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Physics Tomorrow:[*] The Proposal of New Cosmology, the Grand Universe Model

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Abstract

We propose the Alternative Cosmology, the Grand Universe Model. Here, its Physical Principles and a methodology based on Special Relativity Dynamics of gravitating matter and its Newtonian limit are presented. This is a model of the steady-state, matter-antimatter symmetric Universe in infinite space-time. The Universe is self-sustained in a process of matter-antimatter annihilation and recreation. The Model explains all basic observations. Longstanding and newly appearing problems of the Standard Cosmological Model on small and large observational scales do not arise there.

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[*] Issue 2, Emphasis on Physics. For issue 1 see [1]

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> *"The growth of knowledge depends entirely upon disagreement."*
>
> — Karl Popper, *The Myth of the Framework*

1 Introduction

Nowadays, *the Standard Cosmological Model* (SCM) having several Big Bang versions, becomes more and more mathematically complex and highly hypothetical but still it is the leading model, though, in growing doubts due to aggravating controversies and failures in dealing with puzzles. The proponents may insist that observations give us a solid scientific evidence of the existence of phenomena, which, though looking "strange" and physically unexplainable, are well fit to the Model. They used to say that, to disprove the SCM, one needs to get through a scrutiny of hundreds of parts of it. We argue, however, that no matter how many accurate observations have been accounted for, it is still a tiny sliced space-time image of the Universe in its enormity.

In retrospect, treatment of observations related to the key parameters in the SC Model, – the densities of matter and energy, seems to be instructive. The observations reveal mysterious or controversial phenomena, such as *Inflation*, *Dark Matter*, *Dark Energy*, and others. Facing a failure of physical understanding, cosmologists labeled them with names actually making the Big Bang in all its modifications the *New Physics* umbrella. In this way, the Model acquires additional degrees of fitting freedom and seems to become "a true theory", which may not be falsifiable by observations, measurements, or calculations. Such an illusion of reality can philosophically appear beneficial but only in the short term: the Model is not amenable to continuous testing, and it is ultimately doomed to fall apart. So we are talking about signs of the crisis and the quest for a true Alternative.

We state that, when "strange" (to wit, not explained) phenomena are embedded in the Model in the form of abstract mathematical structures, it is *bad New Physics*, or pseudo-Physics, actually, leading to a chain of new controversies arising with observations of progressive precision. Such mathematization of Nature leads to a disconnection of the Model from the heritage of physical knowledge, hence, a departure from physical reality. We advocate the statement that this trend damages the integrity of Physical Science [2].

Meanwhile, real *good New Physics* can and do arise from a discovery of new phenomenon, physical explanation of which comes from a development of a new theory bringing our past understanding of Physical Nature to a new, deeper level. In a true physical theory, “mysteries” and “puzzles” are expected and wanted to be scientifically explained, not labeled.

Next, we outline our criticism of the SCM concerning, firstly, the Inflation and Early stages; secondly, the metric space expansion based on Einstein’s field equations and their mathematical solutions with no proof of their validity on Cosmological scales. The reader can find more detailed criticism in [1] and related literature. Review of the Big Bang history and different cosmological models competing with the SCM is out of the scope of this work; numerous articles and textbooks is available, e.g.[3, 4, 5, 6].

The main part of this work is devoted to the proposed New Cosmology of the Grand Universe, which is based on Fundamental Physical Principles and radically differs from the SC Model. Longstanding and newly appearing cosmological problems in interpretation of high precision observations are either explained, or do not arise there at all.

2 Reasons for rejection of the Standard Cosmological Model in favor of the GU Model

2.1 The Beginning, the Early Universe, and the era of metric expansion of space

In the first place, we would never to admit an instant appearance of a space-time and a physical world there from nothing in the scenarios of the Big Bang Beginning and its Earlier Stage. There is a suspiciously detailed Bible-like picture of world passing through the Plank and the Inflation epochs of about 10^{-32} second of duration after the Big Bang (and by which clock could it be measured?). The whole scenario changes from version to version to keep the Model “fit” consistently with changing interpretations of the observed cosmological phenomena such as Cosmic Microwave Background (CMB), Dark Matter, Dark Energy, all actually not explained from the First Principles of Fundamental Physics. In this sense, the Big Bang cannot be scientifically criticized, so, many scientists refuse to accept it and, for this sole reason, reject the whole Model.

We are also critical in the part of metric expansion of space. It constitutes the main SCM part of the Observable Universe, but still remains crucially dependent on the Beginning. The metric space expansion is adopted from Einstein’s field equations and their mathematical solutions. It reflects Einstein’s original idea of gravity caused by the space-time curvature. This could be viewed as an increasing radius $R(t)$ of 3D surface embedded into

4D space-time [3].

This kind of expansion is different from that observed in a physical "explosion" of substance or gas in Newtonian space, when adiabatically expanding gas cools down due to work against pressure. Contrarily, the metric space expansion is free of forces. It is usually illustrated by an imaginary string of infinite length, when it is constantly stretched uniformly everywhere. One can momentarily fix any two points however close to each other and observe how a distance between them continuously increases exponentially in time. From extrapolating back in time, one can conclude about the singular point of "the Beginning".

In the current SC Model with the Friedmann-Lemaître-Robertson-Walker (FLRW) metric, the 4-space has a negative curvature so that the radius $R(t)$ changes non-uniformly and initially makes the expansion accelerating due to the cosmological constant, the Λ term. It comes to the scene in full swing as the new form of hypothetical Dark Energy contributing about 70 % of total Ω density and radically changes the whole Universe time-line with the only purpose, – to explain new observations of high redshifts. The latter have actually large uncertainties of data treatment in comparison with the effect.

The Model is claimed to be successful by "the fitness criterion", but it does not physically explain many phenomena and patterns observed on local and large scales, especially, recently discovered with the use of high precision technique. Examples are extremely intense "flares" and energy releases in the Milky Way and other galaxies, shining halos around distant galaxies, unusual behavior of Black Holes, and other "strange" phenomena. They are reported in publications, the list of which grows fast. As cosmologists try to understand them, more questions arise rather than clarification. New problems continue to appear with a development of observational techniques including the evidence for large overestimations of the role of Λ because of poor statistics in previous reports, [7, 8]. At the same time, there are attempts to improve confidence level in our empirical knowledge of the cosmological constant Λ, [9].

