussed dielectric media. The different experimental schemes for the generation and detection of high frequency gravitational waves in media during Comb Parametric Simulated Raman Scattering in laboratory are compared. This work was supported by Russian Science Foundation, grant 19-12-00242.

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RELATIVITY PROPERTIES OF QUASIPARTICLES IN DIAMOND CRYSTAL

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Diamond is a unique optical material due to its high refractive index, chemical inertness and resistance to deformation [1–3]. Therefore, it is important to study the optical and acoustic properties of diamond. In this paper, the phonon dispersion law in diamond crystals was established based on the use of models of crystalline lattices with additional bonds and the continuum approximation.

To simplify the calculation, diamond was considered as a one-dimensional monoatomic chain with additional bonds. In this case, the dispersion laws of acoustic and optical phonons of diamond crystal approximated as [4–6]:

$$\omega_{opt}(k) = \sqrt{\omega_0^2 - 4\frac{S^2}{a^2}\sin^2\left(\frac{ka}{2}\right)},\ \omega_{ac} = 2\frac{S}{a}\left|\sin\left(\frac{ka}{2}\right)\right|. \quad (1)$$

Here, $\omega(k)$ is the cyclic frequency, a is the period of the crystal chain, S - sound velocity, k – wave vector. Thus, at small wave vectors we have new relativistic laws as:

$$\omega_{opt}(k) = \sqrt{\omega_0^2 - S^2k^2},\ \omega_{ac} = Sk. \quad (2)$$

Quasiparticles, corresponding to optical phonons, have negative rest mass and described by new type relativity theory, in which $E^2 = E_0^2 - S^2p^2$; $E = \hbar\omega_{opt}$, $E_0 = \hbar\omega_0$, $p = \hbar k$; E, p – energy and quasimomentum of quasiparticles correspondingly. Acoustic phonons are similar to the spare photons, and satisfy to relations: $E = Sp$.

Thus, elemental excitations of optical branch in diamond crystals are quasiparticles with negative rest mass, satisfying to new type of relativity theory.

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POLARIZATION AND STRATIFICATION OF AXIONICALLY ACTIVE PLASMA IN A DYON MAGNETOSPHERE

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The state of a static spherically symmetric relativistic axionically active multi-component plasma in the gravitational, magnetic and electric fields of an axionic dyon is studied in the framework of the Einstein - Maxwell - Boltzmann - axion theory. We assume that the equations of axion electrodynamics, the covariant relativistic kinetic equations, and the equation for the axion field with modified Higgs-type potential are non-linearly coupled; the gravitational field in the dyon exterior is assumed to be fixed and to be of the Reissner-Nordstrom type. We introduce the extended Lorentz force, which acts on the particles in the axionically active plasma, and analyze the consequences of this generalization. The analysis of exact solutions, obtained in the framework of this model for the relativistic Boltzmann electron-ion and electron-positron plasmas, as well as, for degenerated zero- temperature electron gas, shows that the phenomena of polarization and stratification can appear in plasma, attracting the attention to the axionic analog of the known Pannekoek-Rosseland effect.

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SPECTRUM OF GRAVITATIONAL RADIATION FROM A MULTI-LAYER SINGLE PULSARS

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Assuming that the observed periodic variations of pulsar emission are due to the Chandler Wobble (CW) and Free Core Nutation (FCN) of the spin axises, we investigate the spectrum of gravitational waves (GW) from two/three-layer neutron stars (NS) using the Hamiltonian method. We model the interior dynamical characteristics of a rotating NS using the observed variations of the radio emission of seventeen pulsars. We estimate the frequencies and amplitudes of GW from different internal layers of the pulsar depending on the CW, FCN, and the dynamic ellipticity of the crust, the outer core and the inner core of the NS.

THE SELF-CONSISTENT FIELD METHOD AND EINSTEIN'S MACROSCOPIC EQUATIONS FOR THE EARLY UNIVERSE

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Using the self-consistent field method, a complete theory of a macroscopic description of cosmological evolution is constructed, which includes a subsystem of linear equations of evolution of perturbations and nonlinear macroscopic equations of Einstein and a scalar field. Examples of the solution of this system are presented, illustrating the fundamental difference between the cosmological models of the early Universe built on homogeneous and locally fluctuating scalar fields. Corrections to the equation of state of the fluid are found, based on the macroscopic Einstein equations which were obtained by averaging over microscopic spherically symmetric metric fluctuations created by primordial black holes in a fluid medium. It is shown that these corrections are effectively equivalent to addition to the system of a fluid with the equation of state $p = -\varepsilon$.
Keywords: macroscopic gravity, self-consistent field, cosmological model, scalar fields, averaging of local fluctuations, asymptotic behavior, cosmological singularity.

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THE GENERAL FORM OF GRAVITATIONAL SUPERPOTENTIAL IN THE THEORIES WITH HIGHER ORDER DERIVATIVES

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Since the dawn of the development of general relativity in 1915 a number of theoretical physicists found that gravitational energy-momentum density is not tensor quantity. At that time this problem, often called problem of the localization of the gravitational energy in modern papers, attracted attention of numerous researchers. However, it still has no generally accepted solution.

In most theories of gravity Noether's (canonical) stress energy-momentum tensor $\mathcal{T}^{\mu}{}_{\nu}$ can be expressed as a divergence of superpotential (i.e. double divergence of this quantity with respect to the pair of indices equals to zero). In many modern investigations of the gravitational energy localizability problem one usually constructs superpotential $B^{\alpha\mu}{}_{\nu}$ which satisfies a number of reasonable conditions as the solution to the problem. Nevertheless these superpotentials are often valid for concrete theories of gravity and, with a few exceptions, can't be used for it's modifications.

The present report is mainly concerned with the most general form and properties of energy superpotentials for theories with diffeomorphism-invariant action. For these theories we derive the explicit form of the canonical stress energy (pseudo)tensor and use Nother's procedure to obtain its superpotential. The technique used to analyze Noether's identities is exactly the same as that used to derive the relation between metric and canonical stress energy-momentum tensors for theories with higher order derivatives. In some cases this similarity allows one to replace canonical superpotential with the one, analogous to Moller and Freud superpotentials in general relativity. As an example of this general approach, higher order derivative generalizations of affine-metric, Einstein-Cartan, mimetic and Regge-Teitelboim theories are considered.

