Astronomy & Astrophysics manuscript no. isasi33 January 20, 2011
(DOI: will be inserted by hand later)

Equivalence between the empty microspace and the cosmological space

R.A. Isasi

Departamento de Física, Ex-Instituto de Educación Superior, 3260, Entre Ríos, Argentina
* Present Adress: M. López 121, 3260, E. Ríos. (ra_isasi@arnet.com.ar)

Received ¡date¿ / Accepted ¡date¿

Abstract. In this article, we discuss the origin and nature of the total photons number N_γ of the CMB radiation in relation with the critical baryons number N_b and the energy of the empty space. The CMB radiation, is considered as a huge amplification of the phenomena at atomic scale originated in the past, as the background microwawes are also the support of all the prints originated by posterior perturbations. This allows us to establish a connection between the microphysics and macrophysics by means of their reduction to a problem of scale and dimensional analysis. Taking into account the mean wavelength of the CMB radiation, we can parametrize the total number of photons as an invariant number through the succesive evolutive phases. The equivalence between the electrical potential and the gravitational potential is established by the relativistic implications which are found in Millikan's experiment. This generalization makes it possible to extend the formula of Saha used specifically in the inverse thermal ionization, and extend it to the gravitational collapse when the Universe had the size of 1.032 Mps. Furthermore, this scale unit, marks as much as the initial conditions, as the present one for the Hubble Law.

Key words. cosmology: theory cosmic microwawe background cosmology: dark matter - distance scale cosmology: nucleosynthesis

1. Introduction

At present, there are enough theoretical foundations, and also, well proved experimental observations which allow us to design a simple and consistent cosmological model.

1. The meaning and the nature of the Hubble constant as a scale parameter to establish the age and size of the Universe. Nowadays this constant shows an acceptably precise value, and by means of different methods of observation converges within $72(\pm 5)r(\pm 12)\mathrm{s\,Km\,s^{-1}\,Mps^{-1}}$ (Madore *et al.* 1998) and $71(\pm 3)r(\pm 7)\mathrm{s\,Km\,s^{-1}\,Mps^{-1}}$ (Freedman 2001).
2. The background radiation, with the typical characteristic of a blackbody whose distribution curve has a maximum at 2.73°K.
3. The number of photons per unit of volume for this temperature.
4. The Cosmological Principle, which determines the isotropy and homogeneity of cosmological space-time. Consequently, all positions are essentially equivalent, except for local irregularities. This principle has an unequivocal meaning by considering the same mean CMB frequency, and the same Hubble constant value for a simultaneous time at any point in the Universe contour.
5. The cosmological space acts as an entity, since it expands by itself as an active element, instead of considering a simple removal of the galaxies in a passive space. This fenomenon becomes clear by the stretching of the N_γ photons which permeate the whole cosmic space in a homogeneous way. Simultaneously, the light from the galaxies undergoes a correlative cosmological redshift (non Doppler redshift)
6. The angular power spectrum, with a peak at $l = 200$ implies a flat Universe (De Bernardis *et al.* 2000, Melchiori *et al.* 1999). This allows the use of the Euclidean geometry, as well as the re.-significance of Newton's mechanism to interpret the cosmological phenomena.

In this presentation we believe , that we arrive at some answers in a research line that accounts for important preliminary studies (*i.e.* Weyl 1919, Eddignton 1936, Dirac 1938, Jordan 1955, Dicke 1965 and recently Wilczek 1999). Clearing away some unfitting speculations given in the precursory analysis, due to the lack of experimental information, we consider the physics of the large and small adimensional numbers, as a cosmological approach whose structure and logical foundations exceeds those opinions that holds that it deals with pure coincidences.

2. The need to generalize the relativistics equivalences

2.1. Equivalence between the microscopic space and the macroscopic space

The empty space, understood as a "physical vacuum" within the microscopic contour of an isolated atom, as well as the macroscopic space, extends this later one to the limit known as the Universe, are subjected to an equivalent physical formalism. This spatial equivalence is a generalized property, and is sustained despite of the marked contrast between both magnitudes.

The significative scale difference between both extremes gives rise to the following properties which have relativistic significance.

