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ОБОБЩЕННЫЙ ЗАКОН ГРАВИТАЦИИ НЬЮТОНА: ВОЗМОЖНЫЕ ПРИЛОЖЕНИЯ

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There are more things in heaven and earth, Horatio,
Than are dreamt of in your philosophy.
William Shakespeare

«И в небе и в земле сокрыто больше,
Чем снится вашей мудрости, Горацио».
У. Шекспир. Пер. М. Лозинского.

«Есть многое на свете, друг Гораций,
Что не присниться даже мудрецам».
У. Шекспир. Пер. Б. Пастернака.

«Сколь разумны чудеса натуры,
дорогой брат мой Бертран!
Сколь обильна сокровенность
пространств, то непостижимо даже самому
могучему разумению
и нечувственно
самому благородному сердцу!»
А. Платонов. «Епифанские шлюзы»

"Реку, в которую я вступаю, не переплывал еще никто" (вариант перевода фрагмента из 3-ей песни, который любил А.А. Фридман).

PROFESSOR ERNST MACH
1838-1916

"… we see that even in the simplest case, in which apparently we deal with the mutual action of only *two* masses, the neglecting of the rest of the world is *impossible*. Nature does not begin with elements, as we are obliged to begin with them. It is certainly fortunate for us, that we can, from time to time, turn aside our eyes from the overpowering unity of the All, and allow them to rest on individual details. But we should not omit, ultimately to complete and correct our views by a thorough consideration of the things which for the time being we left out of account" (p.235).

Ernst Mach. The Science of Mechanics. A Critical and Historical Account of its Development. 4th Edition. Chicago-London. The Open Court Publishing CO. 1919, 628 p.

I. What is the physical essence of gravitation?

The "internal mechanism" of the gravitational interaction remains unknown in contemporary physics. Two quotes:

In 1964, in the lectures at Cornell University on the nature of fundamental interactions, R. Feynman emphasized that "… up to today, from the time of Newton, no one has invented another theoretical description of the mathematical machinery behind this law which does not either say the same thing over again, or make the mathematics harder, or predict some wrong phenomena. So there is no model of the theory of gravitation today, other than the mathematical form".

Creating GRT (1921), A. Einstein, being aware of the limitation of the available information for solving this kind of problems, wrote: "We have seen, indeed, that in a more complete analysis the energy tensor can be regarded only as a provisional means of representing matter. In reality, matter consists of electrically charged particles, and is to be regarded itself as a part, in fact, the principal part, of the electromagnetic field.

A question appears. Is the gravitational constant G is a carrier of information about gravity as a fundamental interaction and can be regarded as a universal constant together with $\hbar$ and c.

In the talk will be shown that the physical essence of emerging problems should first of all be understood at the level of the transcendental phenomenology (Husserl, Kant), i.e. before developing the corresponding theoretical models.

Certain hopes in solving the problems of cosmology were associated with Planck's numbers, dimensionless characteristics of length a_{Pl}, time t_{Pl} and mass m_{Pl} introduced in 1899 on the basis of the fundamental constants $\hbar$, c and G:

$$a_{Pl} = 2^{1/4}\sqrt{\frac{G\hbar}{c^3}} = 2^{-1/2}\frac{\hbar}{m_{Pl}c} \approx 1.91\cdot 10^{-33}\,\mathrm{cm} \qquad t_{Pl} = \frac{a_{Pl}}{c} = 2^{1/4}\sqrt{\frac{G\hbar}{c^5}} \approx 0.64\cdot 10^{-43}\,s \qquad (1)$$

$$m_{Pl} = 2^{-3/4}\sqrt{\frac{\hbar c}{G}} \approx 1.31\cdot 10^{-5}\,g \qquad \text{or} \qquad w_{Pl} = \frac{m_{Pl}c^2}{t_{Pl}} \equiv \frac{\varepsilon_{Pl}}{t_{Pl}} = \frac{c^5}{2G} \approx 1.8\cdot 10^{59}\,erg/\mathrm{s}$$

Unfortunately, the collection of Planck numbers was insufficient to become even a heuristic guideline for the realization of the well-known $\hbar Gc$ -plan, which began to be developed by M. Bronshtein already in 1933, and which meant to achieve an epistemological unity of the quantum theory (with its constant $\hbar$), special relativity theory (with its constant c) and the theory of gravitation (with its constant G).

Остается вопрос: существует ли неявный параметр, определяющий планковские параметры a_{Pl} и t_{Pl} как параметры микромира, а параметры m_{Pl} и w_{Pl} как параметры макромира?

Есть еще одна проблема в космологии, которая пока практически не обсуждается – установление причин различия динамики Вселенной в разные временные эпохи. Действительно, удельная плотность наиболее мощных источников энергии, возникших на ранних стадиях эволюции Вселенной, была существенно (в тысячи раз!) выше наблюдаемых соответствующих значений для последующих эпох [Burenin R.A., Bikmaev I.F., Khamitov I.M. et al. Optical identifications of high-redshift galaxy clusters from Planck Sunyaev-Zeldovich survey // arXiv:1801.04464v1 [astro-ph.CO] . Именно на ранних этапах развития Вселенной, которым соответствуют красные смещения z ~ 1 (~ 6 млрд. св. лет) и более, формировались квазары, проявлялись гамма-барстеры. Существование такого типа мощных источников энергии в последующие этапы эволюции Вселенной не фиксировалось. Если исходить из единой сущности Мироздания, в соответствии с концептуальной позицией Маха, особенности динамики Вселенной на макромасштабах («астральный лад») следует связывать с пониманием процессов на микромасштабах (познанием «атомосклада»).

В таком случае различия особенностей динамики Вселенной на разных этапах ее эволюции можно связывать с идеей П.А.М. Дирака об изменении во времени мировых констант - $\hbar$, c и G.

Но при этом надо понимать причины таких изменений! Что их вызывает?