ACCRETION DISK PROPERTIES AROUND KERR-SEN BLACK HOLE

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String theory is a promising candidate for a consistent quantum theory of gravity, it is of interest to examine black holes in string theory. The predictions of string theory differ from those of general relativity. The reason for this difference is the presence of a scalar field called the dilaton that can change the properties of the black hole geometries. The dilaton field can be interpreted as an eclectically or magnetically charged.

The spinning regular black hole (spin a) metric of string theory derived by Ashoke Sen [1] contains string parameter ξ marking deviation from the Kerr metric. Non-zero value of ξ, if observed, would vindicate the string theory. We shall study the physical properties and characteristics of matter forming thin accretion disks around the Kerr-Sen black hole using the Page-Thorne model [2]. For illustration, we choose as a toy model a stellar-sized spherically symmetric black hole and find that charged black holes are always hotter and brighter. Disk efficiency also increases with increasing spin and charge parameters.

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ON SYMMETRIES OF FIVE-DIMENSIONAL SPACES

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According to the theorem of E. Noether and the research of a group of American scientists, space-time symmetries in the form of projective and affine motions lead to fundamental mechanical and field laws of conservation. The main difficulty in constructing such conservation laws is, according to the authors, in finding these movements. This report is devoted to solving this problem for 5-dimensional spaces, which contains the general solution of Eisenhart's equation in 5-dimensional h-space of the type {221} of non-constant curvature and establishes necessary and sufficient conditions for the existence of non-homothetical projective motion in such a space. As a result, the structure of a nonhomothetic projective Lie algebra of an h-space of type {221} is determined [1].

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MULTI-FREQUENCY ANALYSIS OF SUSY DARK MATTER ANNIHILATION IN THE GRAVITATIONALLY LENSING CLUSTER ABELL 1689

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The annihilation of dark matter particles in dark matter halos is expected to yield observable standard model products that can be detected in the radio, X-ray, and gamma-ray regime. In this work we explore the astrophysical implications of supersymmetric dark matter annihilations in galaxy clusters, with a specific application to the gravitationally lensing galaxy cluster Abell 1689. We do this by first determining suitable dark matter halo models and diffusion properties of the annihilation products for the central halos using gravitational lensing observations. We then use these models to calculate the resulting multi-frequency signals at different masses and annihilation channels and compare our results to current radio observations of the A1689 cluster. We also determine the best fit WIMP mass, annihilation channel and magnetic field values which will allow the detectability of dark matter annihilation emission by-products in the radio, X-ray and gamma-ray surveys.

COSMOPARTICLE PHYSICS OF DARK MATTER

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The lack of confirmation on the existence of supersymmetric particles and Weakly Interacting Massive Particles (WIMPs) implies the extension of studies of the physical nature of dark matter, involving non-supersymmetric and non-WIMP solutions. We briefly discuss some exmples of such candidates, like mirror matter, axion-like particles or non particle candidates like Primordial Bleck Holes in their relationship with cosmological reflection of the structure and pattern of symmetry breaking of theories beyond the Standard model of elementary particles. The nontrivial solution of puzzles of direct dark matter searches in the approach of composite dark matter is presented. The advantages and open problems of this approach are specified.

MAGNETARS, MAGNETIZED BLACK HOLES AND QED PROCESSES

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Neutron stars, in particular, magnetars (highly magnetized neutron stars) provide the most intense magnetic fields in the universe [1], which go by order of two or more beyond the critical field $B_c = 4.41 \times 10^{13} G$ of the lowest Landau energy equaling the rest mass of the electron. The quantum nature of matter in neutron stars and magnetars entirely differs from that of ordinary matter in weak electromagnetic (EM) fields in laboratory. The vacuum birefringence, a vacuum polarization effect, had been predicted for neutron stars [2] and has recently been observed by measuring optical spectrum from a neutron star [3]. Blanford and Znajek proposed a central mechanism for gamma rays bursts (GRBs), in which magnetized rotating black holes power jets by mining the rotational energy through magnetic fields [4] (for recent review, see [5]). Damour and Ruffini studied the Schwinger mechanism in KN black holes and discussed a possibility of astrophysical source for GRBs [6]. An electrically and/or magnetically charged black hole and the Bonnor-Melvin universe in a uniform magnetic field are solutions of the Einstein-Maxwell theory [7,8]. The most well-known spacetimes are charged black holes, such as the Reissner-Nordstrom (RN) black hole or the Kerr-Newman (KN) black hole or both electrically and magnetically charged RN and KN black holes [9,10]. The Killing vector of a rotating black hole allows a magnetic field with the same polar axis as the hole spin [11], and magnetized black holes have been intensively studied [12,13]. The general black hole solution with a magnetic field has recently been found [14]. To the best knowledge of the author, however, no solution has been found yet for the Einstein equation equated to the stress-energy tensor of the Maxwell theory together with QED effective action at the one-loop level. It has been well known for long that a strong EM field can make the vacuum polarized due to the interaction of the photons with virtual electrons from the Dirac sea [15,16], and that a strong electric field even creates electron-positron pairs, the so-called (Sauter-)Schwinger mechanism, which can be explained by quantum tunneling through a titled barrier by the electric potential [16]. The vacuum polarization and Schwinger mechanism is genuinely nonperturbative quantum effects in background gauge fields of the Maxwell theory. Schwinger pair production is the most efficient mechanism that produces a pair per unit Compton volume and per unit Compton time at the cost of the electric field energy, which plays an important role in astrophysics [17].

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GENERAL PARAMETRIZATION FOR SPHERICAL AND AXIAL BLACK HOLES AND REPRESENTATION OF NUMERICAL BLACK-HOLE SOLUTIONS IN ANALYTICAL FORM

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We propose a new parametric framework to describe the spacetime of axisymmetric black holes in generic metric theories of gravity. In this case, the metric components are functions of both the radial and the polar angular coordinates, forcing a double expansion to obtain a generic axisymmetric metric expression. In particular, we use a continued-fraction expansion in terms of a compactified radial coordinate to express the radial dependence, while we exploit a Taylor expansion in terms of the cosine of the polar angle for the polar dependence. These choices lead to a superior convergence in the radial direction and to an exact limit on the equatorial plane. As a validation of our approach, we build parametrized representations of Kerr, rotating dilaton, and Einstein-dilaton-Gauss-Bonnet black holes. We also construct relatively compact analytical representations for metric of spherical black holes in the Einstein-scalar-Gauss-Bonnet, Einstein-Weyl and Einstein-scalar Maxwell theories.

