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The gravitational-optical methods for examination of the hypothesis about galaxies and antigalaxies in the Universe

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Abstract. The optical-gravitational methods for distinction between photons and antiphotons (galaxies, emitting photons and antigalaxies, emitting antiphotons) in the proposed *hypothesis* of totally gravitationally neutral (TGN)-Universe are considered. These methods are based on the extension of the earlier proposed the gravitationally neutral Universe concept, including now gravitational neutrality of vacuum. This concept contains (i) enlarged unbroken baryon-like, charge, parity and time and full $\pm M_{\mathrm{gr}}$ gravitational symmetries between all massive elementary particles–antiparticles, including (ia) ordinary matter (OM)–ordinary antimatter (OAM), (ib) dark matter (DM)–dark antimatter (DAM) and (ii) the resulting gravitational repulsion between equally presented (OM+DM)-galactic and (OAM+DAM)-antigalactic clusters, what spatially isolates and preserves their mutual annihilations in the large-scale TGN-Universe. It is assumed the gravitational balance not only between positive and negative gravitational masses of elementary particles and antiparticles, but also between all massless fields of the quantum field theory (QFT), including the opposite gravitational properties of photons and antiphotons, etc, realizing the totally gravitationally neutral vacuum in the QFT. These photons and antiphotons could be distinguishable optically-gravitationally, if one can observe a massive, deviating OM-star or a deviating (OM+DM)-galaxy from our galactic group, moving fast enough on the heavenly sphere, crossing the line directed to spatially separated far-remote galactic clusters (with the visible OM-markers, emitting photons) or antigalactic cluster (with the visible OAM-markers, emitting antiphotons).The deviations and gravitational microlensing with temporarily increased or decreased brightness of their OM and OAM rays will be opposite, indicating the galaxies and antigalaxies in the Universe.

1. Introduction

The cosmological phenomenon of dark energy (DE) is the recent experimental discovery (made by Perlmutter, Schmidt and Riess *et al* about 20 years ago) of the very surprising—accelerated expansion of the Universe [1,2]. These cosmological observations and measurements have shown that in the Universe dominates a mysterious dark energy. The total energy density of the Universe consists of the positive-repulsive energy density part (DE $\simeq 70\%$) and the attractive energy density ($\simeq 30\%$) of unknown dark matter (DM $\simeq 25\%$) and known ordinary matter (OM $\simeq 5\%$). This specific $\mathrm{DE}_\Lambda > 0$ density is artificially introduced—this positive density part is

missing in the empirically completely flat (OM+DM)-Universe with the correspondingly critical energy density. The modern classical cosmological Λ-CDM model contains:

(i) gravitationally attracting cold dark matter (CDM) plus OM;

(ii) purely hypothetical—gravitationally repulsive—positive vacuum energy density ($DE_\Lambda > 0$) with the corresponding hypothetical cosmological constant $\Lambda > 0$.

Einstein intuitively introduced this positive-repulsive value Λ into the field equations of the general relativity (GR) to construct a presumably finite and static—noncollapsing Universe, filled with attractive matter, where the $\Lambda > 0$ prevents its gravitational collapse [3].

The GR theory was historically formulated before the discovery of ordinary antimatter (OAM). The GR is based on the well experimentally (for OM–OM gravity) tested empirical equivalence principle (EP), assuming that all types of matter will have identical (attractive) acceleration in gravity field. According the EP, the OAM must also gravitationally attract OM, however the OM–OAM gravity was not yet possible to prove experimentally, because of extremely high sensitivity, needed in these gravity tests [4–6]. The assumed OM–OAM attraction (despite the absence of any direct experimental verification) was accepted and deeply affected in modern cosmology. Indeed, two basic circumstances—the assumed (i) attractive OM–OAM gravity and (ii) the totally unbroken fundamental OM–OAM (baryon–antibaryon) symmetry lead together to the dramatic cosmological consequence—to the total mutual OM–OAM annihilation after the Big Bang (BB). These attractive counterparts must be strictly equally created and later equally annihilate after the BB. On the contrary, cosmologists find plenty of attractive OM and DM in the Universe, but detect practical absence of massive gamma flashes, which must accompany the sporadic massive OM–OAM collisions and mutual annihilations in the Universe (if the OM–OAM counterparts yet exist and are gravitationally attractive).