Researchers in Cosmology and General Relativity are both optimistic and skeptical about the correctness of current status of the SC Model and its GR methodological basis. For example, in the detailed review of problems [10], the issues of GR completeness on all scales, accuracy of approximations, and necessity of alternative theories are emphasized.

Detailed reviews and discussions of the unresolved problems in the SC Model are beyond the scope of this work. Let us outline some of old and new problems, which are of fundamental importance studied in the GU Model. Those problems are real but actually dismissed, or silently ignored. Among them, there are those rooted in the SCM methodology of the GR metric expansion of space:

- the matter-antimatter asymmetry of the Observed Universe
- the origin of observed Cosmic Rays of ultra-high energy
- the physical nature of observed phenomena, such as Quasi-Star Objects (QSO) and Blazars; the gamma bursts; the CMB; Dark Matter and Dark Energy
- the origin of galaxies and large scale structure of matter
- unpredicted pictures of Hubble Deep and Ultra-Deep fields
- strange behavior of Black Holes in galactic centers
- mysterious release of radiation of huge energy in the Milky Way and distant galaxies

2.2 Basic observables in the SC Model

Redshift in Hubble's diagrams

A metric expansion of the space can be characterized by a scaling factor $a(t)$, a function of time. Let t_{em} be a photon emission time, and $t_0 = t_{ob}$ is the current observation time, so that $a(t_0) = 1$.

In the Λ-CDM Model, Hubble's diagrams connect the redshift z with the distance to a receding galaxy $d(t)$. All variables are defined in "the curved space" characterized by Hubble's expansion rate parameter $H(t)$

$$H(t) = \dot{a}/a = \dot{d}/d\,, \tag{1}$$

This is a functional of the matter/energy critical density $\Omega(t)$. The latter includes dark matter, dark energy, neutrino, radiation, and a few percent of ordinary matter

$$H(t) = f(\Omega, z, H_0)\,, \tag{2}$$

where $H_0 = 67.6$ km/Mps is the Hubble's constant.

The total mass/energy density Ω takes into account all kinds of matter, Dark Energy, and radiation. Notice, it is multiplied by the Universal Gravitational Constant G in equations of Hubble plots, determining scales of of d, $\dot{d}/d$, z, and t as functions of Ω. In addition, the "supplementary" luminosity characteristic is model dependent, and it essentially influences the results.

We have the variables z, t, d, where the time t, presumably, is recorded by our Observer's wristwatch. It can be considered the look-back time $t_l =$

$t_0 - t(z)$. It is related to the age of a high red-shifted galaxy $T(z)$, hence, the Observed Universe age T_O can be calculated.

At small z, observations show linear dependences between z, d, and v_r, similar to that known from the kinematic Doppler effect. For a larger z, the concept of the cosmological redshift z is drastically different from that in Special Relativity theory.

Assessments of high redshifts requires a reconstruction of highly diffused images to fit the observations to Hubble's diagrams, which are based on mathematical solutions of Einstein's field equations. Details of high redshift observations, treatment, and fitting are available in literature, e.g. [11, 12, 13, 14]. The Λ acceleration effect is determined in the "standard candle" model, which assumes that luminosities produced in explosions of certain type of supernovae are identical. The absolute values of z are normalized in consistence with the previous (lower z) data.

The physical quantity z is the basic observable in the Model so that the fitting procedure assumes scaling space-time quantities being functions $t(z)$, $d(z)$ to be laid out on curves (1), (2). As a result, explanations of observations and predictions of new phenomena become predetermined by a Model version. The reason for a series of versions is "unfitting" of new observations. A refitting is made, mostly, by variations of abstract parameters related to Dark Matter and Dark Energy.

We reject the methodology of metric space expansion, and doubt a validity of of Hubble's diagrams, firstly, in part of non-physical (effective) redshifts z depending on the presence of hypothetical Dark Matter and Dark Energy; secondly, in part of correctness of the concept of metric space expansion claimed to be a reflection of Physical Reality. Recall, the Hubble diagrams in the Model describing the whole history of the Universe are sensitive to its Early stage scenario, particularly, to the role of such an observable as the CMB, which is one of cornerstones of the SCM. Not surprisingly, the redshift issue has its continuation in the treatment of the CMB.

Cosmic Microwave Background

The issue raised by Peebles [3] is the CMB energy balance. Since the metric expansion is a non-Euclidean space property, to wit, the space-time curvature, the expansion cannot be driven by any kind of forces and energies. However, the coefficient G in the Ω function reflects a connection of the metric expansion with Newtonian gravitation, which is characterized by a balance of potential energies with kinetic energies of motion of massive bodies. The question arises how the CMB preserves its Black-Body thermal radiation being in thermodynamic equilibrium with its environment, when the temperature T varies through the whole history of the Universe, starting from the Early stage till now. Notice, the temperature is a characteristic of energy of both matter and radiation.

Unlike in Newtonian Dynamics, the density Ω, by definition, includes all kind of gravitating stuff with only small (if any) portion of ordinary matter. According to the metric, the temperature varies as a scaling factor $a(t)^3$. However, the Stefan-Boltzmann law requires the thermal radiation density to be proportional to the temperature T^4, hence, the Ω should behave similar to $a(t)^4$ in order to preserve the equilibrium with the changing environment. The way to settle the issue is to admit (as Lemaître did) that the redshift for all kind of photons is due to photon's work against radiation pressure. In other words, the temperature $T(t)$ itself must change independently as $a(t)$, and this makes the $a(t)^4$ law. However, the admitting this fact is in contradiction with the GR concept of metric space expansion. So the problem remains open.

There are additional difficulties in the above problems. First, at *the initial high temperatures*, the classical Stefan-Boltzmann law should be replaced with its relativistic analog. Second, Cosmological Principle validates metric space stretching on scales greater than the large structure of matter in the Universe, while we are talking about the microwave radiation.

3 The Grand Universe Cosmological Model

3.1 Physical Principles of the GU Model

The idea, the framework

The GU conceptual idea was presented years ago, [15, 16, 17, 18]. It was clear at that time that a promotion of alternatives to the Big Bang Cosmology would be hard without thorough understanding of the role of GR Theory. Yet, cosmological observations were not as much numerous and precise as today. The studies have taken a lengthy time. Now, we are fully confident in our criticism of the SC Model and strong competitiveness of the New Cosmology proposal.