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GENERATION OF COMPOSITE VACUUM WORMHOLES IN GENERAL RELATIVITY

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After the leading work by Moris and Thorn [1], wormhole connecting two asymptotically flat spacetimes is now well known classic in relativity theories. Within the framework of general relativity the class of spherically-symmetric thin-shell wormholes, the dynamics of the wormhole is completely specified once an equation of state is specified for the "exotic matter" which is located at the wormhole throat [2, 3]. By describing such a wormhole as a limiting case of a constant-density spherical shell [4], it was shown that the structure must be unstable to linearized radial perturbations.

On the other hand composite wormholes have been also investigated previously and it was demonstrated that the requirement of exotic matter can be avoided. To describe a thin shell wormhole configurations one may construct such system by two distinct strategies. Actually, the essence of the standard method is the following: One takes two the same copies of space-time manifolds with appropriate asymptotic, cuts and casts away 'useless' regions of space-times (containing horizons, singularities, etc.), and pastes remaining regions. As the result, one obtains a geodetically complete wormhole space-time with given asymptotic and a throat being a thin shell of exotic matter violating the null energy condition. In other case, we have initially a wormholes made from appropriate interior and exterior vacuum solutions matched at the shell [5].

We have analyzed the role played by the gauge freedom in wormhole geometries, namely composite wormhole. One of the most striking features of wormhole solution is that one can generate closed timelike curves ("time machine") from them [1]. Applying the analysis to composite wormhole geometries, considering the general static spherically symmetric vacuum solution (1) as interior region, we deduced composite wormhole, and found that the latter exist well with a jump in second derivations of metric coefficients but first and second fundamental form are continuous.

Both vacua correspond to the same general static spherically symmetric vacuum solution [6]

$$ds^2 = -\left(1 - \frac{2\mu}{\sqrt{\rho(r)}}\right)dt^2 + \left(\frac{\rho'(r)^2}{4\rho(r)} - \chi(r)^2\right)\left(1 - \frac{2\mu}{\sqrt{\rho(r)}}\right)^{-1} dr^2 + \chi(r)\,dr\,dt + \rho(r)\left(d\theta^2 + \sin^2\theta\, d\phi^2\right), \quad (1)$$

however they are described by the solution with different sets of arbitrary functions $\rho(r)$ and $\chi(r)$. In particular, the exterior vacuum solution reduces to the Schwarzschild one in Hilbert or isotropic gauge.

This approach provides a clear way of showing that the two distinct Schwarzschild spacetimes may be separated by a layer, which is a general spherically symmetric vacuum solution (1) with specific functions $\rho(r)$ and $\chi(r)$. In our toy models the interior region with unusual properties without an exotic matter is hidden behind the matching surface. Moreover, the property of interior region can be tuned by transformation of arbitrary function of solution (1). In this context, the idea of linkages for vacuum regions bounding other metrics may have broad applications.

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CONSTRAINING THE STAR FORMATION HISTORY WITH FERMI-LAT OBSERVATIONS OF THE GAMMA-RAY OPACITY OF THE UNIVERSE

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The star formation history (SFH) of the Universe is of fundamental importance to cosmology, not only to galactic formation itself but also for ongoing efforts to determine cosmological parameters and matter content of the Universe. Measurements of the extragalactic background light (EBL) as a function of redshift can constrain models of the SFH, including the initial mass function (IMF) and dust extinction. The gamma-ray spectra of AGN allow us to study the extragalactic background light (EBL) through $\gamma - \gamma$ absorption of high-energy photons. In this work, we will use a model of starlight and dust re-emission as a function of redshift leading to EBL predictions to be compared with EBL measurements from Fermi data.

VACUUM POLARIZATION OF A QUANTIZED SCALAR FIELD IN THE THERMAL STATE IN THE WORMHOLE WITH AN INFINITELY SHORT THROAT

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The study of vacuum polarization effects in strong gravitational fields is a pertinent issue since such effects may play a role in the cosmological scenario and the construction of a self-consistent model of black hole evaporation. These effects can be taken into account by solving the semiclassical backreaction equations

$$G^{\mu}_{\nu} = 8\pi \langle T^{\mu}_{\nu} \rangle,$$

where $\langle T^{\mu}_{\nu} \rangle$ is the expectation value of the stress-energy tensor operator for the quantized fields.

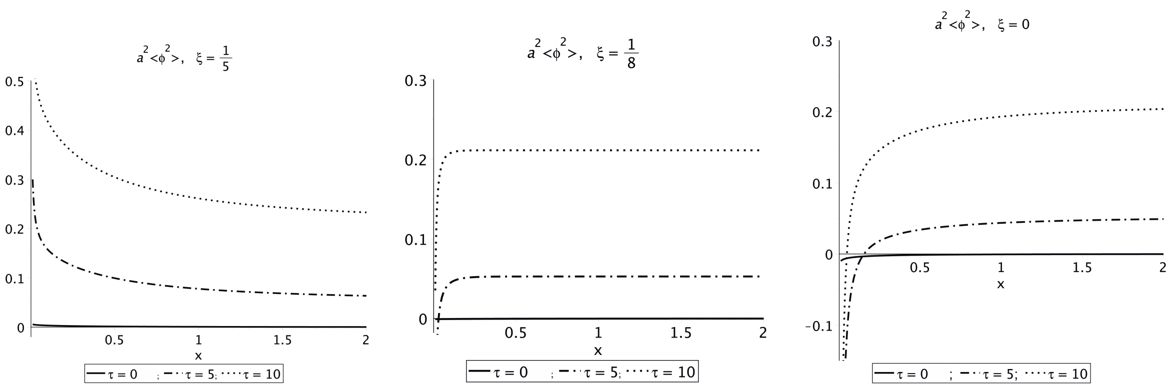
The main difficulty in the theory of semiclassical gravity is that the vacuum polarization effects are determined by the topological and geometrical properties of spacetime as a whole or by the choice of quantum state in which the expectation values are taken. It means that calculation of the functional dependence of $\langle T^{\mu}_{\nu} \rangle_{ren}$ on the metric tensor in an arbitrary spacetime presents formidable difficulty. Only in some spacetimes with high degrees of symmetry for the conformally invariant fields $\langle T_{\mu\nu} \rangle_{ren}$ can be computed and equations of the theory of semiclassical gravity can be solved exactly. Let us stress that the single parameter of length dimensionality in problem (1) is the Planck length l_{PL}. This implies that the characteristic scale l of the spacetime curvature (which corresponds to the solution of equations (1) can differ from l_{PL} only if there is a large dimensionless parameter. As an example of such a parameter one can consider a number of fields the polarization of which is a source of spacetime curvature (*it is assumed, of course, that the characteristic scale of change of the background gravitational field is sufficiently greater than l_{PL} so that the very notion of a classical spacetime still has some meaning*). In the case of massive field, the existence of an additional parameter $1/m$ does not increase the characteristic scale of the spacetime curvature l which is described by the solution of equations (1) (*the characteristic scale of the components G^{μ}_{ν} on the left-hand side of equations (1) is $1/l^2$, on the right-hand side - ${l_{PL}}^2/(m^2 l^6)$*). For the massless quantized fields such a parameter can be the coupling constants of field to the curvature of spacetime [1]. Another possibility of introducing an additional parameter in the problem (1) is to consider the non-zero temperature of quantum state for the quantized field. It is known (see, e.g., [2]) that in the high-temperature limit (when $T \gg 1/l$, T being a temperature of thermal state) $\langle T^{\mu}_{\nu} \rangle$ for such a thermal state is proportional to the fourth power of the temperature T.