These observations created widely accepted (but, we suppose, illusive, as is explained below) conviction about the total "absence" of massive OAM in the Universe [7]. Sakharov hypothesized that antimatter could disappear in the Universe because of very small ($\simeq 1/10^{10}$) violation of the fundamental (baryon–antibaryon) symmetry in the past, so today the rest is only material— totally matter–antimatter asymmetric [8]. The current (OM–OAM)-asymmetric cosmological Λ-CDM model of the Universe is based on this hypothesis of the fundamental baryonic symmetry violation and considers the only gravitationally attractive (OM+DM)-matter counterparts, with absence of the (OAM+DAM)-antimatter counterparts, fully annihilated after the BB. The self-consistent asymmetric Λ-CDM model includes the totally unknown—hypothetical positive vacuum energy DE density ($\Lambda > 0$) to explain the discovered accelerated Universe expansion and its quasi-flatness [1,2]. The DE problem, the related DE–DM-finetuning problem and the baryon symmetry violation nature remain the biggest physical problems in frames of the "asymmetric" Λ-CDM cosmology [9]. Weinberg writes, the discovery of DE "is of great importance, both in interpreting other observations and as a challenge to fundamental theory. It is profoundly puzzling why the dark energy density is so small [10, page 56].

The paper is organized as follows. After Introduction we discuss in section 2 the hypothesis of gravitational neutrality of the Universe. The consequences of gravitational neutrality for physical vacuum are considered in section 3. In section 4, we propose the gravitationally-optical method for distinction of clusters with positive and negative masses, which can be used to testify by astrophysical observations the main hypothesis about gravitational neutrality of the Universe. The generalization of the lensing method in cosmology for the case of two types of masses, when the antilensing can play a role is considered in section 5. Gravitational blueshift–redshift effects in the TGNU-cosmology are estimated in section 5. The conclusions are given in section 7.

2. Hypothesis on totally gravitationally neutral Universe

The proposed paradigm of the TGN-Universe fully restores cosmological symmetry and includes the gravity charges symmetry with the resulting (OM+DM)–(OAM+DAM) antigravity. The precursor for this paradigm is the hypothesis by Shiff about antigravity between OM-particles and OAM-antiparticles [11].

The TGNU concept simultaneously solves five fundamental cosmological problems:

(i) discloses the physical DE-nature, because the hypothetical vacuum energy density $DE_\Lambda \simeq$ 70% is practically replaced by the internal positive repulsive gravity energy (RGE) density part $RGE_{GNU} \simeq 70\%$ in the totally symmetric TGNU-crystallized state with the attractive gravity energy (AGE) density part $AGE_{GNU} \simeq 30\%$;

(ii) the DE–DM—finetuning becomes natural as the ratio $\simeq 70/30$;

(iii) this quasi-stable ratio explains the observable steady quasi-flatness of the large-scale Universe;

(iv) the gravitational vacuum energy density contribution becomes zero ($DE_\Lambda = 0$ and $\Lambda = 0$);

(v) the unbroken baryon symmetry is restored. So, the TGNU-paradigm with the restored–unbroken (OM+DM)–(OAM+DAM) baryon-like counterparts symmetry together with the gravity charges symmetry allows break out of the asymmetric Λ-CDM "deadlock".

The symmetric TGNU-model with equally presented (OM+DE)–(OAM+DAM) counterparts provides a holistic physical explanation of the DE nature with $\Lambda_{vacuum} = 0$ and the large-scale homogeneity in the large-scale Universe [12–15]. The TGNU-model also explains the unified physical nature of the decelerated–accelerated expansion of the Universe and also gives the first reasonable explanation of unknown nature of the regular bubble structure of the Universe as stages of its inevitable decrystallization [14]. These strongly dominating DM–DAM components in the (OM+DM)–(OAM+DAM) Universe are always in the quantitative balance in the weightless large-scale Universe.