Among the main known cosmological problems, we consider "mysteries" of Matter-Antimatter Asymmetry and Ultra-High Energy Cosmic Rays the primary issues in Physical Cosmology. So we come to the idea attractive by its naturalness, – the model of steady-state, matter-antimatter symmetric Grand Universe (GU).

The GU is a world of gravitation. It always existed and will exist with no spatial boundaries, – there is no question about its origin. The amenable scientific questions to be asked are about an evolution of its parts and a state on the whole. The GU is in the equilibrium state due to a balance of continuous matter-antimatter annihilation and creation and a statistical mechanism of matter-antimatter separation on the largest cosmic scale.

The GU consists of finite bounded Typical Universes (TU) made of, mostly, matter or antimatter. They are stable till destroyed in a catastrophe. Therefore, we do not consider the Observable Universe the TU. On the large GU scale, the TUs can be considered either massive point particles, or insular systems characterized by masses, sizes, total energy and angular momentum.

The TUs interact gravitationally at distance and float in the infinite space-time filled with the physical Grand Universe Background. The GUB is a high-energy relativistic medium of gamma rays, particles, as well as matter and antimatter fragments. This is the place for an eternal evolution of Typical Universes interacting with each other and with the GUB itself. Notice, a physical process of matter annihilation and pair creation consists of nuclear reactions between nuclear particles rather than bulk materials. From this, one can figure out about a lifetime of the TU in the GU.

On the microscopic scale, the GUB is a physical vacuum, a field of quantum carriers of forces (the long standing problem of relativistic gravitational field theory).

Our Observed Universe in the GU

Quite naturally, Our Observed Universe (OU) is an ordinary cosmological phenomenon resulting from a collision of a pair of Universes made of matter and antimatter of different masses. This is not an explosive annihilation but rather a lengthy continuous disintegration. It is accompanied by releases of huge amount of radiation and relativistic particles as well as a huge amount of kinetics energy of flying away galaxies, which loose their binding energies. A radiation pressure creates radial forces and torques that makes Dynamics of Observed Universe quite complicated, when galaxies recede in both chaotic and somehow orderly manner. Possibly, some part of OU could survive in the form of a cluster of galaxies.

That is why, galaxies in OU, the Milky Way, in particular, must be very different from freely floating TUs in the GU. The TUs are expected to be much more bounded to the central super-massive core, more densely packed and rotate about the center, the closer to the core, the higher their masses and speed.

Our place in Our Universe occurred to be in a spatial region of initially large but limited volume containing the center of mass of colliding TUs. It is finite but too huge to clearly detect edges. For this reason, the observed picture of receding galaxies is apparently isotropic, but it could be not exactly so. So far, we are talking about Newtonian Physics, in which receding galaxies are freely moving by inertia.

The collided TUs initially had individual centers of mass with the corresponding conserved angular momenta and total energies. Yet, the system of colliding TUs acquires its own momentum due to their relative motion in their common center of mass. For these reasons, Our Observed Universe must have a resulting angular momentum and the corresponding axis of rotation. However, it is hard to directly observe it since we belong to the rotating system of both TUs. However, it could be observed indirectly. Recent researches give supporting evidence of the OU rotation [19, 20].

Main OU observables

The receding galaxies are observable in the red-shifted light coming to our place, which is significantly void of matter annihilated in a large space. We explain the observable redshift in terms of SR Dynamics, namely, the motional Doppler effect, and the effect related to the known gravitational time dilation, and some other factors. We have to analyze statistical data to assess masses, distances, and time of flight of galaxies in a random picture of the collision.

The observable Cosmic Microwave Background (CMB) is another large informative field of observations. This is the known physical phenomenon, which gives us the reference frame of the Observed Universe. We consider it a usual electromagnetic radiation, which, at present and locally, is in the thermal (Black Body) equilibrium with the surrounding matter including fragments and dust in interstellar and intergalactic space. Presumably, the CMB temperature has been decreasing during the adiabatic process of matter and gas expansion.

The scientifically amenable questions are about the GU physical properties and the OU past and future. To answer them, firstly, a completely reinterpretation of the observations is needed concerning space and time scalings, secondly, the extrapolation of OU physical parameters to the infinite GU space-time should be studied, particularly, by statistical simulation methods. This would be a challenging project of testing Classical and Modern Physics beyond their boundaries of conflicts with the observed Physical world.

Next, GU Physics is discussed in more details.

3.2 The matter-antimatter symmetry?

In literature, the problem is usually formulated in terms of Baryon Asymmetry, which should be "proved" by theorems appealing to "the first principles". We are talking about the general concept of matter made up of basic particles such as positive protons (baryons) and negative electrons (leptons) with a change of sign of charge or magnetic moment in anti-matter. Consequently, the neutron has its counterpart, the anti-neutron, and so forth. Of course, all non-stable particles from high-energy reactions have also their anti-particles. We consider this matter-antimatter symmetry one of "the empirical First Principles".

Our Observed Universe is apparently a matter dominated Universe. It can be explained by admitting an existence of multiple Universes symmetrically dominated by matter or anti-matter. One needs to think about physical conditions, in which such a picture is possible. First of all, there is a mechanism of statistical separation of matter and antimatter in the process of annihilation and creation, [18]. Yet, the TUs evolutions should be viewed in the process of their interaction with each other and with the Grand Universe Physical Background. The GUB must be a relativistic physical medium containing massive and massless matter, the product of TUs distraction in matter-antimatter collisions. At the same time, the GBU has to provide material for the TU evolving. As a result, TUs have a great variety of masses and sizes.

Our Observed Universe is not a type of TUs. It is an exemplary case of collision of two matter/antimatter TUs of significantly different sizes; one of them or both have to be perished. That is why we observe a picture of "receding galaxies", which can be thought "the Expanding Universe". Overall conditions of TUs interactions with each other and with the GUB must be just right for the GU to be self-sustained in its continuous self-destruction and recreation of the GU eternal steady state.

The question arises: is there antimatter in Our Observable Universe? We state that the antimatter is actually around in a considerable amount. It is, indeed, hardly distinguishable from ordinary matter, and its indirect consequences can be falsely recognized as "unusual" phenomena not related to the presence of antimatter. The annihilation process can take different unprecedented forms, when a release of huge amount of energy $E = mc^2$ takes place in a short or prolong time. It can be a result of collision of super-massive or ordinary stars made of matter and antimatter, or matter-antimatter collisions of a small objects making short gamma burst. It can be an annihilation of slowly colliding dust clouds and galaxy attractors, and there are more variants. In some cases, the initial matter-antimatter annihilation can ignite the fast thermo-nuclear explosion.