In this work we have obtained an numerical approximation for $\langle \varphi^2 \rangle$ for a quantized scalar field in the wormhole with an infinitely short throat

$$ds^2 = -dt^2 + d\rho^2 + (|\rho| + a)^2 \left(d\theta^2 + \sin^2\theta \, d\varphi^2\right).$$

The scalar field is assumed massless, with an arbitrary coupling ξ to the scalar curvature, and in a thermal state at an arbitrary temperature T.

$$\langle \phi^2 \rangle_{ren} = \frac{T^2}{12} - \frac{T}{8\pi} \sum_{l=0}^{\infty} \frac{a^{2l+1}(1-8\xi)(\rho+a)^{-2l-2}}{(l-4\xi+1)} - \frac{T}{2\pi} \sum_{n=1}^{\infty} \sum_{l=0}^{\infty} (2l+1)$$
$$\times \frac{(8\xi-1) I_{\nu}(ka) K_{\nu}(ka) + ka\left(I'_{\nu}(ka) K_{\nu}(ka) + I_{\nu}(ka) K'_{\nu}(ka)\right)}{(8\xi-1) K^2_{\nu}(ka) + 2ka K'_{\nu}(ka) K_{\nu}(ka)}$$
$$\times \frac{\left[K_{\nu}\left(k(a+\rho)\right)\right]^2}{(a+\rho)}, \quad k = 2\pi n T, \quad \nu = l + 1/2. \qquad (1)$$



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THE GENERALIZED VAIDYA SPACETIME AND RELATIVISTIC STARS

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We consider the role of the Vaidya spacetime in relativistic astrophysics. This spacetime has several interesting physical applications which we consider. In particular we investigate its role in modelling a relativistic star. The spacetime may be extended so that the mass function depends on both the radial and temporal coordinates. This allows us to model a star with a generalized external atmosphere.

COSMOLOGY AND ASTROPHYSICS IN KINETIC SCALAR CURVATURE EXTENDED F(R) GRAVITY

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We consider the kinetic scalar curvature extended f(R) gravity applications in cosmology and astrophysics. This theory contains f(R) gravity but gives more freedom through a new function X(R). By using kinetic scalar curvature extended f(R) theory we investigate how it is possible to generate various cosmological and astrophysical scenarios. In

particular we investigate inflation model, models of stellar interior and stellar exterior atmospheres.

NONSINGULAR COSMOLOGY: MODERN DEVELOPMENT CONFIRMS BRICS COUNTRIES MYTHS

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The author comments his non-singular cosmological model, showing that the apparent inevitability of the singularity is due to the unjustified Abraamic religious confirmation biased Methaphysics of the authors of time-limited Universe concept and due to neglect by them the degrees of freedom of the material point of the second kind introduced by the author in the previous his publications. (See the details in: Nurgaliev I. S. Cosmology without Prejudice. Space, time and fundamental interactions. 2014, № 4, pp. 54-58. http://www.stfi.ru/journal/STFI_2014_04/nurgaliev.pdf ; and Nurgaliev I. S. World as Flow, Space, Time and Fund. Interact., 2017, №, pp. 4-25. http://www.stfi.ru/journal/STFI_2017_04/STFI_2017_04_1_Nurgaliev.pdf). These degrees of freedom are presented as vorticity in continuum description of the mater-energy.

An amateur review of Chinese ancient myths are given and those of all BRICS nations cosmological myths are mentioned as an illustrations of more adequate ones to the modern scientific cosmological observations, unbiased logic, analogy to all manifold the other systems – including mechanic ones – and honest mathematical modeling rejecting singularity prejudice.

Just like nuclear scientist of the 20th century struggled against the atomic and nuclear bomb tests after its discovery by them, it is time for cosmologists of 21st century to reveal singularity prejudice of the 20th century and trigger even more fundamental scientists initiative – to prepare manifest and international treaty draft on ban of disinformation, fake news and abuse of sophisticated scientific knowledge, especially via IT-based mass media. Especially, on global problems (climate, food, demography etc.). Science and media literacy have to be considered as new imperative. Human attention needs to be protected against unfair distraction, mercenary interception and abuse. UNESCO has to increase its activities in consolidating scientific community for this endeavor. BRICS Network University and AGAC would be appropriate platform for the endeavor in cooperation with UNESCO. International Educational programs in Gravity and Cosmology, with join faculty and student body, as well as an inter-disciplinary think tank are natural forms to appear for interaction with colleagues on new issues to emerge.

Communication between science, theology of respected world religions and philosophy needs to abolish flourishing demagoguery.

Associated professor of the Chair for Relativity and Gravitation of Kazan University V.I. Bashkov was enthusiast of such communication. We, his colleagues, students, followers and friends, have published second edition of the book of memoirs about him "Sensitivity to the Other", released for the opening of our this forum with the support of Professor Ponomarev Vladimir Nikolaevich (Moscow). The book is available to participants. You can also contribute your memory about V.I. Bashkov into a subsequent edition if you had privilege of knowing him.