Schiff proposed hypothesis of the repulsive OM–OAM gravity in 1958 [11], but it was unpopular till the unexpected discovery of accelerating Universe expansion in 1998 [1, 2]. The self-consistent TGNU-paradigm (including the dominating DM–DAM counterparts) requires radical generalization of the repulsive matter–antimatter gravity hypothesis [11] to the gravitational repulsion between equally presented composite (OM+DM) and (OAM+DAM) counterparts. The OM–OAM (and the DM–DAM) repulsive gravities where predicted theoretically and are naturally substantiated in frames of the considered TGNU paradigm [12–15]. This means an additional $\pm M_{gr}$ gravitational mass symmetry in the expanded fundamental matter–antimatter CPT (charge, parity and time)–symmetry $\rightarrow \pm M_{gr}$ CPT—symmetry between the OM–OAM counterparts and between the OAM–DAM counterparts. This additional gravitational "charges" symmetry is crucial in the TGNU-cosmology, because it protects the totally symmetrically created (OM+DM)-matter and (OAM+DAM)-antimatter via the BB against the complete annihilation and protects existence of the survived weightless (OAM+DM)–(OAM+DAM) symmetric Universe.

3. The consequences for the gravitational properties of vacuum in TGNU

Therefore, we can suppose that the TGNU-vacuum also possesses exactly zero own gravitational mass density properties. Moreover, cosmological constant $\Lambda_{TGNU} = 0$, because the missed repulsive energy density $DE_{\Lambda\text{-CDM}} \simeq 70\%$ (widely assumed to be the vacuum energy contribution in the standard cosmology) is fully covered by the $RGE_{TGNU} \simeq DE_{\Lambda\text{-CDM}} \simeq 70\%$ and is the repulsive gravity energy density of the TGNU mixture itself. So, the (OM+DM)–(OAM+DAM)-symmetric TGNU-concept excludes the positive vacuum energy density hypothesis and brings essentially new and transparent physical explanation of the DE-nature.

Astronomical observations testify that the vacuum fields lead to very small positive energy $DE_{obs\,V} \leqslant 10^{-8}$ erg/cm^3 and the respective effective mass density of vacuum $\rho_V \leqslant 10^{-29}$ g/cm^3 and its energy $\varepsilon_V \equiv DE_{gr\,V} = \rho_V c^2$ (with $\Lambda = 8\pi G \rho_V / c^2$) [16]. The respective gravitational repulsion seems to be the cause of the accelerative Universe expansion [1, 2]. We remember (contrary to the mentioned above—widely accepted astrophysical "vacuum energy density" position) this tiny positive energy density is the physically transparent intrinsic positive (repulsive) gravitational energy density of the (OM+DM)–(OAM+DAM) crystalloid mixture [14]. In the quantum field theory (QFT), according Weinberg, "the contribution of quantum fluctuations in known fields up to 300 GeV, roughly the highest energy at which current theories have been verified, gives estimation" of the vacuum density ρ_V "about 10^{27} g/cm^3" [10, p 57], where 300 GeV corresponds to 320 M_{proton}. So, the nature of the empirically so low $DE_{obs\,V} \simeq 0$ remains the crucial problem of modern physics. The totally symmetric cosmological paradigm of the TGN-Universe with the extended $(\pm)M_{gr}$ CPT-symmetry adopts the Einsteinian EP to the symmetrically presented matter–antimatter (OM+DM)–(OAM+DAM)-counterparts and this helps to solve the gravitational vacuum energy density $DE_{gr\,V}$ problem in cosmology.

At the same time, the TGN-Universe concept naturally supports the microscopic gravitational neutrality (microscopic weightlessness) of the (DM)–(DAM)—expanded QFT-vacuum (now including also canceling of the gravitational masses of the OM–OAM and DM–DAM fields, (additionally to canceling their electrostatic charges). TGN-Universe concept allows keeping zero gravitational mass density $\rho_{gr\,V}$. The model under consideration adds the gravity "charge" symmetry in various virtual processes in vacuum, which are restricted by the conservation of electric charge, spin, baryon, lepton and other charges [17, p 317], keeping e.g. zero average electrostatic charge density, as also zero gravity "charge" density in vacuum.

