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Can the Present-Day Cosmology Really Make the Universe Understandable as a Sheer Physical System Operating as it must?

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Abstract

The modern and present day cosmology starts from the main idea, that our universe had one common begin in the so-called "Big-Bang", and that the traces of this begin can be clearly extrapolated from the presently observable cosmic facts, which still now can be found in the universe. In addition one assumes, based on the "cosmologic principle" that no space point in this universe is privileged with respect to any others, rather this universe in its energy depositions and physical conditionings represents itself as a totally homogeneous building in which everywhere happens the same, i.e. for all space points the past, the presence and the future are identical in this universe - at least when studied on reasonably large space- and time- dimensions and when studied on such "reasonable" dimensions it is subject to a common and ubiquitously identical evolution, bringing up the same future simultaneously at all of its places [1-3].

In this article here, we shall subject this standard cosmologic view to an extended critical exam in order to expose its rational weaknesses and intellectual impudence's. It will be shown that the upcoming fate of the present universe strongly depends on its present internal Hubble expansion dynamics and its internal cosmic ingredients, which influence this expansion dynamics. Amongst these latter ingredients, one finds the mass content of the universe which by its gravitational attraction decelerates the cosmic expansion, and its opponent, the vacuum energy, that is seen as an enigmatic physical phenomenon which accelerates the cosmic expansion. We will show, however, that both these obviously essential cosmic ingredients are only poorly understood.

Especially this concerns the mysterious vacuum energy of which we demonstrate that acceleration of cosmic dynamics can only be connected with pressure, but if vacuum pressure accelerates the expansion of the universe and so does perform thermodynamic work, it then cannot be constant as once proposed by Einstein and thus as such taken for granted by [4]. In addition, the internal cosmic gravity as we show is only poorly understood especially what concerns the source of this internal gravity, which usually is ascribed to the mass content of the universe connected with the mean cosmic mass density. Just this latter quantity, however, is a highly problematic physical quantity as we intensively demonstrate in this article. Taking everything together it is therefore hard to feel safe in this "explained universe" which cosmologists presently are offering to the community as their understanding of how this cosmos works.

The Big Bang: The Standard Paradigm of the Origin of the Universe!

The present day cosmology tries to represent the world in an as simple as possible form - without losing the reality of the world completely - namely by completely symmetrizing the structures of our universe. This strong homogenization in the cosmic energy distributions and in the actual curvature isotropies serves for the advantage that under such circumstances one can use the Robertson-Walker metric and this way can simplify the 10 Einsteinian general relativistic field equations to only two independent, non-trivial differential equations [5,6]. The remaining two differential equations the so called: Friedman equations! describe by the quantities $\dot{R}$ and $\ddot{R}$ the velocity and the acceleration of the changes of the cosmic scale $R(t)$ per world time t [7,8]. In these equations it is assumed, that the massive particles in the universe can be appropriately described by a homogeneous mass density $\rho = \varrho(R)$ which because of the expected particle number conservation then is inversely proportional to the world volume, i.e. inversely proportional to the third power of the scale $R(t)$, i.e. given by $\varrho(R) = \varrho_0 \cdot (R_0/R)^3$.

In addition, a constant vacuum energy is taken into account that enters the field equations via a cosmologic constant Λ, which goes back to an idea of Einstein [29]. With this term as one can say every cosmic volume gets equipped with an amount of energy that is proportional to this world volume itself. This term up to now is not yet physically justified by itself, but, different from concrete masses of particles, it represents an energy connected with the sheer cosmic volume, and in this form causes an accelerative action upon the scale $R(t)$ of the universe. If it can be physically justified, this term acts oppositely to all terms describing the action of "particle-associated" energy depositions, namely by accelerating, instead of decelerating, the cosmic scale evolution.

Concerning the cosmological action and consequences of these terms one herewith gets opened up a game with the cosmologic parameters: Just connected with the ratios of the different cosmologic parameters relative to the critical cosmic density given by $\rho_c = 3H^2_0/8\pi G$ (H_0 = Hubble constant; G = Newton´s gravitation constant) one then finds the multitude of different evolutionary tracks along all individual ones of which the universe could in principal have evolved. These possible evolutionary tracks are shown in Figure 1 below

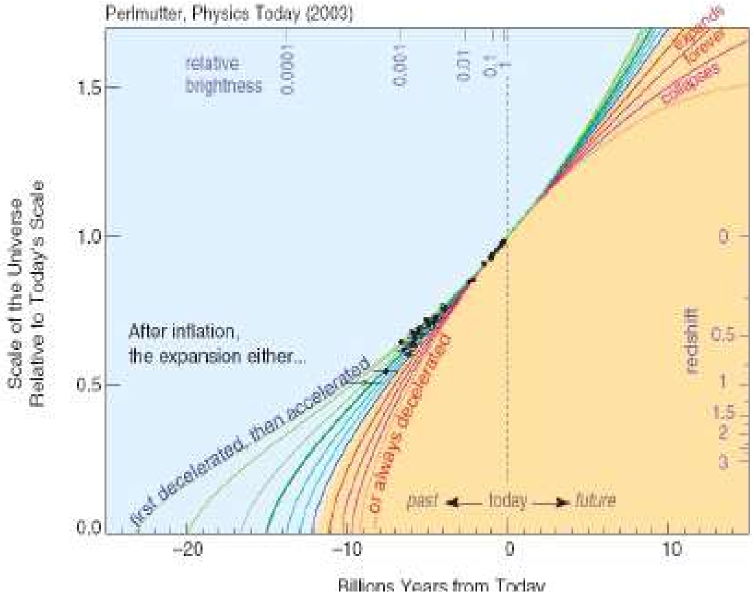

Figure 1: Alternative Solutions of the Friedman-Lemaitre Equations on the Basis of the Robertson-Walker Cosmology [9].