MODELS OF THE EVOLUTION OF THE UNIVERSE WITH ROTATION

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According to the observations from the «Plank» telescope statistical significance of the anomaly (global anisotropy) remains low and the «Plank's» results correspond to the standard cosmological model LCDM [1]. That's why the conventional viewpoint is that the Universe is homogenous and isotropic. However there are some astronomical observations those can testify in favor of large-scale deviations from isotropy in observable part of the Universe. The first type of observations concerns researches of the radiation emitted by far quasars [2].The second type of observations is devoted to so-called spiral galaxies. Therefore, studies of the possible rotation of the Universe are relevant at the present time. The articles [3, 4, 5, 6,] are devoted to the cosmological rotation.

If one believes that there is a small rotation in the Universe, then the modern level of observational cosmology does not allow for making a conclusion on the space – time metric of the observed Universe. Therefore, in modeling the Universe with a global rotation, it makes sense to consider different Bianchi types of the metric.

In present paper, in the framework of general relativity, we have build nonstationary cosmological models with a Bianchi type-VIII and Bianchi type-IX metrics.

We considered two cosmological models with rotation, with the first model containing one rotating component, and the second containing two components. We modeled the entire evolution of the Universe using the above models, qualitatively taking into account the first inflationary stage and considering that the scale factor develops during bloat and subsequent expansion.

Model with the Bianchi type VIII metric:

A nonstationary Bianchi – VIII metric:

$$\begin{aligned}
&ds^2 = \eta_{\alpha\beta}\theta^\alpha\theta^\beta, \quad \alpha,\beta = 0,1,2,3,\\
&\theta^0 = dt - R\nu_A e^A, \quad \theta^A = dt - RK_A e^A,\\
&\nu_A = \{0,0,1\}, \quad K_A = \{a,a,b\}, \quad A = 1,2,3.
\end{aligned}$$

with 1-form

$$\begin{aligned}
&e^1 = \operatorname{ch} y \cos z dx - \sin z dy,\\
&e^2 = \operatorname{ch} y \sin z dx + \cos z dy,\\
&e^3 = \operatorname{sh} y dx + dz.
\end{aligned}$$

In this model there are 4 sources of gravity: accompanying anisotropic liquid, dust, ultrarelativistic liquid and scalar field.

Model with the Bianchi type IX metric:

A cosmological model was constructed for the Bianchi IX metric:

$$ds^2 = (\theta^0)^2 - (\theta^1)^2 - (\theta^2)^2 - (\theta^3)^2,$$
$$\theta^0 = dt - R\nu_1\omega^1, \quad \theta^1 = RK_1\omega^1,$$
$$\theta^2 = RK_2\omega^2, \quad \theta^3 = RK_2\omega^3.$$

$$\omega^1 = \cos y \cos z dx - \sin z dy,$$
$$\omega^2 = \cos y \sin z dx + \cos z dy,$$
$$\omega^3 = -\sin y dx + dz. \quad K_1^2 = K_2^2 + \nu_1^2.$$

Sources of gravity were: anisotropic fluid, pure radiation, and also a scalar field.

The dependences of the energy density of different types of matter and the scale factor on time are obtained, as well as the values of the pressure components at each stage of the evolution of the Universe and the kinematic parameters of the models are found. At all stages of the Friedmann evolution, the dependences of the scale factor on time coincide with those in Friedmann cosmology. The current rate of rotation of an anisotropic liquid (dark energy) during the evolution of the Universe is obtained, which coincides with the value of the angular velocity adopted in [3].

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REDUCED CONFORMAL GEOMETRODYNAMICS

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We demonstrated that in Geometrodynamics of closed manifolds it is possible to introduce the global intrinsic time. After application of the Hamiltonian reduction procedure, we got differential evolution equations for conformal metric components and conformal momentum densities. They do not contain Lagrange multipliers contrary to the ones obtained in [1]. In opposite to the case of asymptotically flat spacetimes, for closed manifolds we got a non-conservative Hamiltonian systems. It was assumed [2–5] that the extrinsic time is the most useful variable in dealing with Einstein solutions on spatially compact surfaces. Our approach is different since these geometric characteristics possess in our case quite an opposite essence. In general, we claim that canonical momenta are not defined within the hypersurface. They refer to the motion in time of the original Σ_t. And the intrinsic time is the variable constructed entirely out of the metric of the hypersurface. So, the roles of the Hamiltonian and global time are interchanged. Our treatment of the Hamiltonian and the global time is in accord with the general principles. The deviation from the mean value of the global time behaves as a classical scalar non-dynamical field. It deserves an additional attention to be physically interpreted. Note that it emerged without any modification of the Einstein's theory. It was conjectured [6], that the deviations from the mean value of the global time can play the role of static gravitational potentials. In the extrinsic time approach, the program of the Hamiltonian reduction carried out under the condition that the spacetime admits the constant mean curvature foliation. In opposite, we do not use any gauge yet. The reduced Einstein's flow was described by a time-dependent non-local reduced Hamiltonian. In our case, the Hamiltonian of the problem is presented in the explicit form that allows to write the Hamiltonian flow. Earlier to construct a scalar, the Minkowskian metric as a background one was used for asymptotically flat spaces [7]. The intrinsic time interval δD as a scalar field was implemented in the symplectic 1-form [8, 9]. For splitting one degree of freedom, the average of the trace of the momentum density was used as the York time in the shape dynamics [10]. The key difference of our study is the consideration of closed manifolds without the asymptotically flat space condition. Our choice is motivated by cosmological applications where models with closed manifolds are of great interest. For interpretation of the latest data of the Hubble diagram, the global time as the scale factor of the Friedmann model was successfully implemented in refs. [11, 12]. The choice of conformal variables allows to suggest a new interpretation of the redshift of distant stellar objects. Both the changing volume of the Universe in standard cosmology and the changing of masses of elementary particles in conformal cosmology [13] can serve as the measure of time. We have shown that the cosmological observable redshift effect can be directly related to the global time of the Universe. In general, we claim that the intrinsic time can be considered as an evolution parameter of cosmological evolution.

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THE CONNECTION OF THE FIELD THEORY EQUATIONS WITH THE EQUATIONS OF MATHEMATICAL PHYSICS. THE NATURE AND ORIGINS OF DARK MATTER AND DARK ENERGY

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It was shown that the mathematical physics equations, which describe material media (such as thermodynamic, gas-dynamical, cosmic, and others), possesses the properties of field theory equations.

It is well known that the mathematical physics equations, which describe material media, are composed of the equations of conservation laws for energy, momentum, angular momentum, and mass. The field theory equations such as Einstein's, Maxwell's, Schredinger's and others, which describe physical fields, are also based on the properties of conservation laws. However, the conservation laws for physical fields are the conservation laws that point to the presence of conservative quantities or objects. Such conservation laws are described by closed skew-symmetric forms. It turns out that closed (inexact) skew-symmetric forms that describe conservation laws for physical fields (the Noether theorem is an example) follow from the conservation law equations for material media.