According to QFT the vacuum in the Universe is made up of matter fields whose quanta are fermions (e.g., electrons and quarks) and force fields, whose quanta are bosons (i.e. photons and gluons) and all these fields have zero-point energy [18, p 35]. Gross writes: "The real puzzle with the cosmological constant is its absurdly small magnitude at the moment and that there is no good explanation for" and also "why matter and the cosmological constant are of comparable magnitude is a puzzle" [19]. It is naturally to conclude, that physicists "have every reason to believe the mysterious relation implied by the vanishingly small value of the cosmological constant indicates that discoveries as important as these remain to be made" [20]. For example, the "electroweak vacuum energy density, caused by Higgs field, is predicted to be 55 orders of magnitude larger than the currently measured" [21, p 8]. In QFT only energy differences between the vacuum and energy states is used and "simply rescale the energy of the vacuum down to zero", but obviously "this rescaling is not possible in cosmology" [22, p 188].

Thus, not only massive fermions–antifermions and their QFT-fields, but also all Standard Model (SM)-bosons and their bosonic QFT-fields (without exceptions), including photons, traditionally assumed to be indistinguishable, must have mutually gravitationally canceling properties in the TGN-Universe with the TGN-QFT-vacuum. Classical QFT considers the OM-photons and OAM-antiphotons, as totally identical particles, so optically indistinguishable in the ordinary detectors and OM telescopes. The symmetrical gravitational properties of matter–antimatter and photons–antiphotons—(OM-photons)–(OAM-antiphotons), etc ensure gravitational weightlessness and flatness of the TGN-Universe after the BB.

4. The methods of galaxies and antigalaxies observation and recognition in the framework of TGNU

Following to the natural extension of GR one can assume that:

(i) the OM-photons are gravitationally slightly attracted to the OM and also are slightly repelled by the OAM and at the same time;

(ii) the OAM-antiphotons are slightly gravitationally attracted by the OAM and also are slightly repelled by the OM [23].

The mutually gravitationally attractive (OM+DM)-galaxies have the positive inertial masses $M_{\mathrm{in}} > 0$ and positive gravitational masses $M_{\mathrm{gr}} = M_{\mathrm{in}} > 0$ in the TGNU. We consider below the visible (detectable) OM-photons and OAM-antiphotons, which are relevant for this article. The visible beams of OM-photons, emitted from the (OM+DM)-galaxies will be gravitationally slightly attracted in the direction of the (OM+DM)-galaxies and also will be slightly repelled by the (OAM+DAM)-antigalaxies, placed near to these beams. These beams will remain quasi-straight on a way through this gravitationally neutral, quasi-homogeneous large-scale TGN-Universe, being a homogeneous mixture of the galactic and antigalactic clusters.

The (OAM+DAM) antigalaxies have positive masses $M_{\mathrm{in}} > 0$ and negative masses $M_{\mathrm{gr}} = -M_{\mathrm{in}} < 0$. The gravitationally mutually attractive (OAM+DAM)-antigalaxies in the TGN-Universe emit the OAM-antiphotons which are also equally visible and detectable to us, like the OM-photons. Indeed, they must be equally detectable as two gamma quanta of 511 keV which according to the TGNU-concept, are the pair of photon–antiphoton, created after e^+–e^- annihilation. The OM-photons and the OAM-antiphotons are both optically perceptible and detectable by the OM-devices as the same particles. Therefore, cosmologists (to date) do not find optical differences between the (OM+DM)-galaxies and (OAM+DAM)-antigalaxies, quasi-regularly distributed in the Universe, according the TGNU-concept. The opposite gravitational properties of the OM-photons and the OAM-antiphotons in the TGNU allow, however, their gravitationally-optical distinction [23] due to the evident physical properties:

(i) the quasi-straight cosmic OM-photons beams are slightly attracted by the surrounding matter (OM+DM)-galaxies and are slightly repelled by the surrounding antimatter (OAM+DAM)-antigalaxies on the way to Earth;

(ii) the quasi-straight cosmic OAM-antiphotons beams are slightly attracted by the surrounding antimatter (OAM+DAM)-antigalaxies and are slightly repelled by the surrounding matter (OM+DM)-galaxies on the way to Earth.