To sum up, next is not a full list of “unusual” phenomena, which are explained by matter/antimatter annihilation:

- annihilation of slowly colliding large clouds with gravitational attractors in quasars
- star “explosions” and gamma bursts with single releases of huge amount of energy
- universe large scale structure: walls and filaments separated by immense voids
- unusual radiation flares around the center of Milky Way and other galaxies
- X-ray busts of a huge intensity and strange phenomena of central Black Holes in galaxies

Some recent surprising observations reported in literature, particularly, in the Milky Way and other galaxies, and some parts of the Universe are referred, as as follows:

- frequent events of high intensity flares in the central MW part, also, unexplained physical properties of the BH_{mw} [21, 22, 23, 24]
- huge X-ray busts in galaxies [25, 26, 27]
- shining halos around quasars [28]

A full review of observable “strange” pictures and events, which could be considered the evidence of the antimatter presence in Our Observable Universe, is out of the scope of the present work.

3.3 The Primary Cosmic Rays and the Causality Principle

There are numerous galactic and intergalactic contributions to the observed Cosmic Rays (CR). The problem is that they contain particles of ultra-high energies $E > 10^{18}$ eV reaching values 10^{21} eV and beyond, physical origin of which is a mystery [29, 30]. For decades, physicists tried to unveil a mysterious mechanism of particle acceleration up to such an inexplicably ultra-high energy, though, physical mechanism of such accelerations are beyond a technical imagination. We state that it cannot be explained by any physically reasonable mechanism of their origination within the Observed Universe, and suggest radically new idea consistent with the GU Model.

The GU picture brings us to the issue of exposure of TUs to the GUB radiation, which is supposed to be highly energetic. The observed ultra-high CRs have so high energy that cannot be explained by any physically reasonable mechanism of their origination within the Observed Universe. The explanation of this phenomenon with no need of "acceleration" is, as follows. The Primary CRs come from the GUB radiation in the form of extremely high energy particles. During penetration through the Universe, they loose energy. The observed ultra-high energy tail is a contribution from the GUB radiation. The latter is transformed by the process of inelastic scattering leading to deceleration of primary GUB particles. Thus, the observed ultra-high energy particles come from the ultra-high relativistic tail of the GU Background (as a result of the deceleration within the Observable Universe rather than the acceleration).

We predict that the observed CR ultra-high energy tail contains antimatter particles, since the Primary CRs must be matter-antimatter symmetric, and it must contain equal amount of protons and anti-protons as well as electrons and positrons. Also, it must contain the corresponding gamma rays of ultra-high energy.

The question arises about the role of the Causality Principle in the GU containing infinite numbers of TUs and their groups, clusters, and likely further, and how it affects relativistic properties of the primary GUB Cosmic Rays. One can speculate that the GU Steady State is maintained under conditions of weakening casual connections between GU members so that a total casual disconnection eventually occurs.

A breakage of the Causality Principle on the largest GU scale leads to some consequences. Particles departed from some, say, TU-1, can travel most of the time in the GU background at a distance exceeding a scale of casual connection that is, the time exceeding a TU lifespan. The particle could reach some other TU-2 having a relative speed with respect to the TU-1 however high. A relative velocity dispersion has to grow with a travel distance. This is the idea of a statistical formation of the Lorentz invariant energy spectrum of Primary CR with ultra-high energy particles.

3.4 Randomness in the collision scenario, and hierarchy of matter clustering

Though the GU Model is fully based on the Fundamental Physical Principles, its treatment of observational data must be conducted in terms of

Statistics of randomness in complex scenarios of the TUs collision [1]. The complexity is caused by the hierarchy of matter clustering. Consequently, a reconstruction of the GU image in full space-time volume from an extremely limited sample of the OU data has an inevitable limitation of confidence. A statistical treatment is usually made by the method of trial and error within the Bayesian approach with the maximum likelihood criterion. A scientific intuition and logics of beyond customary imagination would be important in defining the prior information.

A physical explanation of the gravitational hierarchy of clustering, the origin of galaxies, in particular, is one of the fundamental problems unsolved in the SC Model. Its explanation in the GU Model we relate to "seeds" from fluctuations of densities of colliding matter and antimatter.

3.5 The SR Dynamics methodology

SR theory applications

In the GU Model, the GR methodology of particle dynamics in the SC Model is replaced with SR Kinematics and Dynamics admitting high speeds and strong fields. Under weak field conditions and slow motion, it is reduced to the Newtonian Physics. Comparison of GR and SR methodologies is discussed in [1, 31, 32], and references there. There are different physical phenomena in the GU Model, which require the methodology of SR Kinematics and Dynamics on both GU large and TU local scales. Below, some examples of SR theory applications in the GU Model are given.

- Treatment of locally observed phenomena related to strong fields there. It can be small and big gravitational attractors, such as neuron stars, on one side, and super-massive objects, on the other side. The important example is the so-called Black Hole, which can be super-massive stars (of a mass notably exceeding the Solar mass). The GR Black Hole concept assumes the gravitational collapse leading to a central singularity. In SR Dynamics, the collapse and singularities (infinities) are impossible. Therefore, we prefer to use the term of super-massive object (SMO) instead of Black Hole.The SMO can be found isolated in space or located in a center of galaxy. In vicinity of such objects, matter can reach a speed of motion comparable with the speed of light in vacuum. Dynamics of galaxies, especially, their central parts, should be considered relativistically.

- The SR methodology is needed for physical treatments of galaxy dynamical properties and the corresponding observables, for example, redshifts.

- "Unusual phenomena" characterized by a huge release of different types of energy are, basically, effects subjected to SR Dynamics treatment.
- Generally, Physics of Cosmic Rays and matter-antimatter interactions are parts of Relativistic Physics.

The concept of field dependent proper mass and physical units in SR Dynamics

The term "proper" for a mass, time, and other quantities is related, first of all, to physical quantities formulated *in the abstract proper 4-space* assuming that there is no physical "observations" outside the proper world line. The connection of proper and coordinate systems is made by means of Lorentz transformations. Similarly, in the coordinate system of observables, the term is preserved for those quantities when the imaginary observer does not conduct measurements except her/his own world line (the test particle trajectory). When "the comoving coordinate system" is introduced in the coordinate system, one should think about the observer interacting with the outside world that is, conducting measurements by information exchange with other imaginary observers.