Such a connection, which is realized discretely, discloses a connection between the field theory equations and the mathematical physics equations. This follows from the evolutionary relation that is obtained from the mathematical physics equations and corresponds to field theory equations. The evolutionary relation discloses a mechanism of evolutionary processes in material media accompanied by the emergence of physical structures that made up physical fields and the advent of a dark energy and a dark matter.

PARTIALLY BOSE-CONDENSED DARK MATTER

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Light bosons forming a Bose-Einstein condensate are attractive candidates for dark matter particles. These models produce realistic halo density profiles and can solve the missing satellites problem. The most known models are axions with masses $m \sim 10^{-6} - 10^{-5}$ eV and ultralight bosons with masses $m \sim 10^{-23} - 10^{-22}$ eV. Both types of the particles can form condensates that occupy the galactic halo completely.

We study bosons that form relatively small Bose condensates with a radius of about 100 astronomical units. These objects (which are known as Bose-stars) are part of the dark matter halos, which consist of non-condensed bosons. The halos have a minimum radius. The bosons condense to form Bose stars, and this prevents the formation of smaller halos. We found that bosons masses lying in the range between 10 and 10^3 eV are in agreement with observational data.

DE SITTER SOLUTIONS PROPERTIES IN THE GAUSS-BONNET GRAVITY

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We investigate the model with the Gauss-Bonnet term in general background. We present the Einstein and field equations in the form of a dynamical system.We consider de Sitter solutions and introduce the effective potential which determines the stability of de Sitter solutions. We illustrate our investigations by several examples including models with exponential potential, with the Higgs potential, with a massive scalar field and model with the Gauss-Bonnet interaction playing a role of the effective potential. The report is based on the paper by E.O. Pozdeeva, M. Sami, A.V. Toporensky, S.Yu. Vernov, arXiv:1905.05085.

RELATIVISTIC TIDAL EFFECTS ON CLOCK-COMPARISON EXPERIMENTS

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We consider the relativistic tidal effects on frequency shift of clock-comparison experiments. The relativistic formulation for frequency shift and time transfer is derived in the gravitational field of a tidal, axisymmetric, and rotating Earth. With the help of Love numbers describing the tidal response of solid Earth, we formulize the mathematical connection between tidal effects from the ground-based clock-comparison experiments and the local gravity tides from the gravimeters, which in turn provides us an approach to eliminate tidal influences on clock comparison with the local gravity tides data. Moreover, we develop a method of the perturbed Kepler orbit to determine relativistic effects of clock comparison for space missions, which allows more precise calculations comparing to the conventional method of unperturbed Kepler orbit. With this perturbed method, it can give the perturbation of relativistic effects due to the orbital changes under the influences of tidal forces, Earth's oblateness etc. In addition, as the applications of our results, we simulate tidal effects in frequency shift for the clock comparison on the ground and also give some estimates for TianQin mission and GPS.

DARK MATTER AND DIFFUSE RADIO EMISSION IN SPIRAL GALAXIES

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Diffuse radio emission in the form of the "Planck haze" has been detected to exist within the Milky Way. If this "haze" is a product of dark matter annihilations, it should be detectable in spiral galaxies that are similar to the Milky Way. In my research, I will use galaxy simulations to predict the existence, morphology and characteristics of the "Planck emission" of a particular galaxy and then compare the prediction to radio observations of the same galaxy. We will also look for optimal MeerKAT targets for future observations in this study.

ON THE INSTABILITY OF SOME K-ESSENCE SPACE-TIMES

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We study the stability properties of static, spherically symmetric configurations in k-essence theories with the Lagrangians of the form $F(X)$, $X \equiv \phi_{,\alpha}\phi^{,\alpha}$. The instability under spherically symmetric perturbations is proved for two recently obtained exact solutions for $F(X) = F_0 X^{1/3}$ and for $F(X) = F_0|X|^{1/2} - 2\Lambda$, where F_0 and Λ are constants. The first solution describes a black hole in an asymptotically singular space-time, the second one contains two horizons of infinite area connected by a wormhole.

MATTER INDUCED BRANES

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The extra space paradigm plays significant role in the modern physics and in cosmology as the particular case. In this report, the dependence of the main cosmological parameters - Planck mass and Cosmological constants - on a metric of extra space is discussed. The latter is characterized by a new type of brane the tension of which depends on matter distribution along the extra space. The ways to solve the Hierarchi problem are analyzed.

JOINING THE TWO ENDS: MODEL BUILDING REQUIREMENTS AND IMPLICATIONS

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We discuss the generic requirements for the paradigm of quintessential inflation. We focus on the model independent aspects of the framework and discuss the features of relic gravity waves specific to the paradigm. We also investigate the possibility of baryogenesis sticking to model independent treatment. Finally, we point out future directions for the investigations to be undertaken on the related theme.

ABOUT PROJECTIVE MOTIONS OF 4-DIMENSIONAL MANIFOLDS OF THE SPECIAL TYPE

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The work is devoted to the problem of determining of 4-dimensional pseudo-Riemannian manifolds (M,g) admitting projective motions (h-spaces). A similar problem for n-dimensional proper Riemannian and Lorentz spaces was solved by Levi-Civita, Solodovnikov, Petrov and Aminova. For pseudo-Riemannian manifolds of arbitrary signature and dimension the problem of their classification in Lie algebras and Lie groups of projective transformations, set more than a hundred years ago, is still open. In this work 4-dimensional h-spaces of the type [2,2] and [4] are determined using the method of skew-normal frame (Aminova) and necessary and suficient conditions for the existence of projective motions of the same type are established.