To answer the last questions it turned out to be sufficient to modify the known result of S. Weinberg, who noticed the approximate equality:

$$\hbar \approx \frac{1}{2\pi} G^{1/2} m_\pi^{3/2} R_H^{1/2}$$

where R_H is the characteristic ("Hubble") radius of the Universe, $R_H = (1.29 - 1.53)\cdot 10^{28}$ cm, and m_π is the mass of π-meson ($m_\pi \approx 140$ MeV/c^2), and represent the expression for $\hbar$ in the form of the equality:

$$\hbar = \frac{1}{2\pi} G^{1/2} m_Q^{3/2} R_H^{1/2} \qquad (2)$$

(In fact, here is the idea of Dirac about the time dependence of world constants)

Here we introduce a new energy parameter $E_Q = m_Q c^2 \approx$ 209.5 MeV. The introduced parameter E_Q corresponds to the energy scale of 200 MeV: at the corresponding intranuclear temperatures quarks are no longer bound in the nucleons, and the quark-gluon plasma is formed. The expression (8) can be conveniently represented in the form:

$$G = \frac{(2\pi\hbar)^2 H}{m_Q^3 c} = \frac{2\pi^2 c H}{m_Q} a_Q^2 = 2^{3/2} \pi^2 \frac{\hbar c}{m_Q^2} \frac{a_Q}{R_H} \qquad (3)$$

$a_Q = 2^{1/2}\hbar / m_Q c \approx$ 1.3×10 $^{-13}$ cm; $m_Q = E_Q / c^2 \approx$ 3.72 10 $^{-25}$ g

Dimensionless constant α_g of the gravitational interaction is defined as:

$$\alpha_g = \frac{G m_Q^2}{\hbar c} = 2^{3/2} \pi^2 \frac{a_Q}{R_H} \approx 2.85 \cdot 10^{-40}$$

$q_g^2 \equiv G m_Q^2 -$ the squared "elementary gravitational charge"

The usage of the introduced collection of the basic universal constants $\hbar$, c, m_Q and R_H allows presenting in a more "compact" fashion not only the gravitational constant G and the dimensionless constants of the gravitational interaction, but also the Planck numbers (4):

$$a_{Pl} = 2\pi a_Q \left(\frac{a_Q}{R_H}\right)^{1/2}, \quad t_{Pl} = 2\pi \tau_Q \left(\frac{a_Q}{R_H}\right)^{1/2}, \quad m_{Pl} = \frac{1}{2^{3/2}\pi} m_Q \left(\frac{R_H}{a_Q}\right)^{1/2}, \quad w_{Pl} = \frac{m_Q c^2}{2^{5/2}\pi^2 \tau_Q} \cdot \frac{R_H}{a_Q} \qquad (1a)$$

where $\tau_Q = a_Q / c \approx 0.43\ 10^{-23}$ s is the time scale, corresponding to the space scale a_Q. The parameter a_Q / R_H clarify the cosmological essence of the "smallness" of the Planck parameters l_{Pl} and t_{Pl}, as well as the cosmological scale of the quantities m_{Pl} and w_{Pl}, thus demonstrating the heuristic justification of the representation (1) for the Planck constant.

The expression (1*a*) allows to understand that the nature of the unique smallness of gravitational interaction is the smallness of characteristic size a_Q in the neighborhood of the atomic nucleus to the characteristic size R_H of the Universe. Of course, so far there remains the question: what is the physical essence of the spatial parameter a_Q having a nuclear origin?

For the time being, we note the name of "the Law of Universal Gravity" for the relation describing the gravitational interaction of two arbitrary masses is "justified" at the conceptual level.

II. EM vacuum as a basic medium – the "ether" of the Universe

The ground for creating the corresponding phenomenological construction is an introduction into the physical science of a basic energy-containing medium, a sort of an "ether".

At this point, the author completely agrees with the opinion of Prof. Robert B. Laughlin (Nobel Prize winner, 1998): "Space is more like a piece of window glass than ideal Newtonian emptiness. It is filled with "stuff" that is normally transparent but can be made visible by hitting it sufficiently hard to knock out a part. The modern concept of the vacuum of space, confirmed every day by experiment, is a relativistic ether. But we do not call it this because it is taboo." (*Laughlin, Robert B.* A Different Universe: Reinventing Physics from the Bottom Down. — NY, NY : Basic Books, 2005. — P. 120—121).

As such an environment ("the relativistic ether"), the author considers the electromagnetic component of the physical vacuum – EM vacuum, "tied" to the expanding Universe, which is considered as the reference system, common for all points of the expanding Universe. It is also natural to adopt for this system a global time scale t, counted from the time $t = 0$, corresponding to the Big Bang.

Let us define this reference system as "Mach system", since Mach was the first who introduced the base system connected with "the center of all Universe masses" [Einstein A. The meaning of relativity. Four lectures delivered at Princeton University, May, 1921. Princeton: Princeton University Press. 1923, p. 44]. It is known [38] that EM vacuum reveals itself via fluctuating average values of squared intensities of the electric and magnetic fields.

EM vacuum manifests itself through the fluctuating mean values of the squared intensity of the electric and magnetic fields. This means that a noise electrodynamic component acts from EM vacuum upon the system of concentrated charges and local currents of any atomic nucleus trated as a set of distributed charges (quarks in nucleons) and local exchange currents. In accordance with Casimir idea, we believe that EM vacuum in the vicinity of outer and inner boundaries of any atomic nucleus is polarized: the oscillation spectrum of EM vacuum is rearranged in accordance with the type III boundary conditions, and a unified open dynamic system is formed composed by the atomic nucleus and vacuum, an "EM vacuum polaron".