Out of the multitude of different, but physically possible solutions, one can now try to select that single solution which in view of astronomical facts seems to be the best fitting one. Astronomical facts that are helpful in this respect are, however, not simply available off hand, but need to be found by the astronomical observers in a theory-immanent form, i.e. astronomical data are not theory-free. For instance, the distance of the farthest supernovae SN1a in connection with cosmologically interpreted redshifts can be found such that apparent and expected luminosities of these farthest objects in this frame of the cosmologic standard modelling nicely correspond to each other [4]. Such attempts to determine best-fitting cosmic parameters do, however, lead astronomers these days to a rather strange form of the universe:

According to present day results the main portion of the present-day world energy, namely 72 percent, according to this attempt is constituted by the so-called "dark energy" or the "vacuum energy" , while the second big portion, namely dark matter which is thought to be required to bind galaxies gravitationally together, is represented by 23 percent [10].

Astonishingly enough, just that part everybody thought would be the most important one, since we and all the planets, stars and galaxies are all made of it, namely baryonic matter, amounts only to 4 percent of the total cosmic energy budget, a nearly negligible contribution to the whole energy of the universe!

The quintessence of this cosmology thus is: The most essential energetic ingredience of this universe is the **cosmic vacuum - or in other words** - the emptiness of the universe! The famous philosopher G.W. Leibniz in 1719 had formulated the essential, ontologic question why at all is there something in the world instead of simply nothing? (Pour quoi il y a plutot quelque chose que rien?). Today in these present times of cosmological research, it seems that the timely question must rather sound: Why is there so much "nothing" in the world instead of something? - Isn't that an irony of science contra philosophy?

For many people amongst our thinking mankind it would really appear as something like the final wisdom to know, that the world consists of **nothing**. Because **then**! It would be easy to understand that this world could originate also from nothing, and the ever-plaguing question how this gigantic world could at all be created, would have an evident, trivial answer: This world is nothing; it originates from nothing and forever will remain nothing. Nevertheless, how to bring in conciliance this philosophically pleasing view with the fact of this huge stage of matter and dynamics, which the universe is presenting to us? Nothing in physical sense means "vanishing energy". However, is it possible to dream of a universe with vanishing energy, though on the other hand the energy of stars and stellar systems around us represent such a huge amount of positive energy? - The answer astonishingly is YES! Namely , if the gigantic amount of positively valued energies E of this universe is compensated by an equal amount of negatively valued energies U - like for instance gravitational binding energies -, so that one obtains as a result E + U = 0! In fact as we shall show later in this article this is an exciting solution and it is well possible, but leads to a cosmological model of our universe which is strongly different from the present day standard model.

Introductory Aspects

For many of the thinking present-day human beings already the attempt of mankind to subject the whole universe to a pure rational and physical explanation appears to them as something like a big sacrilege in itself. For them it resembles already to something like a complete loss of estimation of the independent greatness of the infinite cosmic nature: How can mankind be so overambitious and kean as to offer a rational explanation of this grandiose self-sustaining universe in its entity and in all of its contexts? To these latter people it obviously appears equivalent to the complete loss of the independence and genuineity of the glorious universe around us. But should one not at the same time also see that the rational human interpretation of this glorious world is a clear sign for the fact that this world as the transcendental being for the human ratio talks to the human mind in a rational form - without making thereby the transcendental being of this world disappear? Mankind understands the universe, and the universe this way becomes an understood universe, - but all that without making the universe an immanent being of human spirit. As astonishing as it is: The human spirit somehow is a big mirror of the universe! Let us see in the following, how this mirror image of the universe nowadays looks like.

That condition, well thought out, does not make it worthwhile to ask whether the cosmic evolution by itself has the internal anthropic commission to create, besides all the other things around, humankind. It should rather be asked , how does it come that the universe in a Kantían sense can be a transcendental aesthetic object of our human mind or even, said in other words his rational partner of conversation. An early, but fully comprehensive answer to this fundamental question was already given by the Dominican Priest Nikolaus Kusanus in his book "De docta ignorantia" where he emphasized that the universe is the "reflected image" of our human ratio, as on the contrary our ratio is the reflected image of our universe [12]. We understand the universe as its mirror image in our human ratio. In the following part of the article we shall hence try to investigate and to pinpoint, how this type of "image universe" at present looks, if seen as its reflected image in our mind.

The Universe Seen as Reflected Image in our Mind

The standard cosmology is based on the assumption that the universe is built according to the so-called "cosmological principle", i.e. based on the fact that no space point in this universe is privileged with respect to all its neighbor points, so that even, should it turn out, that mankind is only hosted within our solar system, that does not mean any substantial and physical distinction from here to there [1,2,12]. If on the other hand, at least at the begin, no space point in the universe is physically conditioned different from all other space points, then rather the universe in its energy depositions and physical conditions everywhere is completely alike. In fact even nowadays, when astronomers detect, after expected gigayears of cosmologic evolution, - stars, galaxies and galaxy clusters, they can confirm that the large-scale universe, seen and averaged over correspondingly large distances, nevertheless still now is characterized by its large-scale homogeneity, even though material structures of different scales are typical and essential for it [3].