In order for the vector field X to be a projective motion, the following conditions are necessary and sufficient:

$$L_X G_{AB;C} = 2G_{AB}\varphi_{;C} + G_{AC}\varphi_{;B} + G_{BC}\varphi_{;A} \tag{1}$$

here $A, B = [1, \dots, 4]$, $L_X G_{AB}$– the Lie derivative of the metric G_{AB} in the direction of projective motion X, φ is the 1-form, and the semicolon denotes the covariant derivative. Equations (1) are splitted into two groups: Eisenhart equations:

$$h_{AB;C} = 2G_{AB}\varphi_{;C} + G_{AC}\varphi_{;B} + G_{BC}\varphi_{;A}$$

and generalised Killing equations:

$$(L_X G_{AB})_{;C} = h_{AB}.$$

Metrics admitting non-trivial solutions of the Eisenhart equations $h_{AB} = cG_{AB}$, are called h-metrics, and the corresponding spaces — h-spaces. The type of projective motion X and metric G_{AB} are determined by the algebraical structure of the Lie derivative $L_X G_{AB}$, defined at each point $p \in V$ by a Segre characteristic χ of the tensor $h = L_X G_{AB}$

We consider the 4-dimensional h-spaces with Segre characteristics of [2,2] and [4]. Due to the method of skew-normal frame by A. V. Aminova [1] the h-metrics of such types were obtained and investigated.

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RECENT PROGRESS ON PROBING LORENTZ VIOLATION WITH GRAVITATIONAL EXPERIMENTS IN HUST

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Local Lorentz invariance (LLI) is an important component of General Relativity (GR). The test of LLI can not only probe the foundation stone of GR, but also help to explore the physics beyond GR and Standard Model. Combining the data of the gravitational inverse square law experiments performed in HUST and Indiana University, we have limited the LLI coefficients at a high level. As the Lorentz-violation signal between two parallel plates is dominated by the edge effects, we further made a special experimental design to enhance the violation signal, hoping to test LLI at a more accuracy level. At present, the experiment is ongoing.

ANISOTROPIC COSMOLOGICAL DYNAMICS IN *F*(*T*) GRAVITY IN THE PRESENCE OF A PERFECT FLUID

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We consider cosmological evolution of a flat anisotropic Universe in $f(T)$ gravity in the presence of a perfect fluid. It is shown that the matter content of the Universe has a significant impact of the nature of a cosmological singularity in the model studied. Depending on parameters of the $f(T)$ function and the equation of state of the perfect fluid in question the well known Kasner regime of General Relativity can be replaced by a new anisotropic solution, or by an isotropic regime, or the cosmological singularity changes its nature to a non-standard one with finite values of Hubble parameters. Six possible scenarios of cosmological evolution for the model studied have been found numerically.

PRESENT STATUS OF INFLATION AND PRE-INFLATION

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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 new physics acted during the last stage of inflation could show itself would primordial black holes be found, in particular, through direct observations of their coalescence in binary systems at present. Since inflation, as a metastable quantum state, had finite life-time (and we can measure differences in its duration in terms of the number of e-folds between various points of space with remarkable accuracy), it is natural to start thinking what might be before it. In the models considered, the most generic predecessor of inflation is an

anisotropic and inhomogeneous space-time near a generic space-like singularity. Conditions needed for the onset of inflation from such a state will be discussed. 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.

PROBING THE DA AND EOR USING DIFFERENTIAL OBSERVATIONS OF THE SZE-21CM

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Probing the Dark ages (DA) and the Epoch of reionization (EoR), remains one of the challenges facing modern cosmology. Numerous probes have been proposed for exploration of these epochs and efforts are already under-way to detect signatures from them through observations of the 21cm cosmological signal, which corresponds to the 21cm transition of atomic hydrogen. Recently the EDGES collaboration claimed the detection of an absorption feature of the global 21cm background signal centered at 78 MHz. When compared to the standard 21cm models this feature appears at the correct frequency (corresponding to a redshift range of $z = (15 - 20)$) but it is larger by a factor of about two in amplitude. This work explores a recently proposed probe for the DA and EoR called the SZE-21cm, we simulate differential observations towards and away galaxy clusters using the standard 21cm models. The SZE-21cm presents advantages as it is a differential measure of the CMB spectrum on and off an area of the sky containing the cosmic structure under study, it is as a result not affected by large-scale foregrounds in observations at low-frequency. We show that observations of SZE-21cm can be carried out with radio interferometers at frequencies between 50 MHz and 250 MHz and used to establish the global properties of the 21cm background spectrum. Noting that detection towards an individual cluster may be challenging we demonstrate how computing the signal for multiple cluster samples may be beneficial and propose the use of the SZE-21cm to test results of current and upcoming experiments such as EDGES.

GERNERAL RELATIVISTIC EFFECTS IN ATOM INTERFEROMETRY

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Atom interferometry is currently developing rapidly, which is now reaching sufficient precision to motivate laboratory tests of general relativity. Thus, it is extremely significant to develop a general relativistic model for atom interferometers. Here, we studied the dynamics of the interferometer where both the atoms and the light are treated relativistically, and first gave a complete vectorial expression for the relativistic interferometric phase shift. Based on this, the detection of gravitational wave with atomic interferometers is also discussed.

AN EXPLICITLY SOLVABLE MODEL OF CORRELATIONS IN THE SPATIAL DISTRIBUTION OF GALAXIES

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An explicitly solvable model of random points distributed in 3-D Euclidean space with correlations close to observed in galaxy distribution is described. The model is based on ideas introduced by B. Mandelbrot and mathematically derived in [1-4]. In its frame, the correlations are similar to those which generated by statistical ensemble of Markov chain realizations whose nods are interpreted as galaxy positions. With the use of 3D-Levy stable lows as a transition probability, results of the simulations look close enough to observed data and can be taken as a first approximation to a real distribution in such calculations when only qualitative estimations are of interest.

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INFLUENCE OF ADDITIONS TO A NEWTONIAN GRAVITATIONAL POTENTIAL ON THE PERIHELION PRECESSION OF BODIES IN THE SOLAR SYSTEM

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Currently, there is a need to explain astrophysical observations in which unexpected behavior of some galaxies is obtained (rotation curves of galaxies, observations of gravitational lensing, etc.) [1,2]. The usual explanation is based on the assumption of the presence of dark matter in galaxies [3]. Another way of explaining this is to create theories that, on a galactic scale, somehow generalize or modify the modern theory of gravity - the general theory of relativity (GR) [4]. Typically, such theories contain one or more additional constants. The selection of the numerical values of these constants can explain the existing astrophysical observations. In the Newtonian limit (low speeds and weak gravitational fields), these theories lead to different potentials, different from the potential of the law of universal gravitation. At scales much smaller than the scales of galaxies (characteristic of planetary systems, including the solar system), these potentials lead to small corrections to the law of universal gravitation, due to the above constants of the theory. Taking these corrections into account leads to a change in the description of the nature of motion of the celestial bodies of the solar system, for example, to additional corrections in the formulas that describe the precession of the perihelion of the planets [5]. The numerical values of these corrections can be obtained if the constants of the theory are known. On the other hand, these corrections can be compared with the predictions of GR, which are verified with good accuracy by observations. An analysis of the results allows, in particular, to obtain restrictions on the constants of a particular theory of gravity.