The introduction of the EM vacuum polaron allows to understand qualitatively the genesis of *a priori* limitation of the speed of moving material objects with nonzero rest mass to the value of the speed of light c in EM vacuum which is equal to $c = 3 \cdot 10^{10}$ cm/s. In accordance with the ideas of Casimir, for the corresponding potential energy in the neighborhood of a material object (for definiteness, a point particle with the mass m_0 localized at the origin) has the form:

$$U(\vec{r}) = -\gamma_0 \frac{\hbar c}{r} \qquad (2)$$

Here $\vec{r}$ is the radius-vector (assume that the particle at rest is localized at the origin); γ_0 is a dimensionless parameter. The energy levels $\overline{E}(n_r)$ of the discrete spectrum, reflecting the degree of interconnection of the particle of the mass m_i with EM vacuum due to its polarization, and the corresponding expression for the radius a_{Vi} of the domain of the EM vacuum Casimir polarization in the neighborhood of the particle i, have the form:

$$\overline{E}(n_r) = -\gamma_0^2 \frac{m_i c^2}{2n_r^2}, \qquad a_{Vi} = \frac{2\hbar}{\gamma_0 m_i c}. \qquad (3)$$

For $\gamma_0 = \sqrt{2}$, the position of the lower energy level, $\overline{E}(1) = U(\vec{r})\big|_{r=a_{Vi}} = -m_i c^2$, characterizing the binding energy of the particle with EM vacuum, $E_{Vi} = m_i c^2$, corresponds in the absolute value to the "rest energy of the considered particle" in the form suggested by Einstein.

The value of the domain of the EM vacuum Casimir polarization in the neighborhood of the proton equals a_{Vp} = 2.82×10 $^{-14}$ cm, i.e. corresponds to the action scale of the nuclear forces. Thus, the quantity $q_s^2 \equiv \sqrt{2}\hbar c$ in the expression (4) can be defined as the squared "elementary charge of strong interaction", so that the dimensionless α_s constant of such interaction, by analogy with the fine structure constant α_e can be naturally represented in the form $\alpha_s = q_s^2 / \hbar c = \sqrt{2}$.

If a particle possesses a structure (hadron), then the Casimir dependence inside such particle can be treated as a "seed" potential energy of the nuclear forces, which are characterized by the "nuclear charge" q_s and the strong coupling constant α_s. As a result of dynamic mobility of the nuclear matter "inside" such particle, the seed potential of the nuclear forces is shielded, and the effective potentials are formed of the "short-range" nuclear forces, exponentially declining with the distance, of the type of the Yukawa potential :

$$U(\vec{r}) = -\frac{q_s^2}{r}\exp(-\kappa_s r) \qquad (4)$$

where $\kappa_s = m_\pi c/\hbar$ is a screening factor and m_π is the mass of π-meson. This corresponds to the standard idea about the dynamic nature of the nuclear forces, which are usually related to the π-meson exchanges by nucleons.

We see, that EM vacuum is a source of the nuclear forces appearance.

We assume, in accordance with the idea of J.J. Thompson, that the frontal and opposite domains of EM vacuum Casimir polarization in the vicinity of the vacuum polaron moving with the velocity u relative to the basic reference system is transformed for $u \to c$ from a spherical shape to spheroid one. That transformation can be regarded as the

Heaviside factor $\eta_u = \left(1 - u^2/c^2\right)^{-1/2}$, which characterizes the rate constant of losing localized photons which provide "lubrication" for moving of the particle in the EM vacuum. It is precisely because of the disappearance of the "lubricant", which is necessary for moving atomic nuclei in the base medium, the potential energy of such nuclei increases. This phenomenon is perceived as a relativistic increase in mass: $m(u) = m(0) \cdot \eta_u$.

Это означает, что в любой системе отсчета, движущейся с ненулевой скоростью относительно выбранной базовой системы отсчета, из-за деформации области казимировской поляризации в окрестности каждого атомного ядра, возрастает инерционная масса этого ядра. По этой причине космологические объекты, движущиеся относительно базовой системы с релятивистской скоростью, наблюдатель в базовой системе воспринимает как системы с возросшей массой.

Здесь надо иметь в виду, что введенные представления о связи атомных ядер материальных объектов с ЕМ вакуумом как базовой средой Вселенной позволяет понять сам феномен сохранения целостности галактик в процессе расширения ("разбухания") пространства Вселенной. В то же время процессы внутри некоторых галактик, особенно на ранних стадиях эволюции Вселенной в условиях мощных энерговыделений, могли приводить к образованию звездных систем, движущихся с близкими к релятивистским скоростям относительно остальных объектов.

Однако поскольку с течением времени t после Большого Взрыва скорость света c в ЕМ вакууме уменьшается (см. ниже), исходные нерелятивистские скорости некоторых из звездных систем в таких галактиках с течением времени t могут оказаться релятивистскими и проявляться как системы с возросшей массой.

Именно такой феномен и может восприниматься как проявление «темной материи» в галактике. Другими словами, в рассматриваемых представлениях "темная материя" оказывается фантомом, материей-призраком. Доля темной материи в каждой галактике определяется релятивистской скоростью отдельных звездных систем относительно скорости расширения базовой системы отсчета, "привязанной" к расширяющемуся ЕМ вакууму.

В этих представлениях могут быть поняты недавние результаты о первом обнаружении дальней галактики NGC1052-DF2 (удалена на космологическом расстояние в 65 млн световых лет от Солнечной системы), в которой практически отсутствует "темная материя" [van Dokkum P., Danieli S., Cohen Y. et al. A galaxy lacking dark matter // Nature. 2018. V. 555. P. 629-632]. Такие аномалии считаются загадочными, поскольку, как пояснил Роберто Абрахам, соавтор указанной статьи, обычно полагается «что все галактики состоят из звезд, газа и темной материи, смешанных друг с другом. Теперь, похоже, что в некоторых галактиках есть множество звезд и газа, но почти нет темной материи. Это довольно странно».