1. An observer in the macrospace of the Universe lacks of simultaneity between the phenomenon and the observation, but has the possibility of registering the past events *i.e.* he is able to see a wide interval in the Universe history.
2. On the other hand, the same observer, from his macroscopic referential framework, is placed outside of the microcosmos; so that the experiments that reveal the nature of an isolated atom (excluding the inherent quantum uncertainty) present a practically simultaneous interaction in an unlimited reproducible way and unequivocal exactitude.
3. In both experiments (macroscopic and microscopic) all the information to justify the indistinguishability of both contours and its equivalence, is provided by means of the comparison of atomic spectrums originated in the laboratory with respect to the spectrum registered by the same elements with cosmological redshifts.
4. Every and any massive unity (*e.g.* atom) within the Universe, causes a gravitational interaction (at the event horizon) with all the remainder massive unities. As the N unities of mass-energy are the total mass of the Universe gravitational field, the sum of these unities can be considered as a single mass unity.
5. Likewise, every and any single quantum unity (atom or wave) interacts quantically in reversible equilibrium within the Universe (at the event horizon) with any other single quantum unity of the remainder Universe. As the N quantum unities mark the whole spatial contour, this whole structure can be considered as a single spatial unity.
6. The Universe is a closed system, which expands adiabatically. Corresponingly, any contour of macrospace (open system) interacts with the surrounding by means of absorption or emission of exactly measurable amounts of energy. The redshifted photons due to the cosmological expansion, and the eigenstates excitation intervals of an atom, would have the same energy and space scale proportions, which links both systems. In Sect (2-4) and (7-2) we analyze these implications.

2.2. Relativistic meaning of the spectral lines

For an electron pertaining to an isolated hydrogen atom, when $n = 1$ and $v = c/137$ ($v << c$), the Lorentz relativistic expression may be stated in the following form

$$m_0(1+\delta) = m_0(1+\frac{v^2}{c^2})^{1/2} \simeq m_0(1+\frac{v^2}{2c^2}) \tag{1}$$

When this single electron evolves from a state (i) towards a state (j), there is within the empty contour of the atom a mass increase of Δm

$$m_i = m_{\mathrm{e}}(1+\delta_i) \tag{2}$$

$$m_j = m_{\mathrm{e}}(1+\delta_j) \tag{3}$$

$$\Delta m = m_i - m_j = m_{\mathrm{e}}(\delta_i - \delta_j) \tag{4}$$

Taking into account $\delta = v^2/c^2 = \alpha^2/n^2$, being α the Sommerfeld constant, and as this relationship expresses the relativistic quantum ratio in electromagnetic emission (or absorption), we can insert it in (1) and (4)

$$\Delta m = m_{\mathrm{e}}(\frac{v_i^2}{2c^2} - \frac{v_j^2}{2c^2}) = \frac{m_{\mathrm{e}}\alpha^2}{2}(\frac{1}{n_i^2} - \frac{1}{n_j^2}) \tag{5}$$

Since $\alpha = 2\pi e^2/hc$, we have

$$\Delta m = \frac{2\pi^2 m_{\mathrm{e}} e^4}{h^2c^2}(\frac{1}{n_i^2} - \frac{1}{n_j^2}) \tag{6}$$

As with the expansion, the kinetic energy K diminishes and the potential energy U increases, this means that the potential energy is equivalent to the space[1] that has been created. Likewise, the spectral process of emission , or absorption is an interaction between a microbubble of energy (atom) and the macrospace. In this process, both entities always exchange the same quantum unit of energy simultaneously. The absortion lines expresses the mass-energy quantity proceeding from the exterior space, and the emission lines are equivalent to the mass energy transferred to the macrospace when the electron falls down to an inferior quantum level.

This correlativity of mass-energy and space-time reciprocal exchange is the foundation for establishing the equivalence between both vacuum contours: the microspace "vacuum" mass-energy and the macrospace "vacuum" mass-energy (Sect. 2-4).

2.3. Redshift for the de Broglie wavelength

Although the formalism concerning the redshift phenomena is exclusively related to the process of a cosmological kind, it is particulary interesting to extend it to electronic transition phenomena for an isolated atom.

According to the previous arguments, and considering the equivalence between wave and particle, the atomic excitement (expansion) provokes a stretching of the electron's wavelength λ (redshift) or a reduction of the electron "speed". Simultaneously, an additional depression of the absorbed energy expressed as wavelength through the succesives states of excitement is produced.