We consider the concept of proper mass dependence on the field strength a fundamental physical concept, which should be introduced in theories of fields for any type of forces the core of contemporary SR Dynamics theory. Remarkably, it leads to the elimination of central singularity [33, 31, 34, 32], and literature there. In the conventional SR Dynamics, the constant proper mass is used, what is actually justified when the effect is negligible in a weak field. For the history of this issue and the consequences of the approximation, also see [35].

In the spherically symmetric gravitational field, consider the test point particle of the proper mass m however small comparing to the central mass, $M \gg m$. Then, the proper mass dependence on a radius is given by

$$m(r) = m_0 \exp(-\rho_0/r) \tag{3}$$

Then the potential function $V(r)$ in the radial motion is

$$V(r) = -\left(1 - \exp(-r_g/r)\right) . \tag{4}$$

where the field strength parameter $\rho_0 = r_g/r$ is fixed in the initial conditions $r = r_0$; $r_g = GM/c_0^2$ is the radius of gravitational interaction, $m_0 = m(r)$ at the initial value $r = r_0$. As $r_0 \to \infty$, the proper mass increases up to

$m(r) = m_{inf}$, the value of a free particle "at infinity" that is, in "the physical vacuum" space. Conventionally, proper masses of particles are considered physical constants. However, in the SR Dynamics they are field dependent, therefore, physical unit of mass (the kilogram) at rest is field dependent: it depends on a a radial position in the field created by a central mass.

The proper mass variation $m(r)$ immediately leads to the corresponding variation the physical unit of the standard clock rate $f = f(r)$ (the Hz) and the corresponding time unit, the proper period of a quantum oscillation $\Delta\tau(r)$ (the second). This is seen from the Einstein-de Broglie relationship

$$mc_0^2 = h\,f, \quad \Delta t = 1/f\,. \tag{5}$$

The length unit $d = c_0\,\Delta t$ (m) should be field dependent. Now, from the concept of spatial "infinity hierarchy", we come to the hierarchy of physical unit gauges. At this point, we restrain from discussions of a possible variation of fundamental physical constants such as the universal gravitational constant G, Plank constant h, and others.

The relativistic Doppler effect and the gravitational time dilation

Consider two inertial systems in a relative motion with the speed β so that the emitter of photon is in one of them and the observer's detector in the other. Both the emitter and the detector are tuned to the same proper frequency f_0. When the angle between the line of detector motion and the line of observer's sight is θ, the observed frequency f (the Doppler effect) is given by

$$f/f_0 = \gamma(1 - \beta\,\cos\theta)^{-1} \tag{6}$$

where $\gamma = (1 - \beta^2)^{-1/2}$ is the Lorentz factor. At $-\pi/2 > \theta > \pi/2$, the emitter and the detector are flying away from each other. At $\theta = \pi$, a maximal decrease of frequency (the red shift) is observed. Since the photon wavelength is $\lambda = c_0/f$, it corresponds to the increased λ. The relative wavelength effect is

$$z = \lambda/\lambda_0 - 1 = [\gamma(1 - \beta)]^{-1} - 1 \tag{7}$$

At a small speed, it is reduced to $\delta\lambda \approx \beta$. If the light is observed at $\theta = \pm\pi/2$, we have the transverse Doppler effect, which does not depend on the direction of motion [36]

$$f/f_0 = 1/\gamma \tag{8}$$

The gravitational frequency shift is a static effect. It is associated with the gravitational time dilation in the time interval $\Delta t(r) = 1/f(r)$. $\Delta t(r) =$

$\Delta t_{inf}\exp(r_g/r)$. This is the consequence of the mass/frequency decreases with the depth of the gravitational potential (3):

$$f(r) = f_{inf}\exp(-r_g/r) \tag{9}$$

with respect to the observer's frequency f_{inf} "at infinity" as $r \to \infty$. Here, the emitted photon has a frequency $f(r)$ of the atomic resonance line, say, of the atom on the surface of a central body, which creates a field. This frequency is conserved during a photon flight before it is absorbed. The gravitational frequency shift is the consequence of the proper mass field dependence, – the phenomenon neglected in the conventional SR theory [33].

For the photon wavelength $\lambda(r) = c_{int}/f(r)$, the corresponding relative effect is

$$z = \delta\lambda = \exp(r_g/r) - 1\,. \tag{10}$$

3.6 Treatment of observed astrophysical and cosmological phenomena

Black Holes

As discussed previously, the Astrophysical concept of the Black Hole phenomenon of a matter collapse into a singularity point is misconception from viewpoint of SR Dynamics. Besides, it has nothing to do with the Academic GR framework. Our arguments for the rejection of such a gravitational collapse is actually in agreement with the Birkhoff's Theorem admitting the matter-filled internal solution of the Schwarzschild metric, also with the non-singular solution originally obtained by Schwarzschild himself [37].

Undoubtedly, the physical phenomena similar to "Black Holes" do exist and are observed but with no evidence of a central singularity whatsoever. We prefer to call them Super-Massive Compact Objects (SMCOs), which create a strong field environment around them. Such gravitational (seemingly looking "compact") attractors are typically located in centers of galaxies, but could be located otherwise. The SMCO concept follows from SR Dynamics of particles having field dependent proper masses [38]. There are no any singularities in SR Dynamics. From (3), the SMCO binding energy is characterized by the proper mass defect $\Delta m = m(r) - m_0$, which could be a large part of its proper mass at infinity.

Astronomers try to find some evidence of star orbits approaching the no-return point,– the Schwarzschild radius $r_{sch} = 2\,r_g$, which is the GR event horizon. As of today, astronomical instrumentation allows them to observe such conditions when a star should be "swallowed" by the Black Hole at the r_{sch} point. In SR Dynamics, the event horizon does not exist in principle.

We must completely ignore the GR concept of "gravitational collapse into a central point", and forget about the the GR Schwarzschild radius concept. Instead, we should accept the existence of material spheres of any radius and the finite mass density.