В рамках развиваемых представлений может быть понят и противоположный феномен – существование галактик, содержащих более 99% «темной материи». В частности, было обнаружено, что в галактике Dragonfly 44 , находящейся от нас на расстоянии в 300 млн световых лет, содержится 99.99% "темной материи" [van Dokkum P., Abraham R., Brodie J. et al. A high stellar velocity dispersion and ~100 globular clusters for the ultra-diffuse galaxy Dragonfly 44 // The Astrophysical Journal Letters. 2016. V. 828:L6 (6 pp)].

Due to the infinite range of action of Casimir potential energy, the presence in the medium of various material objects with the masses m_i inevitably leads to overlapping of the potential fields and forming the fields of the particle attraction – gravity fields. Consider for example the corresponding Casimir potential energy $U\left(\vec{\xi};\vec{r}_1,\vec{r}_2\right)$ of two particles with the masses m_1 and m_2. We associate the coordinate system with EM vacuum:

$$U\left(\vec{\xi};\vec{r}_1,\vec{r}_2\right)=-\frac{\sqrt{2}\hbar c}{\left|\vec{\xi}-\vec{r}_1\right|}-\frac{\sqrt{2}\hbar c}{\left|\vec{\xi}-\vec{r}_2\right|},\qquad \vec{R}=m_{12}\left(\frac{\vec{r}_1}{m_2}+\frac{\vec{r}_2}{m_1}\right),\qquad \vec{\rho}=\vec{r}_1-\vec{r}_2,\qquad m_{12}=\frac{m_1m_2}{m_1+m_2}.$$

$$U\left(\vec{\xi};\vec{r}_1,\vec{r}_2\right)=-\sqrt{2}\hbar c\left[\left|(\vec{R}-\vec{\xi})+\frac{m_{12}}{m_1}\vec{\rho}\right|^{-1}+\left|(\vec{R}-\vec{\xi})-\frac{m_{12}}{m_2}\vec{\rho}\right|^{-1}\right]=-\sqrt{2}\,\frac{\hbar c}{m_{12}^2}m_1m_2\cdot B\left(\vec{\xi};\vec{\rho},\vec{R}\right),$$

$$B\left(\vec{\xi};\vec{\rho},\vec{R}\right)=\frac{1}{m_1+m_2}\left[m_1\left|\vec{\rho}+\frac{m_1+m_2}{m_2}\left(\vec{R}-\vec{\xi}\right)\right|^{-1}+m_2\left|\vec{\rho}-\frac{m_1+m_2}{m_1}\left(\vec{R}-\vec{\xi}\right)\right|^{-1}\right],$$

If we are only interested in the potential energy of attractive interaction between two particles, then for the exclusion from consideration of the dynamics of the system as a whole, there must be chosen $\vec{\xi}=\vec{R}$.

We obtain in this case:

$$B\left(\vec{R};\vec{R},\vec{\rho}\right)=\frac{1}{\rho}\qquad \text{and}\qquad U\left(\vec{r}_1,\vec{r}_2\right)\Big|_{\vec{R}=0}=-\frac{\sqrt{2}m_1m_2}{m_{12}^2}\cdot\frac{\hbar c}{\rho}$$

It is obvious that each of the masses m_1 and m_2 is attracted by other masses of the Universe. In order to obtain Newton's expression for the potential energy of attraction of these masses, we will connect the reference origin with their center of mass and assume, following Ernst Mach, that all the masses of the Universe exert influence on these masses, and also assume that these effects can be taken into account by carrying out the averaging procedure of the factor $1/m_{12}^2$ in the indicated formulas with the distribution function $f(m_{12})$. Since this function is unknown, we assume that the mass distribution in the Universe is isotropic and introduce the definition $\left\langle 1/m_{12}^2 \right\rangle \equiv 1/m_M^2$ where m_M is the "Mach mass". From the comparison in Newton's formula it follows that

$$G = \sqrt{2}\,\frac{\hbar c}{m_M^2} = \frac{\hbar c}{2^{3/2} m_{Pl}^2} = 2^{3/2}\pi^2 \frac{\hbar c}{m_Q^2}\frac{a_Q}{R_H}; \qquad m_M = 2m_{Pl}. \qquad (5)$$

We are considering a_Q as a spatial extent of the polarization region of the EM vacuum in the neighborhood of the atomic nucleus.

$$U\left(\vec{\xi};\vec{r}_1,\vec{r}_2\right) = -\sqrt{2}\hbar c\,\frac{m_{12}}{m_M^2}\left[m_1\left|\vec{\rho}+\frac{m_1}{m_{12}}\left(\vec{R}-\vec{\xi}\right)\right|^{-1} + m_2\left|\vec{\rho}-\frac{m_2}{m_{12}}\left(\vec{R}-\vec{\xi}\right)\right|^{-1}\right] = \qquad (5a)$$

$$= -Gm_{12}\left[\frac{m_1}{\left|\vec{\rho}+\frac{m_1}{m_{12}}\left(\vec{R}-\vec{\xi}\right)\right|} + \frac{m_2}{\left|\vec{\rho}-\frac{m_2}{m_{12}}\left(\vec{R}-\vec{\xi}\right)\right|}\right], \qquad m_M = 2^{1/4}\left(\frac{\hbar c}{G}\right)^{1/2}.$$

The expression (5) elucidates the physical essence of the G constant and its relatively small value due to the small spatial extent of the Casimir polarization region of EM vacuum in the vicinity of gravitating masses

Можно полагать, что представления об изотропном распределении масс во Вселенной, используемые при введении массы m_M и определении через эту массу гравитационной постоянной G, должны нарушаться для объектов, находящихся за пределами орбит планет Солнечной системы, в частности, в гелиопаузе, где солнечный ветер полностью тормозится галактическим звездным ветром и другими компонентами межзвездной среды. При рассмотрении гравитационного взаимодействия таких объектов с Солнцем проявляется очевидная асимметрия: помимо Солнца основные гравитационные воздействия на такие объекты оказывают тела именно этих "внутренних областей" Солнечной системы.