These distinctions are schematically shown on figure 1 for the far-remote on a distance R_{GC} from us galaxies and antigalaxies. This distance estimate is approximately $R_{\mathrm{GC}} > 2$ Mpc [14]. This distance could be also estimated from the upper limit on anti-helium in cosmic rays and "the nearest single antigalaxy, should be at the distance larger than 10 Mpc (very crudely)" [24].

Figure 1 show schematically a quasi-regular distribution of far-remote (OM+DM)-galactic clusters $\mathrm{GC_+}$ and also similarly far-remote (OAM+DAM)-antigalactic clusters $\mathrm{GC_-}$, in two cases: figure 1(a)—without the presence of the close $\mathrm{G_{+dev}}$ and figure 1(b)—with the presence of the close $\mathrm{G_{+dev}}$. The galaxy $\mathrm{G_{+dev}}$ attracts the $\mathrm{GC_+}$ rays (visible as light points) and repulse the $\mathrm{GC_-}$ rays ("anti-light" points) and the figure 1(a) will be the slightly deformed as the figure 1(b) shows. The light points of the galaxy clusters $\mathrm{GC_+}$ will be slightly shifted in the direction of the $\mathrm{G_{+dev}}$, and the "anti-light" points of the antigalaxy clusters $\mathrm{GC_-}$ will be slightly shifted opposite to the direction of the $\mathrm{G_{+dev}}$.

We can use mentioned above opposite gravitational deviations of the far-remote galactic clusters ($\mathrm{GC_+}$) and far-remote antigalactic clusters ($\mathrm{GC_-}$) by any particular (OM)-deviation-galaxy ($\mathrm{G_{+dev}}$) selected from our local OM-galaxy group [25]. The relatively close to us deviation-galaxies $\mathrm{G_{+dev}}$ certainly belong to our (OM+DM)-galaxy. This is, for example, the Andromeda I star, or the Milky Way satellites, such as the Canis Major Dwarf. Such dwarf satellites often have almost no OM and are built practically from DM. They are enough DM-massive and deviate light, but at the same time very dark and not disturb the optical observation of a far-remote galaxy or antigalaxy rays on the Earth.

We propose to use a telescope for detection a suitable closest to us deviation-galaxy (on the R_{dev} distance), which has a sufficiently large angular velocity ω_{dev} on the celestial sphere

(with the velocity $V_{dev} = \omega_{dev} R_{dev}$ perpendicular to the R_{dev}). The G_{+dev} trace on the celestial sphere moves with the speed V_{dev} perpendicular to the directions from a far-remote and almost "immobile" GC_+ galaxy-cluster on a distance R_{GC+}, or from a far-remote GC_- galaxy-cluster on a distance R_{GC-} to the Earth observer—figure 1(*b*). Distances $R_{GC+} \simeq R_{GC-} \gg R_{dev}$ provide the relative angular "immobility". We measure the ($\pm$) deviations of the GC_+ und GC_- rays for two cases (i) when the moving G_{+dev} is far from the direction of the rays— figure 1(*a*) and (ii) in the vicinity of the moving G_{+dev}—figure 1(*b*). Positive (nearing to the G_{+dev}) gravitational deviations will correspond to OM-photons, emitted from the nearing GC_+ galactic cluster and negative deviations to the OAM-photons, emitted from the nearing GC_- antigalactic cluster—figure 1(*b*).

The Universe has presumably quasi-regular $(\ldots/+M_{gr}/-M_{gr}/+M_{gr}/-M_{gr}/+M_{gr}/\ldots)$ quasi-crystalline order from far-distant (OM+DM)-galactic clusters GC_+ and (OAM+DAM)-antigalaxies clusters GC_- [14]. In this case the ($\pm$) shifts of the GC_+ rays and GC_- rays will appear alternately along the G_{+dev} track—figure 1(*b*). Therefore, this method can approve existence of the quasi-crystalline TGN-Universe structure and the presence of photons and antiphotons in the Universe. Edington measured effects of gravitational light bending by searching for shifts in positions of stars just next to the Sun, using the GR, where this shift $\triangle\varphi_s = 4M_s/(R_s c^2)$ and the measured shifts were exactly as Einstein calculated $\pm 1.75''$ (arc sec) [10]. We roughly estimated examples of similar gravitational light bending shifts for the star Alpha Centauri A, for Andromeda galaxy and these shifts are very near to the Sun shift. These small oppositely directed ($\pm$) shifts allow a clear detection of the galaxies and antigalaxies clusters (as also single galaxies and antigalaxies) in the Universe. The simultaneous observation of the small shifts of the far-remote clusters of galaxies, simultaneously visible in telescope, is convenient—figure 1. This can improve the accuracy of these fine gravitational displacements measurements and will also increase simultaneously amount of data on these galaxy and antigalaxy clusters.