What is surprising: A universe which is infinite and has structures on all smaller scales, but tends to reveal itself as a large scale homogeneity, can, however, be imagined also on quite a different basis compared to how it is practiced in the present day standard Big-bang cosmology. This we only briefly want to mention here to keep eyes of the critical reader open for alternatives. One namely could alternatively to the present day standard Big-Bang model think of a universe that in fact is a chaotic system with uncountable many multicausal, nonlinear feedback couplings, acting back to each of its space wide physical states. Also this way it would be accomplished, that at least averaged over correspondingly large time cycles no world point would be privileged with respect to all the others. Everywhere, seen over correspondingly large space volumes and time-periods, seen over the long run the same would happen at each place in the universe. This given for our present world would make the question about the beginning of the universe - and especially the event of the Big bang - an obsolete and useless one. Nonlinearly chaotic systems namely are known to let their initial states completely disappear in the fog of the past. At no place the present physical events can be connected with or reduced to their initial states. Somehow as useless, as it is to ask for the beginning of the weather on Earth. This is only mentioned as an alternative possibility showing, how completely different possibly the history of our universe could perhaps also have been.

Coming now, however, back again to the well believed standard Big-bang cosmogical view where one describes a "structured homogeneity" which from its given facts allow to go back to its origin. In this present-day standard cosmology, just this imputed homogeneity serves as the basis of all cosmologic modellings. The assumed cosmic homogeneity of the energy depositions in the universe then allows to presuppose a curvature isotropy valid for all space points in this universe (i.e. either globally positively curved with $k = +1$, or negatively curved with $k = -1$, or non-curved with $k = 0$), so that under such conditions the so-called Robertson-Walker metric can be used to reduce the system of Einstein‘s 10 independent partial differential General Relativistic field equations to only two independent differential equations (now called in the literature: "Friedman equations" which via the quantities $\dot{R}$ and $\ddot{R}$ describe the first and second derivatives with respect to the world time of the scale $R = R(t)$ i.e. the velocity and the acceleration of the general world scale expansion $R(t)$ [5-8].

From the first of these Friedman equations one can then derive the way (e.g. Goenner, 1996) how the universe must be expected to have expanded including the following solution for the Hubble parameter also shown in Figure 2.

$$H^2(t) = \frac{\dot{R}^2}{R^2} = \frac{8\pi G}{3}[\rho_B + \varrho_D + \varrho_\nu + \varrho_\Lambda]$$

Hereby G is Newton‘s gravitational constant and ρ_B, ϱ_D, ϱ_ν, ϱ_Λ denote the corresponding mass densities of baryonic matter (B), of dark matter (D), of photons (ν) and of the vacuum energy (Λ). Especially this latter quantity Λ, i.e. the energy- or mass density of the vacuum hereby has meanwhile become a cosmologically very important, one can say: "Omni-determining", but also up to now very mysterious, not understood, and physically not anchorable quantity. The properties and virtues of this mysterious quantity Λ we therefore shall now investigate deeper in the following article.

For the present epoch, one has obtained best-fit values for the above quantities $\Omega_B = \rho_B/\varrho_V$, $\Omega_V = \rho_V/\varrho_C$, $\Omega_\Lambda = \varrho_A/\varrho_C$, $\Omega_\Lambda = \varrho_A/\varrho_C$ with $\rho_c = 3H_0^2/8\pi G$ (H_0 = Hubble constant; G = Newton´s gravitation constant) given by of [4,10]:

$\Omega_B = 0.04$
$\Omega_D = 0.23$
$\Omega_V = 0.01$
$\Omega_A = 0.72$

Inserting now the known dependences of ρ_B; ϱ_D; ϱ_V; ϱ_A on the scale R of the universe leads us to [12]:

$$H^2 = \frac{\dot{R}^2}{R^2} = \frac{8\pi G}{3}[\rho_{B0}(R_0/R)^3 + \rho_{D0}(R_0/R)^3 + \rho_{v0}(R_0/R)^4 + \rho_\Lambda]$$

or introducing the present-day Ω - values, one obtains the function that is shown in Figure 2

$$H^2 = \frac{\dot{R}^2}{R^2} = H_0^2 \cdot [\Omega_B(R_0/R)^3 + \Omega_D(R_0/R)^3 + \Omega_v(R_0/R)^4 + \Omega_\Lambda]$$

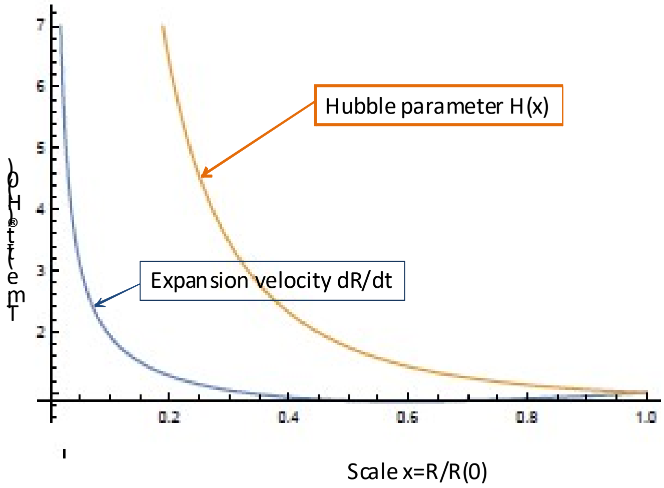

Figure 2: Shown are the Hubble parameter $H = \dot{R}/R$ (yellow curve) and the cosmic expansion velocity $\dot{R}$ (blue curve) as functions of the normalized cosmic scale $x = R/R_0$ calculated on the basis of the best fitting values for Ω_B, Ω_D, Ω_V and Ω_A found by Perlmutter et al. for the present universe [4].