Со стороны остающейся, "внешней части" Солнечной системы, включающей облако Оорта — местообитание долгопериодических комет, и последующей звездной среды гравитационные воздействия на рассматриваемый объект слабее. Это означает, что гравитационная постоянная G^*, определяющая взаимодействие объекта в отдаленных областях Солнечной системы с Солнцем несколько превосходит величину G, а соответствующая масса Маха m_M^* меньше массы m_M.

По-видимому, в таких представлениях можно понять аномалии «Пионеров» - наблюдаемое отклонение в траектории движения космических аппаратов «Пионер-10» и «Пионер-11» от рассчитанной по стандартной модели для космических тел. Эти аппараты были запущены в 1972 и 1973 годах, соответственно, и траектория их фиксировалась вплоть до февраля 1998 года. При этом было обнаружено дополнительное, линейно растущее со временем, фиолетовое смещение получаемого сигнала, что интерпретировалось как проявление очень слабой силы, не учитываемой при расчете, которая вызывает постоянное ускорение аппарата в сторону Солнца, равное $(8{,}74 \pm 1{,}33)\times10^{-10}$ м/с^2 [Anderson J.D., Laing P.A., Lau E.L. et al. Study of the anomalous acceleration of Pioneer 10 and 11 // Physical Review D. 2002. V. 65 (8). P. 082004]. В качестве наиболее вероятной причины такой аномалии рассматривается техническая версия, согласно которой фиксируемый эффект имеет тепловую природу и объясняется анизотропией интенсивности теплового излучения энергетических элементов аппаратов [Turyshev S.G., Toth V.T., Kinsella G. et al. Support for the thermal origin of the Pioneer anomaly // Phys Rev Lett. 2012. V. 108. P. 241101 (arXiv 1204.2507)]. У позже запущенных, в 1977 году, аппаратов Voyager-1 и Voyager-2, чья траектория полета схожа с траекторией «Пионеров», и с которыми до сих пор поддерживается связь, выраженного эффекта отклонения не наблюдалось. Это объясняется тем, что «Пионеры» находятся в свободном полёте, а их ориентация стабилизировалась за счёт собственного вращения аппаратов. У «Вояджеров» же нужная ориентация обеспечивается малыми импульсами маневровых двигателей, что оказывает влияние на траекторию.

Если будущие экспериментальные исследования подтвердят предложенное в данной работе заключение, это даст основания полагать, что определяющий вклад в величину гравитационной постоянной в произвольной планетарной звездной системе дает формирующееся распределение масс во "внутренней области" этой системы, включающей звезду и планеты, так что величины G для каждой звездно-планетарной системы могут иметь свои определенные значения. Из изложенного следует также, что гравитационная постоянная, характеризующая гравитационное взаимодействие в изотропных областях межзвездной среды, в которых отсутствуют какие-либо звездно-планетарные объекты, должна характеризоваться еще большей величиной G и меньшей массой Маха m_M, чем соответствующие значения в Солнечной системе.

Весь проведенный анализ, вывод выражения для обобщенного закона Ньютона, упомянутый комментарий Эйнштейна при введении гравитационной постоянной G в тензор энергии-массы и приведенные заключения однозначно указывают на то, что гравитация не может рассматриваться как фундаментальное взаимодействие, и поэтому соответствующего калибровочного бозона ("гравитона") в Природе нет. Нет и гравитационных волн.

Really, gravitation can be considered as a manifestation of a strong nuclear interaction (~ α_s) outside atomic nuclei and can be defined as an attractive interaction that arises as a result of overlapping the regions of Casimir polarization of every two atomic nuclei of every two material objects. It means again that gravitation is not a fundamental interaction, and therefore there is no gauge boson for gravity. Therefore we can assume that it is the wave propagation of the EM vacuum perturbation was recorded in the recent LIGO observation [6], and this disturbance could arise in the collision of two neutron stars or by some other large-scale events.

For Newton's law, an alternative formula can be proposed, if we consider m_Q as the fundamental mass characterizing the strong nuclear interaction:

$$U_g(\rho) = -\frac{q_g^2}{\rho}\mu_1\mu_2 = -\frac{\alpha_s \hbar c}{\eta_g \rho}\mu_1\mu_2, \quad \mu_i \equiv m_i/m_Q\,. \qquad (6)$$

$$\eta_g = \frac{m_M^2}{m_Q^2} = \frac{2m_{Pl}^2}{m_Q^2} = \frac{2^{1/2}}{\alpha_g} = \frac{1}{2\pi^2}\frac{R_H}{a_Q} \approx 0.46\cdot 10^{40}.$$

The value η_g can be defined as a "gravitational permeability" of the EM vacuum. The Universe is a Unified System! The anomalously large value of the introduced parameter η_g may mean that, in accordance with the idea of Mach, the masses of the Universe that are at "cosmologically distances" make a contribution to the "gravitational interaction" of the two considered masses.

The conclusion on the contributions of different factors to the observed precession of the perihelion of Mercury's orbit can be done only after the appropriate calculations using the general expression (5*a*) for the Universal Gravitation law in the frame of reference associated with the center of mass of the solar system. In this case, $\vec{\xi} = \vec{R}_b$, where $\vec{R}_b$ is the radius-vector of the barycenter.

According to the developed ideas about the nature of gravity as a consequence of EM vacuum Casimir polarization in the vicinity of any material objects, absolutely all material bodies of the Universe are pairwise connected through the EM vacuum. Gravitational interaction of any pair of bodies is weakened if there appears between these bodies a third body which partially or completely screens these bodies from each other ("gravitational shielding"). This phenomenological approach open the possibility to understand the phenomenon of change of the gravitational acceleration during the total solar eclipse (Allais effect). Analysis of the Allais phenomenon, which is also allow to understand possible reasons for the observed differences in the recorded values of the gravitational acceleration value during the observation of solar eclipses in different parts of the Earth, linking the observation results to the differences in the geological features of diverse regions.