We could easy observe these enough big, order of $\pm 1.7''$ (arc sec), gravitational shifts, (i) using the orbital Hubble telescope which has the angular sensitivity $\simeq \pm 0.05''$, (ii) observing, e.g., the highest known angular transverse sky velocity $V_{tr.} = 0.5°$ per 174 years, that is near $\pm 10''$ per year, passing by the Barnard's star from the nearest Alpha Centauri system [26]. A self-luminosity of the Barnard's star is about 2000 times lower than of our Sun and it could be somehow masked–filtered in these measurements. So, the orbital Hubble telescope can simultaneously observe many far-distant GCs (e.g., with $R_{GC} \geqslant 1$ Gpc), spatially enough deeply placed on different distances from the Earth along the track of the deviating Bernard's star and simultaneously measure enough big consequent angular GC-deviations about $\pm 1.5''$, met on the $\pm 10''$ per year track. The problem is that 3D-space volume in the visible Universe, touching by so short (one year) and thin Barnard's star track is very small—less then needed even for 1 GC in it (in average), if the GCs are randomly–homogeneously (as gas) distributed in the Universe. But the GCs are densely placed within thin spherical layers of huge empty voids and there is an enough high probability that this track will touch some of these quasicrystallized spherical layers or some linear cosmic filaments of the cosmic net tangentially—when the density of the GCs sharply increases and a waiting time for such events decreases drastically.

5. Gravitational focusing–defocusing effects in the TGNU-cosmology

The method suggested above for the distinction of gravitational masses of opposite gravitational charge is based on the GR effect of light deviation near the celestial bodies. This effect is used in the standard model of cosmology with only one—positive sign of gravitational masses for the focusing gravitational lensing (GL) of the far-removed objects. Therefore, in the cosmology with two signs of gravitational masses the defocusing—gravitational antilensing (GAL) effect also should exist. In this connection, let us consider this effect in more detail.
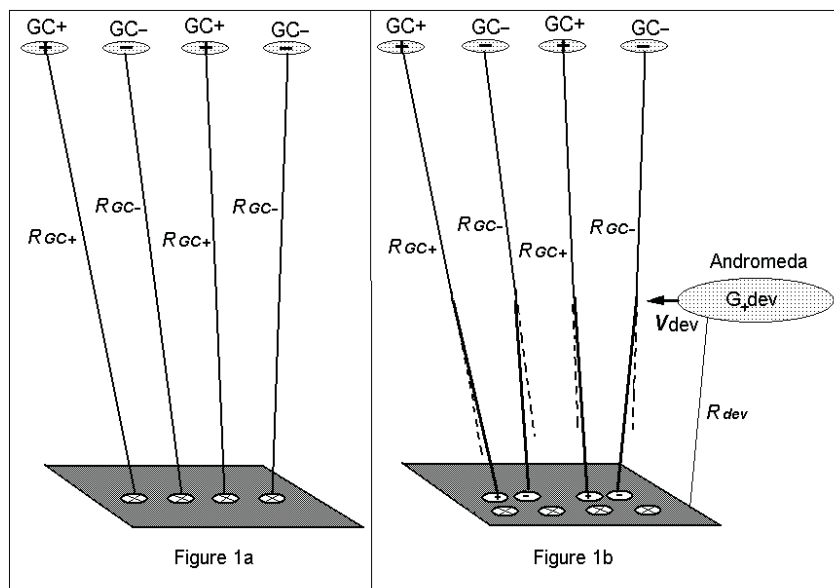
Figure 1. The way of the rays from the far-remote galaxies and antigalaxies (a) (from the left) and the gravitational deviations of these rays (b) (from the right) in the presence of the close deviation-galaxy $M_{gr} > 0$.