The Damned Mystery with Empty Space

The question what actually means "empty space", or its synonym "vacuum", in a strictly physical context has not been answered up to the present days, but nevertheless this question is a very fundamental, outstanding one and an adequate and comprehensive answer is definitely needed here. This question thus has been put all over the periods from the Greek natural philosophers up to the present times of modern quantum field theories, and always in new forms and aspects, but never a final answer was formulated or has been given. The given answers over the past centuries have been reviewed and analyzed by several authors in the recent past like [13,14]. We do not want to repeat all these argumentations here, but we want to stress the main points in the following part of the paper.

As a specially seducing aspect it may be mentioned here , that the empty space, despite of its conceptual "emptiness", nevertheless needs to be considered as energy-loaded - simply because of its genuine property being manifested as physical space stage with disposable space points allowing for individual energy depositions, i.e. "Topified Energy Representations". In case of an empty space these topifications naturally cannot be due to concrete particles or photons, nevertheless it must be discussed whether such empty spaces, even if they do not allow for differences between one and the other space point, can yet be energy-loaded. This space energy needs to be connected with the sheer size of space or perhaps with the space-geometry, however, in that case with the special property that a single space point by this geometry is not different from all the other space points. If curvature properties of space should play a role in this context here, then only without making different space points discernible. That means: If at all curvature properties could play a role, then only as general, global curvature properties like the general space curvature itself.

In this context Fahr has recently shown, that the conservation of vacuum energy of a dynamic cosmic space-time can only be formulated as conservation of the proper-energy of the proper volume co-moving with the dynamical space-time [12]. The conservation of this proper energy can of course only then be expected, if this quantity by itself does not perform work upon just this dynamics of the cosmic space-time. If to the contrast, work is performed upon this dynamics, then automatically the thermodynamic conditions have to be fulfilled as the following relations between vacuum energy density ϵ_{vac} and vacuum pressure p_{vac} in the form:

$$\frac{d}{dR}[\epsilon_{vac} \cdot R^3] = -p_{vac}\frac{d}{dR}R^3$$

This thermodynamic request for the vacuum energy can, however, as one can easily show, only be accomplished, if vacuum energy density ϵ_{vac} and vacuum pressure p_{vac} are connected by the following polytropic relation:

$$p_{vac} = -\frac{3-\xi}{3}\epsilon_{vac}$$

where ξ is a pure number, namely the polytropic vacuum index, which, as becomes evident from the above, for the case of $\xi = 3$ represents the case of a completely vanishing vacuum pressure $p_{vac} = 0$ (i.e. pressure-less vacuum!).

This tells us interestingly enough that even, if one more or less does not know anything substantial and apriori on this vacuum energy , at least the above relation between its pressure and its energy density can ahead of more upcoming details be fixed. Nevertheless, the big open rest in this theoretical concept still needs to be supported by reasonable physical inputs. The nowadays favored and required, form of the vacuum - inflating the universe under the action of the vacuum pressure is, however, as one may immediately see, loaded with quite a series of physical controversies, which shall shortly be mentioned here. A universe which together with its internal mass distribution according to observational redshift data is claimed to be enlarged by the specific action of vacuum energy from scales $R_0 \leq R_1 \leq R_2$ such a vacuum cannot keep its energy density constant, since this energy reservoir must do the work against the internal gravitational attraction forces of these cosmic masses [4]. These forces for an un-curved isotropic universe are proportional to M_U/R^2, where M_U denotes the total mass of the universe.

If just the vacuum energy now is thought to do this expansion work, then it is clear that this vacuum energy of the universe has to diminish at enforcing this expansion, unless the mass of the universe M_U vanishes. If nevertheless the vacuum energy, as done in the standard cosmology is assumed to be constant, as also according to Einstein‘s proposal $\epsilon_{vac} = \Lambda = const$, then one would create the confusing and absurd physics, that in this case the quantity ϵ_{vac} acts upon the mass distribution of the universe without getting any back reaction from the universe for that (i.e. an absurdity in Newton‘s sense, since: Nulla actio sine reactionem!) [4]. It would mean that though the vacuum does work for the expansion of the cosmos, it nevertheless increases its total energy. It would resemble the bizarreness of a "Münchhausen"- cosmos that draws itself with his "vacuum hairs" out of the singular gravitational mud - and even though doing this, gains more energy.

Let us ask here, whether perhaps there exist alternative formulations of these cosmic conditions, which would let an accordingly adapted cosmology, make look more reasonable. However, perhaps the following questions should ahead of that first be answered here:
How does the total mass M_U of the universe behave at the expansion?
How does the mass density behave in an expanding curved universe?
How scales the vacuum energy with the scale R of the universe?

Is the Total Cosmic Mass of the Universe Constant in an Expanding Universe?

Over all times of the past it has tacitly been assumed that the total mass of the universe, M_U, represents a physical conservation quantity , and thus it has been assumed that this latter quantity is constant over the periods of cosmic expansion, i.e. $M_U = const$! However, when forced to think deeper on this cosmological context, the question may arise why at all the total mass M_U in an expanding universe should be invariable and constant? In addition, following a first question a second question would necessarily arise, namely: How would one define logically correct this total mass of a universe which latter perhaps evolves in cosmic times? What mass is denoted as M_U? Is it the space-time sum over all masses in the universe? Alternatively, does it express the simultaneous mass of the universe? In both cases, as it turns out, a cosmologically irrelevant physical quantity?