III. EM vacuum in different periods of the evolution of the Universe

It is known the fine structure constant of $\Delta\alpha_e/\alpha_e$ ~ 0.6 10^{-6} practically remains unchanged for regions of the Universe with redshifts z> 0.4, when the size of the Universe was $1/(1+z) \approx 0.7$ from the modern size. If we also neglect the time variations in power $w_{Pl} = c^5/2G$ and assume that the value of the elementary charge "*e*" remains constant during the evolutionary expansion of the Universe. We also introduce the dimensionless variable $h(t) = H/H_0 = t_0/t$, where t_0 and t are, respectively, the "our" time and the time of the preceding epochs. Note, $1+z = \nu/\nu_0 = R(t_0)/R(t)$

Зависимости $\hbar(t)$, $c(t)$ и $G(t)$ (see (9a)) будем представлять в виде:

$$\hbar(t) = \hbar_0 \cdot h^x(t), \quad c(t) = c_0 h^y(t), \quad G(t) = \sqrt{2}\frac{\hbar c}{m_M^2(t)} = 4\pi^3 \frac{\hbar^2(t)H(t)}{m_Q^3 c(t)} \equiv G_0 h^z(t).$$

где $\hbar_0, c_0$ и G_0 - значения соответствующих мировых констант в нашу эпоху. Из независимости величин α_e и w_{Pl} от времени t, а также из указанного представления константы $G(t)$ следует:

$$x + y = 0, \quad 5y - z = 0, \quad z = 2x - y + 1.$$

Разрешая эту систему, получаем искомые зависимости:

$$\hbar(t) = \hbar_0 \cdot h^{-1/8}(t), \quad c(t) = c_0 h^{1/8}(t), \quad G(t) = G_0 h^{5/8}(t). \qquad (12)$$

Note, the last conclusion $G(t) \sim t^{-5/8}$ corresponds qualitatively with the results of J. Mould et.al [7].

According to the developed phenomenology, for R_H (t), we get

$$R_H(t) = c(t)/H(t) = c_0 t_0^{1/8} t^{7/8}; \quad \dot{R}_H(t) \sim t^{-1/8}$$

(we draw attention to the decrease in the rate of increase in R_H as it evolves, in contrast to the conclusion of the standard model). This relation means that the volume V_U (t) of the Universe increases according to: $V_U(t) \sim R_H^3 \sim t^{21/8}$, and since $\varepsilon_V^e \sim t^{-13/8}$, we have $\varepsilon_V^e(t) \cdot V_U(t) \sim t$, which is a consequence of the linear increase in the total EM vacuum energy content of the Universe (Eq. (8)) due to the Planck source: $E_{tot} = w_{Pl} t$.

Остается главный вопрос: в чем состоит причина вводимых, следуя идее Дирака, изменений во времени мировых констант. Из приведенных соотношений следует, что основная причина состоит в уменьшении с ростом времени t плотности энергии ЕМ вакуума: $\varepsilon_V^e \sim t^{-13/8}$, что должно приводить к уменьшению интенсивности всех реализующихся во Вселенной взаимодействий, генезис которых, согласно развиваемым представлениям, определяется плотностью энергии ЕМ вакуума. По этой причине уменьшается величина c, возрастает величина $\hbar$, что затрудняет реализацию квантовых переходов, понижает вероятности соответствующих процессов. Уменьшение во времени интенсивности гравитационных взаимодействий, $G(t) \sim t^{-5/8}$, связывается с увеличением во времени общей массы Вселенной и возрастанию связи каждой из двух притягивающихся масс с остальными массами Вселенной при ослаблении взаимного притяжения этих масс из-за роста массы Маха: $m_M^2(t) \sim t^{5/8}$.

Заключение

возможные задачи астрометрии в рамках развитых представлений о сущности гравитации и «темной материи»

1. Проведение полного анализа данных по траектории "Пионеров" с целью определения зависимостей $G = G[L(t)]$, где $L(t)$ - расстояние аппаратов от Солнца в моменты t времени полета. Отметим, что отказ от корректировки траектории «Вояджеров» с переводом аппаратов в режим свободного полета позволил бы на основе новых данных (полагается, что связь с «Вояджерами» сохранится еще несколько лет) подтвердить или опровергнуть предлагаемые представления о природе гравитации.
2. Проведение на основе обобщенного закона Ньютона расчетов для анализа дрейфа перигелия Меркурия (возможно, и других планет) с целью установления корреляции дрейфа перигелия планет с движением барицентра Солнечной системы.
3. Установление возможных различий в величинах гравитационной постоянной, реализующихся в разных звездных системах.
4. Астрометрия космологических объектов с целью разрешения проблемы "темной материи". Установление пространственных корреляций в распределении «темной материи» и звездных подсистем с максимальными локальными скоростями в дальних галактиках.

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ATTACHMENT

Estimate ε_V in the frame of the phenomenological model of the Universe dynamics as a solution of the problem of "120 orders".

In accordance with the standard model, the vacuum energy density ε_V must determine the cosmological term Λ in the equations of general relativity and plays the role of "antigravity":

$$\Lambda = \frac{8\pi G}{c^4}\varepsilon_V \qquad (1A)$$

According to the present-day data, $\varepsilon_V \approx (0.5 - 0.7)\cdot 10^{-8}$ erg/cm^3. However, the attempts to link the quantity ε_V, determined on the basis of the relation (1A) from the experimentally determined value of $\Lambda \approx (1.03 - 1.45)\cdot 10^{-56}$ cm^{-2}, with the parameters of the physical vacuum, were unsuccessful. The differences were 120 orders of magnitude!!!
This long-standing problem was still in the field of the great attention of Ya.B. Zel'dovich and S. Weinberg.