When an electron confined to an isolated hydrogen atom, and considering it as a stationary wave[2], is promoted from the n_i level to a n_j superior quantum level, it undergoes a z "redshift". This may be expressed as

$$''z'' = \Delta n_{ij}^2 \tag{7}$$

Then, transfering the cosmological formalism to an isolated hydrogen atom for $n_i = 1$ (*i.e.* $n_i = 1$ is the individual ground state of the thermal inverse recombination)

$$v_i = \frac{v_{a0}}{n_i} = \alpha \frac{c}{n_i} = 2,190 \mathrm{Km\,s^{-1}} \tag{8}$$

When the atom is excited or "expanded" to a Rydberg state of $n_j \simeq 240$, the wave energy is equivalent to 2.73°K

$$v_j = \frac{v_{a0}}{n_j} = \frac{\alpha c}{240} = 9.12 \mathrm{Km\,s^{-1}} \tag{9}$$

Using the Eq. (5), the relativistic mass equivalent for $n_j = 240$ electron state is

$$m = \frac{m_\mathrm{e} v^2}{2c^2} = \frac{m_\mathrm{e}}{2}\left(\frac{\alpha}{n}\right)^2 = 4.21 \times 10^{-37} \mathrm{g} \tag{10}$$

This equation establishes the dynamic mass ($m_{\mathrm{e}\Lambda}$) of an interacting electron respect to a hydrogen nucleus *i.e.* an electron has an energy equivalent to $m = 4.21 \times 10^{-37}$g for a degree of freedom, when it is promoted to a maximum state of excitement (or minimal temperature of nature).

As the empty space is indistinguishable, a parameterization for the cosmological space may turn out to be scale equivalent with respect to the contour of the intra-atomic empty space (Appendix E). This makes it possible to use the physical formalism belonging to the cosmology for the energetic phenomena of atomic excitation (expansion).

Because of this, the relativistic dynamic mass, both in cosmological and atomic scale, may be expressed in esentially identical equations:

$$m_\Lambda = M_V \frac{v^2}{c^2} \qquad \text{(cosmological)} \tag{11}$$

$$m_j = m_{\mathrm{e}\Lambda} = m_\mathrm{e} \frac{v_j^2}{2c^2} \qquad \text{(isolated atom)}$$

In Eq.(11) the cosmological expansion rate decreases continously as the expansion progresses. That is, v comprehends values from c when the spatial extension R_G was 1.032Mps (gravitational collapse) up to 77.9$\mathrm{Km\,s^{-1}}$ for any point in the space when the Universe has the present size (R_U^0). These assertions are dealt with in more detailm, in Sect. 4-2

This leads to the following relationship

$$\frac{v}{c} = \frac{R_G}{R_U} \tag{12}$$

[1] the space is equivalent to mass or energy
[2] we considered the equivalence between wave and particle

Or by reordering it

$$H_0 = \frac{v}{R_G} = \frac{c}{R_U} \qquad \text{(Hubble Law)} \tag{13}$$

Likewise, according to Bohr's formalism, the electron "velocity" is v_i for $n_i = 1$ and $r_i = a_0$ (Bohr radius). When the atom is excited or "expands", v decreases inversely and linearly in terms of the Bohr's radius: $v = \hbar/(m_e n a_0)$. As the velocity depression is also parametrized with respect to a scale unit (a_0), it allows us to establish a formalism similar to the one expressed in Eq. (13)

$$\frac{v_j}{v_i} = \frac{a_0}{r_j} \tag{14}$$

Reordering, we have

$$''h_j'' = \frac{v_j}{a_0} \qquad \text{isolated atom} \tag{15}$$

$''h_j''$ is a Hubble expression in scale of atomic order. According to Eq. (8) and (9) it gives us the following numerical value:

$$''h_1'' = 2,190\mathrm{Km\,s^{-1}}a_0^{-1} = 4.14 \times 10^{16}\,\mathrm{s^{-1}} \;; n_i = 1$$

$$''h_{240}'' = 9.12\mathrm{Km\,s^{-1}}a_0^{-1} = 1.72 \times 10^{14}\,\mathrm{s^{-1}} \;; n_j = 240$$

By extrapolation towards the nuclear size, this $''h''$ expression is the same as the inverse form of the light-crossing time in Dirac's natural units.

$$''h_n'' = 3 \times 10^5\,\mathrm{Km\,s^{-1}}r_n^{-1} = 2.13 \times 10^{23}\,\mathrm{s^{-1}}$$

Since we will use this concepts in Sect. (3),(4) and (7), it is valuable to anticipate that as well as v becomes c, a_0 becomes r_n, according to

$$a_0 = \frac{e^2}{m_e v_i^2} \qquad ; \qquad r_n = \frac{e^2}{2m_e c^2} = \frac{e^2}{1.022 M\mathrm{ev}}$$

where r_n is the nuclear interaction radius.