To address this basic question let us start here with a fundamental idea of the Austrian physicist, Ernst Mach, who was a Professor of Physics at the university of Vienna and wrote an important book: "Die Mechanik in ihrer Entwicklung: Eine historisch, kritische Darstellung [15]. Inertia of a mass is measured by the acceleration, a force does realize when acting upon that mass. Mach interestingly enough was expecting a correlation between the inertia of all massive things and the scale R of the universe. In his view, the inertia of all objects in this world is not a genuine preselected or predetermined quantity of nature, but it rather is a relational quantity, which has to do with the size or the scale R of the universe. This Machèan idea is fascinating in its internal logics, but has never till now be taken serious and physically fully respected in its cosmological consequences [16,17]. Nevertheless, there exist serious hints that such a Machéan mass behavior could make a good sense in cosmology, and could deliver important explanations for several basic cosmological problems [13,18-21].

If cosmology would actually have to respect this Machean idea, then the present-day cosmology as a whole would be nearly obsolete, since the concept of a Machean inertia does not yet have any place in it, but at the same time just this would also reveal, that with its present endeavors this present-day cosmology cannot be considered as giving a final satisfying view of the world evolution and its behavior in the coming future. So let us ask now, what else besides Mach´s conviction may give a support for the idea of cosmic masses changing with the scale R of the universe. First: If one tries to deduce the general relativistic field equations from a variation principle applied to a matter- and metric-comprehending action function $L_{g,M}(x_i, \dot{x}_i)$, this will lead one automatically to a scaling of the rest-energy of cosmic particles with the world line element which evidently must be understood as a Machèan phenomenon of cosmic masses [22-26]. When on the other hand the equivalence of rotations at the choice of the suitable, basic reference system (Principle of relativity of rotations!) is also required for cosmic physical systems, then it becomes evident, that a rotating Earth embedded in a universe at rest only then has identical phenomena with an Earth at rest in a rotating universe around it, if cosmic masses do grow linearly with the cosmic scale R. [13,18, 21,27].

The question, what under such conditions does represent the total mass M_U of the universe, takes one back to very interesting and fundamental ideas concerning the question how and whether at all the mass M_U of the universe may be gained as sum of the mass density in the universe as a simultaneous quantity. Because under these conditions the four-dimensional space-time geometry of the universe had to be taken into account, and in addition one also has to respect the point that under the given prerequisites this what counts , in fact is the "instantaneous world mass" , i.e. the "space like" sum of all masses in the universe. For that, quantity as shown in Fahr and Heyl [28] one finds that such a space-like sum leads to an asymptotic maximal value, if the integration border is extended to a limiting radius R_U [28]. Since beyond this radius, as has been shown by Fahr and Heyl, further mass contributions do vanish, one could say that the mass $M_U = M_U (R_U)$ is the maximal, total mass of the universe, and could with physical sense be called the mass M_U of the universe [28].

It is interesting to recognize that the limiting radius R_U for such a mass integration is given by [28]

$$R_U = \frac{1}{\pi}\sqrt{\frac{c^2}{2G\rho_0}}$$

where c denotes the velocity of light, G is Newton´s gravitational constant, and ρ_0 denotes the actual mean mass density of the universe. Transcribing the above relation then it may express the fact that this density ρ_0 is inversely proportional to the squared world radius, and not as generally expected inverse to the cube of R_U. In addition, with the above relations, one interestingly enough finds that the simultaneous world mass M_U now is consequently given by

$$M_U \sim \rho_0 \cdot R_U^3 \sim R_U$$

i.e. a clear-cut Machèan mass relation which as well could also have been concluded from Thirring's relations [18].

Mass Generation in the Expanding Universe

Many of cosmology-interested people are irritated by the fundamental question, whether or not perhaps during the expansive evolution of the cosmic goods something new comes to the stage of the universe - perhaps in form of new thermodynamic information's or new particles that could referment the physical goods or gifts. Already the famous astrophysicist Fred Hoyle (1948) in the interest of guaranteeing a cosmic state conservation, thought of a cosmic mass generation or particle creation which could establish a so-called "steady state" of the universe, even though the latter continues to expand. To guarantee that the universe despite of its expansion permanently looks the same, it should create information or new particles in just a balanced rate. Whatever one thinks about Hoyle's ideas these days, it is nevertheless very interesting to find post-hume that the mathematical formulation which Hoyle found for the needed mass creation rate leads to a universe in full analogy to an Einstein-DeSitter universe with a comologic constant Λ just as recommended by Einstein himself, if only this constant Λ is replaced by the following matter creation rate $\dot{\rho}$ [29,31].

$$\Lambda = \left(\frac{8\pi G\sqrt{3}}{c^5}\dot{\rho}\right)^{2/3}$$

This seems to show that vacuum energy described by the cosmologic constant Λ in its cosmologic effect is equivalent to matter creation, at least in the steady state universe. How could such a connection establish itself? Does it perhaps express the eminent truth that vacuum energy and cosmic matter generation are equivalent phenomena? In that case, the standard model of the universe would evidently be wrong. At Fred Hoyle's request concerning the steady state universe it turned out that a mass generation is needed proportional to the actual matter density ϱ itself in order to keep the cosmic state constant. Since the density ϱ in the steady state universe, however, is a constant, this consequently implies as a corresponding requirement: $\dot{\rho} \sim \rho = const$!.