IA. A possible model of the Universe dynamics [4]

Now, after the basic frame of reference for our expanding Universe, "tied" to EM vacuum, was introduced, it is possible to return to the basic questions that could not be solved within the framework of the standard model of the Universe dynamics:

1. What is the source of energy for the Universe and what is the essence of "dark energy" and "dark matter"? Is the "lunch", mentioned by Davies, "free"?
2. How is "the 120-order problem" of establishing a connection between the dark energy and the cosmological constant solved?

It is believed that the Universe, which is represented in the form of a ball whose volume is $V_H = 4/3 \cdot \pi R_H^3$, is an open system, and the source of energy that "feeds" the Universe is a "Proto-vacuum" that is outside the ball-Universe and is more energy-intensive medium (like "False vacuum" in the Inflation theory) than the EM vacuum of our Universe. We believe that the Proto-vacuum existed in the Boundless Universe before the Big Bang. It is assumed that the energetic power that constantly feeds our Universe across the boundary "the Proto vacuum – EM vacuum" is equal to the Planck power $w_{Pl} = c^5/2G$.

1-st equation of the Universe dynamics (the modified Friedmann equations). The total energy E_{tot} received by the Universe during the time $t = H^{-1}$ of the action of the Planck energy source with power $w_{Pl} = c^5/2G$ is

$$E_{tot} = w_{Pl} t = \frac{c^5}{2G} \cdot \frac{1}{H} = \frac{4}{3}\pi R_H^3 \cdot \varepsilon_{tot}, \qquad \text{so that} \quad \varepsilon_{tot} = \frac{3c^2 H^2}{8\pi G}. \qquad (2A)$$

Considering that $R_H = c/H$, as well as that $t = 1/H$ - the age of the Universe and $H = \dot{a}/a -$ the Hubble equation, from (8) we get:

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3c^2}(\varepsilon_V^e + \varepsilon_{dm}^e + \varepsilon_b^e), \qquad (3A)$$ - modified the 1-st Friedmann equation

ε_V^e - is the EM vacuum energy density;

ε_b^e - is the density of the energy binding to the EM vacuum all the mass components of the Universe in their state of rest with respect to the base inertial reference system (this quantity, characterizing the degree of "freezing" of the resting mass components into the space of the EM vacuum, is negative: $\varepsilon_b^e = -|\varepsilon_b^e|$);

ε_{dm}^e - is the energy density component, which is also negative ($\varepsilon_{dm}^e = -|\varepsilon_{dm}^e|$) and which characterizes the relativistic increase in the mass and the degree of "freezing-in" of those star clusters and galaxies that move with relativistic velocities relative to the base reference system (the subscript "*dm*" is used here to denote that the energy density so introduced is related to "dynamical mass"; the hypothetical "dark matter" is a phantom!).

2nd equation of the Universe dynamics

The expression for the work ΔA done under the influence of the EM vacuum pressure p_{eff} during the expansion of the Universe over time Δt is represented as:

$$\Delta A = \frac{\varepsilon_V^e}{\varepsilon_{tot}} w_{Pl} \Delta t = p_{eff} \Delta V_H \Big|_{R_H} = p_{eff} \cdot 4\pi R_H^2 c \Delta t, \qquad \textbf{(4A)}$$

so that $$p_{eff} = \frac{\varepsilon_V^e c^4}{8\pi \varepsilon_{tot} R_H^2 G} = \frac{1}{3}\varepsilon_V^e. \qquad \textbf{(5A)}$$

Можно показать, что раннее определенным в рамках стандартной модели на основе уравнения Фридмана значениям ε_V ≈ (0.5 – 0.7)·10^{-8} erg/cm^3 будут соответствовать вводимые на основе модифицированного уравнения Фридмана значения ε_V^e ≈ (0.93 – 1.30)·10^{-8} erg/cm^3, которым ставятся в соответствие значение космологической постоянной $\Lambda \approx (1.92 - 2.69)\cdot 10^{-56}$ cm^{-2}, а также $R_H = (1.53 - 1.29)\cdot 10^{28}$ cm.

Note, the value obtained $p_{eff} \approx +(3.1-4.3)\cdot 10^{-9}\,\mathrm{erg/cm}^3$ completely agrees with the values in the standard model adopted for the repulsive pressure.

We also indicate that within $\Delta t = 24$ hours the volume of the Universe increases by an amount $\Delta V_H \approx 7.5\cdot 10^{18}\left(light\ year\right)^3$ (in agreement with Davis's estimate).

IIA. Estimate ε_V [5]

The principal difference between the model of the Universe dynamics under consideration and the standard model consists in localization of the energy source, which determines the total Universe energy and its expansion by maintaining the pressure of the EM vacuum, at the False vacuum – EM vacuum boundary, but not in the volume of the Universe. In our model, all energy has an initially electromagnetic nature. Due to linearity of the equations of electromagnetic field, the total energy of any electromagnetic field can be represented as the sum of energies of the field oscillators, and for the average energy per the angular frequency range from ω to $\omega + d\omega$, there holds:

$$u(\omega,\Theta)=\left(\frac{\hbar\omega}{2}+\frac{\hbar\omega}{\exp\Theta-1}\right)dN,\quad \Theta\equiv\frac{\hbar\omega}{k_BT} \qquad (6A)$$

Here $dN=\frac{\omega^2V_\omega}{2\pi^2c^3}d\omega$ is the number of field oscillators having frequencies within the indicated range; V_ω is the volume of the configuration in which the field corresponding to the oscillator with frequency ω is enclosed; k_B is Boltzmann's constant, T is the ambient temperature. The right-hand side of expression (6A) includes two qualitatively different terms. Let us first consider the second term, which is associated with Planck's formula for the spectral distribution of the equilibrium blackbody radiation, and which has a specific binding to the local environmental conditions, to the particular temperature of various extended regions of the Universe.