Our BH problem formulation and the corresponding observation goals are very different from that in the SC Model. For example, consider the so-called G2 object, observations of which showed its passing to the MW central SMCO (Sgr A*), probably, as close as $R \approx 1 \times 10^{12}$ m (and maybe closer), seemingly, to be "swallowed", but it has survived [21]. Observations, which are treated in the GR framework, allow to somehow evaluate the mass of Sgr A* about $5 \times 10^6\ M_\odot$. However, its radius R, therefore, the mass density d, remain uncertain. In the SR framework, having the mass of Sgr A* reasonably varied, one can assess the range of its mass density and then to evaluate the best possible values of R and the closest point the star could reach. This is a real goal to prove the existence of "the material sphere" inside the Schwarzschild internal region. The positive result would immediately disprove the validity of the GR theory.

Neutron Stars

A typical Neutron Star seems to be a very compact, high density object having a mass of several $M_\odot$. In GR terms, it is not considered the Black Hole. In our methodology, the Neutron Stars and the SMCO objects have one common property: they all are characterized by finite size and finite density. There could be a difference, however. Densities of the SMCO objects can be very low, what follows from mass-density curves.

Recall, the gravitational radius r_g of a massive body M depends only on mass

$$r_g = \frac{G\,M}{c^2}\,. \tag{11}$$

On the other side, given M, we have the radius of material object R as a function of the mass density d

$$R = \left(\frac{3\,M}{4\,\pi\,d}\right)^{1/3}\,. \tag{12}$$

Among r_g, R, M, and d, any two parameters can be considered independent variables. We are interested in the mass-density functions.

The mass-radius relationship in Neutron Stars is subject to multi-aspect studies [39, 40].

In our methodology, it is natural to admit the existence of the maximal universal ("nuclear") density d_{nuc}. Let it be fixed under the condition $r_g =$

$R(d_{nuc}) = \tilde{R}$. The assumption imposes a strong constraint on the parameter variations. Indeed, it determines a unique object of minimal mass and size, we would like to call the Neutron Star. Moreover, the devision of masses into two clear categories follows: the condition of $M < \tilde{M}$ leads to $r_g < \tilde{R}$, and the condition of $r_g > \tilde{R}$ leads to $r_g > \tilde{R}$. Consequently, the condition of strong field $r_g > R$ is satisfied for all SMCOs of masses $M > \tilde{M}$ of low densities. It is seen now that the term of "super-massive compact objects" is justified by the fact that they are "seen too small to be super-massive".

In a more detailed considerations of the Neutron Stars, we have to account for the object spin and its "pulsar" properties.

The maximal nuclear density d_{nuc} would correspond to the value obtained from the proton proper mass and its radius, hence, the density d_{nuc} characterizes electric properties of matter. By definition of maximal mass density, it is constant in the material sphere. There are controversies and problems about the proton radius. There is a variety of Astrophysical Neutron Star models based on the nuclear matter state. They all suggest a radial variation of $d_{nuc}(r)$ inside the cosmic material body in the GR framework formulation so that the density inside the core $r = r_{sch}$ essentially exceeds the nuclear density. Because of the GR restriction $R > r_{sch}$ (which is arguable in the SR Dynamics), treatments of NSs observations and the corresponding evaluations of their mass and size are aggravated by different model assumptions [39, 40, 41, 42, 43, 44]. Alternative studies of NSs will be important, particularly, on subject of the existence and the value of the universal maximal matter density. Unfortunately, the Standard Particle Physics Model does not take a lead in Cosmology.

More questions are remained open. One of them is – why some NSs are pulsars while others seemingly not. To our knowledge, stationary material objects in free space have conserved total energy and angular momentum, they cannot radiate. Hence, they are not luminous that is, not visible. To radiate, they should inelastically interact with surrounding matter and have a "internal " viscous" structure. In the conventional NS concept, NSs must have a spin, but, unlike BHs, they must also have an intrinsic magnetic momentum. These properties, combined with the so-called matter accretion, create a hydrodynamical mechanism of generating a beam of radiation. When the NS accidentally casts a light through Earth's line of sight, we see its pulses with the frequency of NS rotation. This picture is highly hypothetical; it is drawn with many independent assumptions, which do not make the whole theory of the phenomenon.

We do not believe in "beams sweeping over the Earth", and hypothesize of the existence of another, much more effective and powerful mechanism of pulsations, in which the proper mass of absorbed matter is converted into radiation. One has to accept the SR Dynamics framework with a relativistic quantum field extension. Without going into details, let us think about a unique cosmic object of minimal mass and size. In the ideal quantum-relativistic model, it could be the stationary state satisfying the condition $r_g = R = \tilde{R}$. It has the critical mass $\tilde{M}$ in "the physical vacuum". One can speculate, for example, about the nuclear (proton-electron) Bose condensate in the ground state. In reality, the object is hit by surrounding debris. Due to the additionally accumulated matter ΔM and quasi-stationary conditions at $r_g > \tilde{R}$, resulting in excitations of meta-stable states of the Bose condensate. The accumulated mass ΔM potentially serves as a fuel to be converted into radiations through continuous transitions to the ground state.

Likely, the object has a form of oblate spinning spheroid. In the SR Dynamics, the spin axis undergoes a precession, which could be accompanied with a radial pulsation of the object in the resonant mode. This pulsation triggers the radiative quantum transitions to the ground state. Its frequency can be greater then the spin frequency. The intensity of the radiation and its frequency can slow down over time with "the fuel store" running out. "The slowdown effect" is observed, [45]. Unlike the conventional treatment of NS observations, our speculations could be good New Physics having a firm ground and potentially perspective for the unification of gravitational and electromagnetic fields [46].

We think that all neutron Stars must be "pulsars" characterized by small masses of huge density in a narrow range. An essential part of them are not visible. They are as strong attractors as SMCOs able to form bounded galaxies. At the same time, an existence of isolated SMCO of different masses is statistically not restricted. For example, there are reports on 'intermediate Black Holes" observations [47]. In the GU Model, the NS phenomenon must be an ordinary one rather than a peculiar result of the TU collision scenario. However, the current SCM assessments of NSs masses, sizes, as well as their location and distances should be revised.

High redshifts

The "high redshift" phenomenon must be treated in terms of gravitational shift of atomic lines under the condition $\rho_0 = r_g/r > 1$, which all SMCOs satisfy. The redshift is defined in accord with the wavelength shift $z = \delta\lambda = \exp(r_g/R) - 1$ (10). The z values for typical SMCO rapidly grow with M. It should be noted, however, that the equation is obtained for statical conditions and a non-rotating object. Correct redshifts from sources in highly strong fields should be found from the SR Dynamics equations of matter motion in the vicinity of SMCO.