In a completely independent study, however leading to very similar relations, Fischer has analysed how the gravitational binding energy of cosmic matter enters the relativistic energy-momentum tensor $T_{\mu\nu}$ i.e. the source tensor of the space-time geometry in the field equations [32]. It is interesting, his ideas lead to the point that in a positively curved universe the corresponding entrance $T^b_{\mu\nu}$ for the binding energy has to happen by the following term:

$$T^b_{\mu\nu} = -C\frac{\rho}{\Gamma}g_{\mu\nu}$$

where C is an appropriate constant containing Newton´s gravitational constant G, and $g_{\mu\nu}$ denotes the metric tensor, and Γ denotes the actual curvature radius of the positively curved universe.

This enlucidates two different things: At first this shows again the proportionality to the matter density ϱ, and at second, this term has a negative sign, has the metric tensor as a factor, and in consequence in the field equations formally has the same appearance as the term which enters the field equations as vacuum energy via the quantity Λ.

Taken this fact, it seems to be demonstrated that in the standard model of cosmology some very important physical contexts between vacuum energy and gravitational binding energy have been overlooked. If taking together the time like tensor components T_{00} and T^b_{00} of cosmic matter and binding energy it namely becomes visible that in the standard model a very interesting dependence of these two quantities becomes evident. If one adds up this time-like tensor components, then quite a surprising connection becomes visible showing a close relation between matter generation and binding energy in the following expression:

$$\hat{T}_{00} = T_{00} + T^b_{00} = (\rho - C\frac{\rho}{\Gamma})g_{00}$$

This expresses more or less the important fact that the gravitational binding energy simply reduces the cosmologically active m atter density to its cosmologically effective quantity ρ^*, the so-called "proper density", given by the following expression:

$$\rho^* = \rho(1 - C\frac{1}{\Gamma})$$

That shows: If in the course of the cosmologic expansion the cosmic curvature radius Γ increases, then it simply means that the binding energy or its equivalent, the vacuum energy, are diminished, while at the same time the proper density ρ^* increases with a rate [33]:

$$\dot{\rho}^* = \frac{d}{dt}[\rho(1 - C\frac{1}{\Gamma})]$$

In case of a steady state universe according to Hoyle (1948), i.e. with $d\rho/dt = 0$, this then simply would mean:

$$\dot{\rho}^* = \rho C\frac{1}{\Gamma^2}\dot{\Gamma}$$

This means one would have a proper density increase proportional to the density itself being positive at increasing curvature radius

Γ or expressed in other words: At decreasing cosmic binding energies, the effective density increases exactly in the form, Hoyle (1948) did posulate it! Introducing the above-mentioned term for the binding energy into the Einsteinìan field equations, then for positively curved universes one finds solutions, which presents a universe that oscillates around an equilibrium scale R_0 between positive ($R \leq R_0$) and negative ($R \geq R_0$) vacuum energy values. Vacuum energy, binding energy, and variations of the effective mass density are clearly related to each other, and therefore they cannot be treated as independent quantities a view upon the cosmic things that does not yet have its merited place within the standard cosmology.

Mass Generation and Mass Density in the Universe

Contrary to a general belief the question, how the mass density behaves in an expanding universe, does not have such a trivial answer, as thought in the past, but has meanwhile become a challenging question, since it would, prior to any answer, need an answer concerning the prevailing space-time geometry and its feedback. This latter can, however, only be given via the solution of the general relativistic field equations.

As so-called "mass density", usually the time-like amount of "mass per volume" is denoted. In this sense the "cosmic density" conventionally is denoted as "proper-density" of cosmic matter, i.e. an amount of matter per unit volume in an inertial, non-accelerated reference frame. In the universe, it is easy to define freely flying inertial systems (i.e. co-moving inertial ff-rest frames!), one has, however, to pay attention to the finite, but extended sizes of such volumes over which non-inertial tidal forces act which geometrically distort such volumes. This complicates extremely the density definition by making space-geometry and "matter content per volume" implicitly interdependent. In a Robertson-Walker universe with Hubble expansion one can take any point at pleasure following this Hubble expansion as a free-fall system, however, taking a volume with finite extent around this point violates the free-fall condition. It is this fact what makes density definitions in cosmology rather difficult.

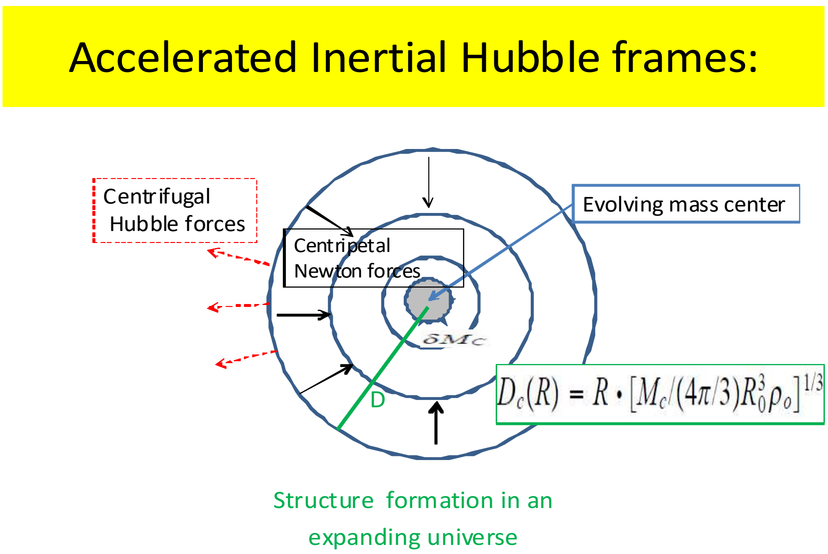

Figure 3: Accelerated Inertial Hubble Frames Surrounding a Central Einstein-Straus Vacuole [34].