We can assume that such regions are randomly scattered over the Universe and have different spatial extent. Therefore, when calculating the energy density of radiation associated with the second term in equation (5A), the result obtained after integration over the entire possible frequency range will be assigned to one of these regions. The configurational volume of this region is represented as a constant value, $V_\omega = V = \text{const}$, assuming that in this volume there is localized the field produced by the oscillators with all possible frequencies. Obviously, in this case, the integration can be formally carried out over the infinite frequency interval. As a result, we obtain for the corresponding Planck density ε_P of the radiation energy, given the fact that to each wave vector there correspond two states of polarization:

$$\varepsilon_P = \frac{\pi^2}{15} \cdot \frac{(k_B T)^4}{\hbar^3 c^3} \equiv \sigma T^4, \qquad \sigma = \frac{\pi^2 k_B^4}{15 \hbar^3 c^2}.$$

Stefan-Boltzmann law

It is believed that the process of this assimilation of the energy of false vacuum with its transformation into the energy of the expanding Universe occurs permanently during the appearance of the sources of Planck power within the border regions of two vacuums: the EM vacuum and the false vacuum. Furthermore, all the freed mass-energy of the Planck source must be emitted into the existing Universe, which is helped by high affinity ("freezing-in") of the formed material particles to the EM vacuum, characterized by the energy of their connection with vacuum.

At the same time, starting from the uniform distribution of the incoming energy across the entire space of the Universe, the length of which is $R_H \sim 1.3 \cdot 10^{28} \mathrm{cm}$, the averaging of the total zero-point energy must be carried out over the volume $V_H = 4/3\pi R_H^3$. The main contribution into the total energy of zero-point fluctuations of EM field is formed by the highest frequencies – from $\omega_Q = 2\pi c / a_Q \approx 1.45 \cdot 10^{24} s^{-1}$ to the Planck value

$$\omega_{Pl} = \frac{c}{a_Q} \cdot \left(\frac{R_H}{a_Q} \right)^{1/2} \approx 0.73 \cdot 10^{44} s^{-1}$$

to which there corresponds the spatial scale

$$a_{Pl} = 2\pi c / \omega_{Pl} \approx 2.6 \cdot 10^{-33} cm$$

Since $a_Q >> a_{Pl}$, as the configuration volume in the calculation of the average density of zero-point energy of EM field we choose $V_{\omega Q} = 4/3\pi a_Q^3$. Then, in the integration of the first term in the right-hand side of expression (10) over the frequency interval $[\omega_Q, \omega_{Pl}]$ with referring of the obtained energy to the volume *VH* and taking into account the fact that to each wave vector there correspond two polarization states, we obtain:

$$\varepsilon_V^e = \frac{2^{1/2}}{16\pi^2} \cdot \frac{m_Q c^2}{a_Q^2 R_H} \approx 1.5 \cdot 10^{-8}\ \mathrm{erg/cm^3}, \qquad (7A)$$

так что $$\Lambda = \frac{8\pi G}{c^4}\varepsilon_V^e = \frac{2^{1/2}\pi}{R_H^2} \qquad R_H = 2^{1/4}\pi^{1/2}\Lambda^{-1/2}.$$

The obtained quantity (taking into account certain conditionality of the selection of numerical coefficients in the introduction of the parameters used) is close the above value, obtained on the basis of observational data.

I believe that the problem of "120 orders" is solved.

For the subsequent estimation it is convenient to introduce the dimensionless ratio φ of the energy density ε_V^e to the density ε_Q of intra-nuclear excitation $E_Q = m_Q c^2$, localized in the volume $V_{\omega Q} = 4\pi a_Q^3/3$:

$$\varphi \equiv \frac{4\pi a_Q^3 \varepsilon_V^e}{3 m_Q c^2} = \frac{\varepsilon_V^e}{\varepsilon_Q}.$$

In this case:

$$G = \frac{\hbar c}{\sqrt{2} m_{Pl}^2} = \frac{\hbar c}{m_Q^2}\alpha_g = 2^{3/2}\pi^2 \frac{\hbar c}{m_Q^2}\frac{a_Q}{R_H} = 2^{9/2}\pi^4 \frac{a_Q^4}{m_Q^2}\varepsilon_V^e = 24\pi^3 \frac{\hbar c}{m_Q^2}\varphi$$

For the dimensionless constant of gravitational interaction α_g, taking into account the numerical values $\varepsilon_Q \approx 3.64 \cdot 10^{34}$ erg/cm^3 and $\varphi \approx 4.1 \cdot 10^{-43}$, we obtain:

$$\alpha_g = \frac{m_Q^2}{\sqrt{2} m_{Pl}^2} = 2^{3/2}\pi^2 \frac{a_Q}{R_H} = 24\pi^3 \varphi \approx 2.85 \cdot 10^{-40}$$

With the introduction of the parameter φ, the representation (1a) of the Planck numbers is also simplified:

$$a_{Pl} = 2^{7/4} 3^{1/2} \pi^{3/2} a_Q \varphi^{1/2},$$

$$t_{Pl} = 2^{7/4} 3^{1/2} \pi^{3/2} \tau_Q \varphi^{1/2},$$

$$m_{Pl} = \frac{1}{2^{7/4} 3^{1/2} \pi^{3/2}} \frac{m_Q}{\varphi^{1/2}},$$

$$w_{Pl} = \frac{1}{2^{7/2} 3 \pi^3} \frac{m_Q c^2}{\tau_Q \varphi}.$$

$$\Lambda = \frac{2^{1/2}\pi}{R_H^2} = \frac{\pi}{R_H^2}\alpha_s.$$

Сон разума рождает чудовищ

“Чего только не сотворит портной!

Гойя

Даже чистый кислород на Марсе”

Дали