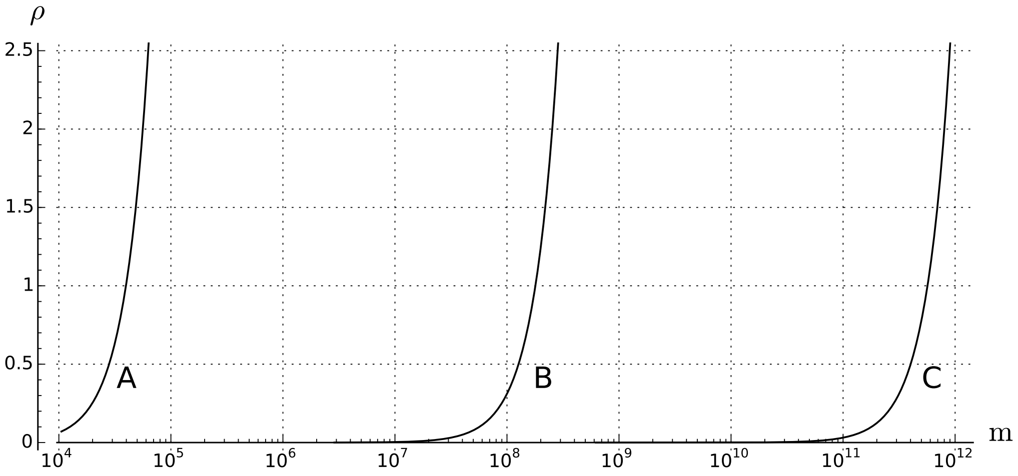

Figure 1: Gravitational field strength at the surface of a massive body depending on radius for different densities: A – nuclear density 2.04×10^{17} kg/m^3, B – 1×10^{10} kg/m^3, C – 1×10^3 kg/m^3.

In Fig. 1, the realistic values of ρ_0 giving the redshifts up to $z \approx 10$ are shown in examples of SMCOs of intermediate and small densities, according to

$$\rho = r_g/R = \frac{G}{c^2}\left(\frac{4\,\pi\,d\,M^2}{3}\right)^{1/3} . \tag{13}$$

For decades, many famous astronomers, such as Arp, Burbidge, and others, argued that some quasars with high redshifts are, actually, linked to close objects such as nearby galaxies of low redshifts [48, 49, 50]. They introduced the notion of "intrinsic redshift", unfortunately, they could not explain the physical nature of it. In the GU Model, the high redshifts depend on SMCO masses, so that objects of high redshifts *statistically* can be located closer than objects of lower redshifts or even be linked to them. Now, there is some understanding among Physical community that the Universe must be somehow disordered, which is actually observed but not widely recognized [51].

3.7 Our Observed Universe

The Milky Way before and after the collision

Our Galaxy, the Milky Way (MW), we live in, is a well studied part of Observed Universe. This is a type of spiral disc with a massive "Black Hole" (SMCO$_{mw}$), called Sgr A*, at the center surrounded by a bulge [52, 53, 54].

There is no evidence of the Sgr A* gravitational collapse, physical reality of which is actually argued in literature, [55, 38]. In our methodology, the SMCO_{mw} has a finite size, and a finite mass density.

Stars orbiting Sgr A* have been studied for a long time. It was assumed that the observed orbits are not too close to the center, hence, can be described by Keplerian model (see discussions and references in [1]). There are more new information is expected from the continuous observations, including the G2 object, with progressing precision.

In the collision scenario, the age of the observed MW galaxy could be approximately assessed, provided the random statistics of the complex history taken into account. Likely, the Galaxy had existed in some mature form before the collision of the two TUs. It is reasonable to suggest that the original MW had been old enough and reached a state of maximal mechanical stability. Such a state requires some optimal conditions to reconcile an extreme binding energy, on the one hand, and the extreme angular momentum, on the other hand. Such a system of stars could rotate about the central attractor of a great mass and density, forming a thick galaxy disc and orbits of minimal eccentricities with no bulges and no spiral arms.

The observed MW structure has been developing during the collision when the galaxy matter was significantly washed out by antimatter. What is survived is currently observed as the galaxy in a nearly decaying state. The Sgr A* has the mass appreciably less then the rest of the galaxy, because the original SMCO_{mw} of much greater mass was destructed during the collision. The bulge formation, flares, and "strange phenomena" are examples of the consequences.

Likely, the SMCO_{mw} mass was about two orders greater than at present; the total mass of stars was greater as well. Originally, the MW was a strongly bounded system, but the collision dramatically changed it. Its binding energy significantly decreased while a great amount of matter lost. Spiral arms were formed in the weakest parts of the disc.

Space-time scaling of the receding galaxies in the Observed Universe

Assume, arbitrarily, that we (the Observer) has stayed in the center of mass of the two colliding TUs, $r = 0$, in some MW space, which has a low matter density due to an intense matter annihilation. "Right now", at $t = 0$, we see a picture of galaxies at points in the whole range of radii r, from which the light may come back to us.

There is a practical limit of depth of observations $r = R$ due to space opacity and "fading" of light signal with r. Let it be $R = 60$ light Gyr so that the light was emitted from galaxies there at the time $t = -100$ Gyr. "The collision peak" might happened somehow earlier or later, while the colliding galaxies might have initial sizes, say, $20 - 30$ light Gyr across, so that the volume of "the collision peak" could be some sphere $R_{col} < R$.

We expect a slow motion (Newtonian Dynamics) picture of receding galaxies with various radial velocities, let it be mainly within the range $\beta < 0.1$. Hence, some survived galaxies from the both colliding TUs would have enough time to reach the maximal distance R. Clearly, such a slow motion will make small corrections to a static picture, hence, should not significantly change our measurements of time-space scales.

The Observable Universe must look very much like a statical picture made by an instant snap. We detect light (photons) coming from galaxies located on spheres of radii in the range $r < R$. Measurements should give us a function $r(t)$ describing slow motion Kinetic of the receding galaxies. Very roughly, assuming the initial condition $t = 0$, $r = 0$, we have a simple expression for $r(t)$ in the range $r < R$

$$r = t \tag{14}$$

with the corresponding maximal time of photon flight $T = R$.

From the above imaginary and simplified picture of galaxies in the suggested TU collision scenario, it is seen that direct measurements of space-time Kinematics of receding galaxies would reveal only a very small part of the collision history.