Strong gravitational lensing causes quasi-stable distortions of the background object (BO), such as the Einstein's ring, arcs and multiply images. Weak gravitational lensing causes only small quasi-stable distortions in the image behind the gravitational lens. In both cases the mass of the lens is large enough (mass of a galaxy or a galaxy cluster) and lensing effects can be well observed by very high-resolution telescope such as the Hubble Space Telescope [27]. Gravitational microlensing (GML), keeps the BO intact, but temporarily (from seconds to hundreds of days) changes its brightness during microlensing and occurs over a characteristic time [28]. The microlensing mass is very low (mass of a planet or a star)—only the apparent brightening of the source may be detected (in time from seconds to years) [28]. Many GML observations historically and technically connected with the not far distant BOs–GMLs with positively charged M_{gr} placed inside our local group of galaxies and so, they must have only focusing property, showing temporarily increasing BO-brightness, when gravitational microlens moves across the line between the BO and telescope. They are connected with the BO with $M_{gr} > 0$ placed inside our galactic group and have focusing property, showing temporarily increasing brightness of BO, when gravitational lens moves across the line between the BO and telescope. The local group microlensing situation can be changed in the TGNU-cosmology if the BO will be far enough ($\simeq$ 2–10 Mpc and more) to belong the GC$_-$ with $M_{gr} < 0$, because the GC$_-$-antiphotons will be defocused and the BO-brightness will be decreased.

Let us analyze two cases of the cosmic gravitational lensing (GL) and gravitational anti-lensing (GAL), arising in the proposed TGNU-cosmology:

(i) Invisible background objects in our telescopes are too far-distant (both, GCs$_+$ and GCs$_-$), equally presented on the large scale Universe and placed very far behind the gravitational lens. If the gravitational lens has $M_{gr} > 0$, it (ia) focuses—and can make visible in telescopes photons from the GC$_+$ and (ib) defocuses—surely makes invisible in telescopes antiphotons from the GC$_-$ and this defocusing GAL-effect is undetectable. If the gravitational lens has $M_{gr} < 0$, it (a) focuses—surely makes visible in telescopes antiphotons from the GS$_-$

and (b) defocuses—surely makes invisible in telesopes photons from the GC_+, and this defocusing GAL-effect is also undetectable.

(ii) Visible background objects in our telescopes are not so far-distant (e.g., GCs_+ and GCs_- or single galaxies–antigalaxies, quasars–anti-quasars, stars–anti-stars) passing behind these GML lenses which belong to the Milky Way possessing $M_{gr} > 0$. They provide (iia) the GML-focusing—temporarily increasing brightness of light from the stars of distant galaxies or quasars from GCs_+, and (iib) the GMAL-defocusing—temporarily decreasing brightness of light from the anti-stars of distant antigalaxies or anti-quasars from GCs_-. So, not so far-distant GCs_+ and GCs_- clusters could be also distinguished by the (focusing–defocusing) GML-technique. Technical availability of the described above GML–GMAL and the possibility simultaneous detection of many these cases in real time makes it possible to verify the predictions of TGNU-cosmology and even to create a detail map of galactic clusters–antigalactic clusters of the large-scale Universe.

6. Gravitational blueshift–redshift effects in the TGNU-cosmology

We also estimate the blueshift $f_{reciever} = f_{emitter}/[1 - 2GM/(Rc^2)]^{1/2}$ for photons (emitted by galaxies) and symmetrical redshift $f_{reciever} = f_{emitter}/[1 + 2GM/(Rc^2)]^{1/2}$ for antiphotons (emitted by antigalaxies), received on the Earth, adopting the corresponding GR-blueshift equation (for photons) [29]:

$$f_r = f_e[(1 - 2GM/((R+h)c^2)]^{1/2}/[1 - 2GM/(Rc^2)] \to f_e/[1 - 2GM/(Rc^2)]^{1/2},$$

where f_r is the frequency of the receiver and f_e is the frequency of the emitter, R is the distance between the receiver and the point mass position:

(i) for the Earth ($R_E \simeq 6.4 \times 10^8$ cm, $M_E \simeq 6 \times 10^{27}$ g), $f_r \simeq f_e(1 \pm 5 \times 10^{-10})$—for photons–antiphotons;

(ii) for the Sun ($R_{E–Sun} \simeq 1.50 \times 10^{15}$ cm, $M_{Sun} \simeq 2 \times 10^{33}$ g), $f_r \simeq f_e(1 \pm 10^{-8})$—for photons–antiphotons;

(iii) for our Milky Way ($R_{S–MWcenter} \simeq 2.7 \times 10^{19}$ cm, $M_{MW} \simeq 10^{12} M_\odot$ [30]), $f_r \simeq f_e(1 \pm 0.005)$—for photons–antiphotons.

The remote-distant emitter has $h \gg R$, M is the corresponding mass, G is the Newton constant and c is the speed of light. These estimations show—the (OM+DM) Milky Way galaxy creates only around one percent frequencies shift between identical photons and antiphotons and gives an independent potential optical-gravitational opportunity to distinguish spatially closed galactic and antigalactic clusters, which have identical distances R_{GC} and Hubble velocities (that seems difficult to find for observations).

7. Conclusions

A gravitational-optical distinction between the cosmic galactic and antigalactic clusters in the Universe is proposed. It is based on the totally gravitationally neutral Universe (TGNU) hypothesis (incorporating the DM–DAM gravitational symmetry) proposed earlier [12–15]. The TGN-Universe concept includes:

(i) enlarged (unbroken baryon, CPT and full $\pm M_{gr}$ gravitational) symmetries between massive fermions of ordinary matter (OM)–ordinary antimatter (OAM), as well as between dark matter (DM)–dark antimatter (DAM) particles;

(ii) the opposite gravitational properties of all massive and massless (as some bosons) particles and antiparticles, including OM-photons–OAM-antiphotons etc.

The composite (OM+DM)-galactic and (OAM+DAM)-antigalactic clusters are equally presented in the considered model and are mutually gravitationally repulsive. This concept excludes contribution of vacuum gravitational energy density ($\Lambda = 0$). The cosmic OM-and OAM-photons, emitted by far-remote galaxies and antigalaxies (both visible but purely optically indistinguishable), get basic gravitational differences in the TGNU-hypothesis. The OM-photons must be gravitationally attracted to the (OM+DM)-clusters and gravitationally repelled by the (OAM+DAM)-clusters and the OAM-photons, on the contrary, must be gravitationally attracted to the (OAM+DAM)-clusters and repelled by the (OM+DM)-clusters.

The galactic and antigalactic clusters are optically-gravitationally distinguishable if (i) we find for observation a massive (OM+DM) deviation-galaxy or a star from our galactic group, which moves fast enough on the heavenly sphere across the direction from an observer to these far-remote galactic and antigalactic cluster, or (ii) we simultaneously use plenty of gravitational microlenses with $M_{gr} > 0$, placed in our local group of galaxies, because the galactic–antigalactic OM-photonic and OAM-antiphotonic rays deviations and (focusing–defocusing) will be opposite. Other possibility is to use arising difference in the photons-blueshift and the antiphotons-redshift from the far-remote galaxies and antigalaxies in the gravity field of our Milky Way galaxy, which is around one percent.

The described three optical-gravitational methods could be used independently or together for better recognition galaxies and antigalaxies in the Universe.

Acknowledgments

Appendix

The abbreviations are as follows: CDM—cold dark matter; Λ-CDM—lambda cold dark matter; GR—general relativity; EP—equivalence principle; OM—ordinary matter; OAM—ordinary antimatter; DM—dark matter; DAM—dark antimatter; DE—dark energy; TGN—totally gravitationally neutral; TGNU—totally gravitationally neutral Universe; GNU—gravitationally neutral Universe; BB—Big Bang; CPT—charge, parity, time symmetry; QFT—quantum field theory; G—galaxy; GC—galactic cluster; AGE—attractive gravity energy; RGE—repulsive gravity energy; MW—Milky Way; dev—deviation; BO—background object; GL—gravitational lensing; GMLs—gravitational microlenses; GAL—gravitational antilensing.

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