Let us briefly investigate this local effect of a geometrical distortion: Isolation of a singular, local mass M in the universe by its associated Einstein-Straus sphere (i.e. the local sphere of inertia) from the rest of surrounding homogeneous universe, this then allows to pursue the following idea with respect to the given matter density in this special sphere [34,35]. Denoting the actual cosmic proper density as ρ_0, so one finds the proper mass $M(R_{ES})$ of this Einstein-Straus sphere with:

$$M(R_{ES}) = \frac{4\pi}{3}\rho_0 R_{ES}^3$$

But the Einstein-Straus sphere in a geometrically curved universe does not have its simple Euclidean volume $V_{0,ES} = \frac{4\pi}{3}R_{ES}^3$, but a metrically distorted, space like volume $V_{ES} \lessgtr V_{0,ES}$, causing the effect that the actual density in this sphere does not equal to the proper density ϱ_0, but equal to a metric-specific density $\tilde{\rho}_0$, given by the following expression:

$$\tilde{\rho}_0 = \frac{\frac{4\pi}{3}\rho_0 R_{ES}^3}{V(R_{ES})}$$

Calculating the space like volume of the Einstein Strauss sphere by use of the inner Schwarzschild metric this then leads to an expression for the effective density which for $R_{ES} \ll R_U$ can be brought into the following form [30]

$$\rho = \rho_0(1 - \alpha\rho_0^{1/3})$$

and consequently does not say anything else but the fact that, the effective density always is smaller than the proper density, all the more - the higher is the proper density in the universe.

We come back to the local mass M_{ES} within an Einstein-Straus sphere which associates this discrete mass of the cosmos to the volume within a spherical surface of a radius R_{ES}, at which the inner Scharzschild metric of the sphere and the outer Robertson-Walker metric of the cosmos steadily merge into one another. Or said in other words, there where the space points on the spherical sphere move exactly with the cosmic Hubble expansion velocity with respect to the spherical centre, i.e. "homologously" with the cosmic expansion off the centre of the Einstein-Straus sphere.

Hence, here the following relation is valid [30,36]

$$\dot{R}_{ES}/R_{ES} = \dot{R}_0/R_0 = H_0$$

where the dot on top of the symbols indicates the derivative of the corresponding quantity with respect to the cosmic time t, and H_0 denotes the Hubble-constant.

A separate and yet unsolved problem is connected with the question of a vacuum in a matter-filled universe. It is a non-trivial task to describe the action of the vacuum in case of a matter-filled universe. In that case when no apriori requests can be formulated concerning the space geometry, and in addition the assumption cannot be made that the vacuum energy density of the matter-filled universe is identical with that of an empty universe, since it is known that the presence of matter polarizes the vacuum and vacuum energy by matter-polarization may be different from the unpolarized vacuum energy [37]. These terrible uncertainties and imponderabilities may, - to clearly say the truth -, not allow for any exact cosmologic predictions at all.

The poor contemporary cosmologist, as a test for himself, may bravely bring in front of his eyes what should have happened in the past - and what should happen in the future - of our universe, if the present day belief would dictate the true cosmologic fate [4]. If for the present time of our universe those values found by Perlmutter et al., Riess et al. (1999). or Schmidt et al. (1999) found for the present time of the universe concerning its vacuum energy density $\Omega_\Lambda = 0.75$ and its matter energy density $\Omega_M = 0.23$ would mark the truth of our present universe, then one would be forced to conclude for the near cosmic future, on the basis of a constant vacuum energy density the upcome of the following astonishing values: $\Omega_\Lambda = 1.0$ and $\Omega_M = 0$!,while back in the near past rather values like $\Omega_\Lambda = 0$ and $\Omega_M = 1$ would have characterized the cosmic truth. Practically this means that in the near past vacuum energy would not have played any role at all for cosmology, while in the near cosmic future practically only vacuum energy would be relevant, disregarded whatever matter content belongs to this universe. This would mean, it should appear as a singular, never before and never after realized, anthropic coincidence, that just in our present cosmic times cosmic vacuum energy and cosmic matter energy are about in balance. The only way out of this basic anthropic enigma would obviously be to prove, that vacuum energy density and matter energy density over all cosmic times keep the same constant ratio. The reasons for that "new enigma" must, however, then first be found.

Why at all should the Vacuum Induce Gravity?

Let us ask us here, how vacuum energy basically should be formulated, if it has to be a valid analogue for effective matter generation in the universe and for gravitational cosmic binding energy, as pronounced in the sections before. For a long time in the past, one was questioning whether the cosmic vacuum should gravitate at all. Why should it influence cosmic space geometry, if it represents nothing? Why should it generate gravity, when it nevertheless is nothing else but pure emptiness? - If, however, some energy is ascribed to this vacuum, it may then appear more plausible or natural, that somehow vacuum might be gravitating and might contribute to the structure of space-time geometry, similar as matter also does. The question then only is: How does vacuum do it? In addition, what in case of the vacuum is its source of gravity?

The general-relativistic action of the vacuum has to be formulated in the field equations by means of an appropriately formulated energy-momentum tensor $T_{\mu\nu}^{Vac}$ for which the vacuum energy density $\rho_{Vac}C^2$ and the vacuum pressure ρ_{Vac} serve as tensor-entrances. In case of a constant vacuum energy density, this allows to write the vacuum-related energy momentum tensor in the following form:

$$T_{\mu\nu}^{Vac} = \rho_{Vac}c^2 g_{\mu\nu}$$

The question then posing itself is how and where Einstein´s cosmological constant Λ is appearing here? Is it already included in the above expression - or does it have to be introduced in addition?