2.4. Cosmological expansion and the hydrogen atom excitation

According to Eq. (14) it may be deduced that the relativistic mass of a photon emitted or absorbed for any transition is inversely proportional to the ratios of the corresponding stable orbits.

Consequently

$$\frac{m_i}{m_j} = \frac{r_j}{a_0}\,, \qquad r_j = 4a_0, 9a_0, \ldots, n^2 a_0 \tag{16}$$

Also the following proportions are valid:

$$\frac{m_i}{m_j} = \frac{E_i}{E_j} = \frac{T_i}{T_j} = \frac{r_j}{a_0} = \frac{n_j^2}{n_i^2} = \frac{\lambda_j}{\lambda_i} \tag{17}$$

This means, that the relativistic interactive photon mass-energy is directly proportional to the relativist temperature, and inversely proportional to the atomic radius. Even though it is certain that the expansion of the Universe operates in a continuous form, it is a particular congruence that the information of the event was provided by quantum transitions of atomic emission systems. If for a practical convenience, we change the sign of these transitions, and instead of emission, it would correspond to the excitement of an electron of an isolated hydrogen atom. Here, its eigenvalues would have the same scale proportions in their spatial development as the cosmological values expressed as redshift or temperature of the CMB radiation.

This correspondence, is due to the equivalence between the energetic mechanism itself that originates the radiation (quantum states) associated to the size of the atoms, and the size of the Universe in expansion.

It is because of that

$$z + 1 = \frac{\lambda_{\rm obs}}{\lambda_{\rm em}} = \frac{R_U^0}{R_{\rm em}} = \frac{n_j^2}{n_i^2} = \frac{T_{\rm em}}{T_{\rm obs}} \tag{18}$$

where $R_{\rm em}$ and R_U^0 are the respective Universes radii when light was emitted, compared with the present radius.

For a transition $n_i = 1$ to $n_j = 2$, the atomic radius is 4 times greater, and $\lambda_{\rm obs}$ for $n = 2$ is 4 times larger too. If $z = 3$, it means that the Universe was 4 times smaller $R_{\rm em} = R_U^0/4$, or what is the same, the wavelength emitted was a quarter of the observed $\lambda_{\rm em} = \lambda_{\rm obs}/4$.

As the monodimensional parameters of cosmological expansion have the same proportions as those of atomic excitation states, it means that the energetic implications of both vacuum contours are identical, despite of their scales magnitudes (see Appendix A).

Thus, due to the cosmological expansion, the Lyman alpha line shift of the atomic hydrogen spectra, coincides with the ratio between the two atomic radii which generates this transition Eq. (18). E.g., for $z = 3$ the Lyman alpha line is shifted to a cosmological expansion with a factor 4. Likewise, when an isolated hydrogen atom originates a photon of $\lambda = 1,216\,\mathring{A}$, the electron has a quantum transition from $n_j = 2$ to $n_i = 1$, due to a spatial transition of $4a_0 \to a_0$. Although we have adopted the intense Lyman alpha line, the same properties for any other electronic transition can be verified.

3. Macrocosmos and microcosmos correspondence

3.1. Corresponding moments of interaction

A unifying context must be determined by a generalized framework of equivalent connections. Thus, the use of the microscopic constants and variables will allow us to put together a formal structure applicable to both extremes of the physical totality (General Equation of State).

In view of the preliminary antecedents of equivalence, especially the microscopic "vacuum" equivalence with respect to the macroscopic "vacuum", it is possible to relate both of them: the atomic and subatomic universe, to the cosmological Universe. In order to accomplish this, we will connect both scales through their corresponding moments of interaction (Law of the Lever). Then, the moments between the microscopic and macroscopic magnitudes can be made equal and be superimposed in the following way:

Energy A = Energy B

$$F_G L_{\rm max} = F_{\rm coul}\, r_n \tag{19}$$

The gravitational interaction between a proton and an electron in the domain of the strong interaction is $F_G = Gm_{\rm p}m_{\rm e}/(8\pi^2 r_n^2)$. As in these conditions $F_{\rm coul} = e^2/(2r_n^2) = m_{\rm e}c^2/r_n$, we can substitute it in Eq. (19) and resolve for $L_{\rm max}$

$$L_{\rm max} = \frac{4\pi^2 r_n e^2}{Gm_{\rm p}m_{\rm e}} = \frac{8\pi^2 r_n^2 c^2}{Gm_{\rm p}} = 1.25\times 10^{28}\,{\rm cm} \tag{20}$$

Being $L_{\rm max}$: Universe critical radius (1.32×10^{10} ly), r_n: neutron radius (1.4×10^{-13} cm), e: electron charge ($4.8\times 10^{-10}{\rm cm}^{3/2}\,{\rm g}^{1/2}\,{\rm s}^{-1}$), $m_{\rm p}$: proton mass (1.674×10^{-24}g), $m_{\rm e}$: electron mass (9.11×10^{-28} g).