Having this said, we did not yet specify the methods of measurements of real function $r(t)$. In practice, one needs to determine directly observable physical variables of the model, such as velocities β, luminosities L, redshifts z, and others, in their interplay in the GU Model based on the SR theory and its Newtonian limit.

Besides, one needs to account for randomness of observable events. Due to randomness of the collision process, there cannot be strict correlation of r, t, L, z, β. Ideally, one would want to independently parametrize every single observed galaxy to unfold GU physical images from the GU predicted physical images.

At the same time, there must be a tendency of order, as noted before. For example, the galaxies, which had a greater chance to escape, might fly farther away being less damaged. Originally, they were more massive and more compact objects, than we observe. Still, they are local sources of strong field. Consequently, their light must be observed from longest distances and greatly red-shifted, up to maximal values of z.

Anti-matter in Milky Way

This issues is previously discussed in the context of observed "unusual" flares and releases of huge amount of energy in Milky Way and distance galaxies, as well as in intergalactic space. We relate such natural phenomena with matter antimatter annihilation, which could be realized in different forms provided the antimatter material objects are present and involved. For example, collision of pair of matter and antimatter stars, a matter (antimatter) star and antimatter (matter) debris and dust clouds, the same could be true with antimatter neutron stars, and, at the next level, antimatter SMCOs (Black Holes). Reports on observations and study of such events grow fast, particularly, concerning the Sgr A* object and QSO objects. On the OU scale, we explain the large matter structure of the Observed Universe by matter being burnt out during the collision.

We think that the annihilation phenomena must be observed and, likely, have been numerous times, in the Earth's atmosphere, for example, due to the presence of antimatter-made asteroids, meteors, meteorites, and debris. It is still hard to assess the relative amount of antimatter in the Observed Universe; however, there is much more of it than previously thought.

Dark Matter issue

Historically, the existence of the gravitating invisible matter was suspected due "flat rotation curves" measured by the Doppler effect technique from observations of stars' orbital velocities. They argued that the observed rotational curve cannot be explained by the Newtonian (Keplerian) model of orbits, and the "Dark Matter halo" is needed to explain the observed picture of the Milky Way and other spiral galaxies. However, the Keplerian model is valid only for non-interacting stars, what is not true in the galaxy case. The correct description requires a model accounting for the MW Dynamics state and interactions of the stars, for example, a complex model of N-body numerical calculations. Some authors state that the flat rotational curve can be also explained in a simplified approximate model with some additional assumptions about the galaxy physical structure, [56, 57, 58],

In fact, the Dark Matter along with the Dark Energy is needed in the SC Model, first of all, to reconcile numerous contradictions in the GR concept of metric space expansion. First of all, it concerns a description of the whole Universe history and the CMB concept of relic radiation.

Clustering and galaxy evolution in the GU Model

The GU collision scenario suggests that, in any mature TU before collision happened, galaxies must be dynamically much more stable that is, more bounded and have a higher angular momentum, compared to what we see in the MW. In other words, in a physically "normal" (typical) Universe, the concept of gravitational clustering at the galaxy level should depict pictures essentially different from what we observe and study in the SC Model. Central attractors in galaxies must have a greater mass and a mass density, the galaxies must be more compact and heavy, their stars must strongly interact with each other, and for this reason, the galaxies must not have spirals. Each galaxy has its own lifetime evolution, generally, from the "embryonic" state to the age of maturity till collision catastrophe. The destroyed galaxies are replaced with newly born ones originated from remnants. This picture gives a clue for the solution of the galaxy origin problem. Also, it makes the GU as a whole self-sustained and recreating.

The question arises, though, how the hierarchy of clustering, including the galaxy formation, is theoretically explained. In our view, the cluster hierarchy exists due *gravitation* in combination with a low scale matter non-uniformity. The latter is produced under conditions of presence of antimatter (matter) in a galaxy made of matter (antimatter). In other words, the matter-antimatter asymmetry at some low level must be a natural property of galaxies. During an annihilation in a collision, matter-antimatter tends to statistically separate rather than being completely destroyed. This makes the continuous process of annihilation and particle pair creation in a perfect balance in the largest GU scale. To confirm this picture, one needs to mathematically simulate the GU Model using the whole arsenal of Fundamental Physics and Applied Mathematics.

4 Concluding Remarks

In our quest for comprehension of physical world at a new level, we respect the succession of Physical knowledge, and hope that methodological novelties of the proposed GU Model will shed light on relationship of Cosmological Science with Fundamentals of Classical Physics as well as Modern Physics branches. In brief, we claim:

- The GU Cosmological Model is radically different from other models. It has an explanatory and predicting power owing to its conceptual methodology based on Newtonian Physics and contemporary SR Dynamics. The Model gives a physical explanation of "expansion" of the

Observable Universe and its “Beginning”.

- The GU Model is constructive since questions are formulated in the form revealing the roots of certain unsolved problems in Cosmology; it gives clues for their resolutions.
- The GU Model is enlightening since physical issues are raised in greater generality to the extent, where validity of Fundamental Physics Principles become questionable. It opens a new room for deeper exploration and comprehension of the harmonious Physical Nature.

Good conceptual ideas having a common sense are rarely completely new. Working on our proposal of the Alternative Cosmology, we have recognized them, one after one, in old alternative models, listed below. The wonderful thing is that those ideas are harmoniously reconciled in the GU Model, which is drastically different from any of old ones:

- Matter-Antimatter symmetry (the Plasma Universe)
- “The Beginning” with the following “space expansion” (Lemaître’s primeval atom, and the Big Bang)
- continuous matter recreation (the Steady State Cosmology, and string collisions in “Brane world”)
- Multiple Universes (in different cosmological versions)

The proposed Alternative outlines the new cosmological framework for further numerical studies, as expected from any new physical model or a theory. There different perspective project proposals are seen. First of all, a full reinterpretations of observational database and the corresponding reassessments of space-time scales in the Observed Universe is needed. Yet, the likely pictures of GU past and future, beyond observations, should be recreated, particularly, with the use known methods of numerical simulation. A special project must be devoted to the presence of antimatter in the Observed Universe, and more.

We hope to find many interested supporters and critics of the Alternative among scientists involved in Cosmological and Modern Physics researches, first of all, Astronomers and Astrophysicists as well as Physicists, Mathematicians, and, possibly, Philosophers.

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