As we have already shown in the sections before, the completely empty space with its "pure vacuum" can be characterized by an "effective cosmologic constant Λ_{eff}" given in the form:

$$\Lambda_{Eff} \equiv \Lambda + \frac{8\pi G \rho_{Vac}}{c^2}$$

i.e. a quantity composed as sum of two other quantities both of which are numerically undefined, namely the cosmological constant Λ and the vacuum energy density of empty space $\rho_{Vac}C^2$. This logically does not improve the situation, but there is an interesting way to solve this latter problem by asking a principal question: What at all should be expected from the "absolutely empty space" [33,38].

Following the advice of a purely mathematical logic, pure vacuum would require the self parallelity of a four-vector at parallel transports over a closed line in this vacuum. Physically this would require for example that the polarization vector of a linearly polarized electromagnetic wave at propagation along a closed way in this vacuum leads back to an identity with itself. For this to happen the commutator of the covariant derivatives with respect to two coordinates μ and ν applied to any transported four vector A_λ should vanish. The latter can in fact be achieved see, if the vacuum is described by a vanishing constant $\Lambda_{Eff} = 0$ or a cosmological constant given by [13]:

$$\Lambda = -\frac{8\pi G \rho_{Vac}}{c^2}$$

Further on physically it should be considered as reasonable, that a photon propagating through such a vacuum does not change its state or physical property at its propagation. Presently it seems, however, evident that empty cosmic space expands under the action of vacuum, and that such conditions would necessarily subject propagating cosmic photons to a permanent red shifting (see e.g. Fahr and Heyl, 2020, Fahr, 2020). This conflicting problem only then would not occur, if the effective cosmological constant Λ_{Eff} of the prevailing cosmic vacuum completely vanishes, or if in fact, the following is valid:

$$\Lambda_{Eff} \equiv \Lambda + \frac{8\pi G \rho_{Vac}}{c^2} \equiv 0!$$

Under less restrictive conditions we, however, have to face a universe with a finite vacuum energy, and this provocates the question what in that case vacuum energy does at the ongoing expansion of the Einstein-Straus globule. Asking for the work, what vacuum energy performs at the expansion of the Einstein-Straus sphere, and then it can be shown that this work seen from the inner sphere has a positive value. If based on the energy conservation assumption for the whole universe this positive work should be reflected by an energy gain of the E-S sphere, then it would make sense to ascribe this energy gain as a mass gain of the globule. This has very interesting consequences for the inner globular mass which according to Fahr and Heyl can be calculated by [30]:

$$\frac{\dot{M}}{M} = \frac{\rho_{0,vac}}{\rho_{0,mat}} H_0$$

Where $\rho_{0,vac}$ and $\rho_{0,mat}$ mark the actual vacuum energy densities and matter densities. For a constant ratio of these two densities (see section above!) the above relation thus simply expresses the fact $\dot{M}/M \sim \dot{R}/R$, or in other words a simple proportionality of the world mass M and the scale of the world R in the form

$$M \sim R$$

exactly identical to the idea that already Ernst Mach had tried to spread in the cosmic community [15].

What Mass Density Gravitates in Cosmology and the End of the Perceivable Universe?

To decide where gravity in this universe comes from one needs an expression for the total cosmioc energy. Hereby the single forms of cosmic energies have to be added up from all over the total cosmic space. All energy equivalents have to be added up. Not only the mass densities itself of real masses, but also their kinetic and thermal energies have to be bilanced taking into account pressures. For a complete bilancing not only the baryonic density ρ_b, the mass density of the dark matter ρ_d, but also the equivalent mass density of the cosmic vacuum ρ_{vac} has to be taken into account. In a similar way one has to proceed with counting all the manifest cosmic pressures in the form $p = p_b + p_d + p_{vac}$.

As many cosmologists do see it, the so-called "Big-Bang"-universe is not only a "begin"- determined, but also it is an "end"-determined cosmic system: As it is, it includes inherently its end. However, are we intellectually ready to accept an end-determined universe for us and the world, even though, as we have shown in the sections above, we do not at all understand the "begin-determined" universe? That universe, which we have created in our cosmological theory, is a poorly and badly thought out system. We should better not so easily allow having our "end" determined by the present rational mathematical misconstruction of the universe, which is so badly elaborated, and permanently creating doubts. This even more, since the easy-minded argumentation for the so-called entropy-death of the universe, if one looks a little closer onto it, cannot convince one, as we shortly want to emphasize here at the end of this article.

Looking a little more serious on this point, one easily finds confirmed that in the frame of the present-day Big-Bang cosmology the entropic end of such a universe is not at all clearly predictable. As it namely easily turns out, the main dogmata of the classical thermodynamics are not applicable to the open, non-closed system of the universe. The validity of the second of the basic thermodynamic dogmata, that the entropy in a closed thermodynamic system always has to increase, cannot be applied to the universe. The universe namely as a whole is not a closed thermodynamic system, it is rather an open system with many intensively radiating subsystems like galaxies and stars embedded in a 3K radiation horizon (i.e. the CMB microwave background with its 2.73 K temperature!). By radiating energy into the 3K -cool cosmic horizon all radiators like stars and galaxies permanently can get rid of a part of their internal entropies, they thus are non-equilibrium systems and in fact they do not approach their entropy maximum [39-50]. Thus, their end is undetermined and open.

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