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EXACT SPHERICALLY SYMMETRIC STATIC SOLUTIONS AND KANTOWSKI-SACHS UNIVERSES IN MODELS WITH NON-MINIMALLY COUPLED SCALAR FIELDS

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We study static spherically symmetric solutions of the Einstein equations in the presence of a non-minimally coupled scalar field and compare them with those in the space filled with a minimally coupled scalar field. We also study the Kantowski-Sachs cosmological solutions, which are connected with the static solutions by the duality relations. The main ingredient of these relations is an exchange of roles between the radial and the temporal coordinates, combined with the exchange between the spherical and hyperbolical two-dimensional geometries. A brief discussion of questions such as the relation between the Jordan and the Einstein frames and the description of the singularity crossing is also presented. The talk is based on the paper by A.Yu. Kamenshchik, E.O. Pozdeeva, A.A. Starobinsky, A. Tronconi, T. Vardanyan, G. Venturi and S.Yu. Vernov, Phys. Rev. D 98 (2018) 124028 [arXiv:1811.08213] and recent investigations.

IMPROVED FREQUENCY-SHIFT GRAVITY-GRADIENT COMPENSATION ON CANCELING THE DURATION RAMAN-PULSE-EFFECT IN ATOMIC GRAVIMETERS

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Although frequency-shift gravity-gradient compensation is currently the technique with the most potential to test weak equivalence principle with atom interferometry at a high precision, it faces an unavoidable obstacle on how to cancel the coupling between the Raman-pulse-duration effect and gravity gradient related to the atomic initial kinematics. According to Einstein equivalence principle, we develop a method to calculate this coupling effect in a space-stretching free-falling frame, based on which an improved frequency shift gravity gradient compensation technique is put forward to make the high-accuracy weak-equivalence-principle tests with the microscopic particles, such as at the level of 10^{-14}, more possible.

THE EFFECTIVE QUINTESSENCE FROM STRING LANDSCAPE

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The quintessence-like potential of vacuum energy can meet requirement from quantum gravity as well as the accelerating expansion of the universe. Since string theory only admits vacuum with negative energy density, one needs to lift the anti-de Sitter vacuum to the meta-stable de Sitter vacuum with positive vacuum energy density to explain the accelerating expansion of the universe. However the two criterion about the swampland conjecture destroys the effort. Based on the possible large scale Lorentz violation, we define an effective cosmological constant which depends not only on the bare cosmological constant known as the vacuum energy density but also on the Lorentz violation effect. We find the evolution of the effective cosmological constant exhibits the behavior of quintessence potential driving universe when the bare cosmological constant is from string landscape regime while the effective cosmological constant exhibits local minimum during evolution which certainly is caused by a meta-stable de Sitter potential in the swampland regime. The critical value of of the transition for the effective cosmological constant is approximately zero. The frozen large scale Lorentz violation can uplift the AdS vacua to an effective quintessence-like one in this sense.

OSCILLATORY SOLUTIONS IN COSMOLOGICAL MODELS AND IN A CENTRALLY SYMMETRIC SPACE IN A MODIFIED THEORY OF GRAVITY

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This work is related to research in the field of the theory of gravity and cosmology in connection with existing problems given below.

1.There is a problem of "accuracy of measurement of the gravitational constant" G. For example, in the International System of Units (SI), for 2008: $G = 6,67428 \times 10^{-11} m^3 c^{-2} kg^{-1}$; the value of the gravitational constant was obtained in 2000 (Cavendish Experiment): $G = 6,67390 \times 10^{-11}$; in 2010, the value of G was corrected: $G = 6,67384 \times 10^{-11}$; in 2013 a group of scientists from the International Bureau of Weights and Measures: $G = 6,67545 \times 10^{-11}$; in 2014, the value of the gravitational constant recommended by CODATA became: $G = 6,67408 \times 10^{-11}$. In fact, G is not determined even with an accuracy of the fourth decimal place.

2.The Λ Cold Dark Matter model ΛCDM represents the current standard model in cosmology. Within this, there is a tension between the value of the Hubble constant, H0, inferred from local distance indicators (the predicted value given in article [1] is $H_{local} = 73.48 \pm 1.66\ km \cdot s^{-1} Mpc^{-1}$) and the angular scale of fluctuations in the Cosmic Microwave Background (CMB) (as follows from [2] $H_{CMB} = 67.0 \pm 1.2\ km \cdot s^{-1} Mpc^{-1}$). These two independent measurements give a discrepancy of approximately 9% and tension with Planck+ΛCDM increases to 3.7 sigma ([1], [2]. It also follows from the above that the measurement accuracy of H_{local} is about 4.5%.

This work is the extension of author‘s research [3] - [5], where the modified theory of induced gravity (MTIG) is proposed. The equations with quadratic potential that are symmetric with respect to scale transformations are considered. The solutions of the equations obtained for the case of centrally symmetric space, as well as the cosmological model, determined by the Friedman-Robertson-Walker metric, are investigated.

Our theory is a phenomenological model used for comparison with observational data dark matter and dark energy. The aim of the work is to solve equations MTIG for the case of a quadratic potential and compare them with observational cosmology and astrophysics data.

The solutions of the equations of geodesic curves for a centrally symmetric metric are qualitatively different from the solutions of the Schwarzschild-de Sitter. The found gravitational potential contains many extremum. which become significant away from the center. For a galaxy model, with a central mass of the order of four million solar masses, these distances are more than 0.1 kpc. Due to quasi-oscillatory solutions, bands (spherical shells) are formed corresponding to the bands of gravity and antigravity. Accordingly, where the acceleration of the test body is directed toward the center, these are the bands of gravity, and where from the center are the bands of antigravity. For simplicity, we model galaxies as centrally symmetric objects with masses of about - $(10^6 \div 10^{11}) \cdot M_{\odot}$, in which the entire mass is concentrated in the center. This is justified by the fact that we are interested in the behavior of the characteristics of the gravitational field at sufficiently large distances $r > r_{cr}$, where Kepler's laws are violated. The presented model satisfactorily describes the rotation curve of galaxies and opens up new possibilities for further predictions. A classification is given (incomplete) of the types of geodetic lines.

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