It is evident that the critical radius L_{max} of the Universe established in this way is a constant, because it was originated by means of constants. Nevertheless, as L_{max} is a superior limit, it is accomplished when the expansive energy is the same as the potential energy.

3.2. Critical number of protons

A microspace contour, and all the whole Universe contour are complementary when these opposite extremes are represented by means of a limited energy bubble with a well defined critical radius in its spherical surface. This makes it possible to determine another critical parameter, which can be found applying the Principle of Correspondence (Bohr 1929) about Eq. (20). Its results lead to the obtainment of the number of baryons $N_{\rm b}$ and the critical mass m_U^0.

Multiplying and dividing Eq. (20) by N, being N a constant

$$L_{\rm max} = \frac{8\pi^2 r_n^2 N c^2}{Gm_{\rm p}N} = \frac{R_U^2 c^2}{Gm_U^0} \tag{21}$$

as $m_U^0 = m_{\rm p}N_b$ and $L_{\rm max}^2 = 8\pi^2 r_n^2 N_b$ (22)

from which we obtain the Schwartzchild Radius[3]

$$L_{\rm max} = \frac{2GM}{c^2} \quad ; \quad 2M = m_U^0 \tag{23}$$

[3] The scale 4.17×10^{17}s: 1.25×10^{28}cm: 1.7×10^{56}g is the same as the Schwartzchild scale of natural units. 1s: 3×10^{10}cm: 4×10^{38}g

Equations (22) and (23) show that N_b represents the critical numbers of baryons. Therefore:

$$N_b = \frac{1}{2}\left(\frac{L_{\max}}{2\pi r_n}\right)^2 = \frac{1}{2}\left(\frac{4\pi r_n c^2}{Gm_{\rm p}}\right)^2 = 2\pi^2\left(\frac{e^2}{Gm_{\rm p}m_{\rm e}}\right)^2 = 1.01\times10^{80} \tag{24}$$

The critical mass m_U^0, though relatively negligible respect to M_V, exerts a decisively crucial action, since it restrains the repulsive effect of the cosmological expansion in such a way that it constrains the critical radius to $L_{\max}$.

The Principle of Correspondence is clearly expressed in the Eq. (21) when microphysics scale gets connected with cosmological scale through the N_b constant.

It is certain that the N elements of mass are required to produce the equivalence between the gravitational phenomena of the matter in bulk, and the coulombic phenomena in the interaction between protons and electrons within the atomic contour.

3.3. Phase transition of matter-antimatter

The energy spectrum of the CMB radiation registered at present, whose mean wavelengh is $\lambda_{\rm CMB}$ represents a huge magnified copy of the photons energy originating from the annhilation of matter-antimatter. Basically this radiation proceeds from N $\cdot$ (1/4 electrons + 1/4 positrons + 1/4 protons + 1/4 antiprotons + 1/4 neutrinos + 1/4 antineutrinos) $= \frac{1}{2}N_\gamma = N_n$ (See Appendix C)

When the temperature of the Universe corresponds to a state of transition know as neutron threshold temperature, we can use Eq. (B.2) in the following way:

$$R_U^3 = \left(\frac{5\lambda_{\rm CMB}}{2\pi}\right)^3 N_\gamma \tag{25}$$

Since $N_\gamma/2$ polarized photons pairs collapse as N neutrons, this transition causes the $\lambda_{\rm CMB}$ wavelength to become the neutron radius r_n. Then, if $(5/2\pi)^3 \simeq 1/2$, and $N_n = N_\gamma/2$, we have

$$R_U = r_n\left(\frac{N_\gamma}{2}\right)^{1/3} = r_n N_n^{1/3} \tag{26}$$

As $r_n = 1.41\times10^{-13}$ cm (Bohr - Wheeler, 1939) and $N_\gamma = 3.15\times10^{87}$, we have $R_U = 1.63\times10^{16}$cm. In these conditions, as the vacuum energy was completly transformed in mass, the space is absolutely homogeneous with only one component. This means, that the mass of the component N_n is the relativistic mass-energy of the empty space

$$M_V = m_n\cdot N_n = 2.64\times10^{63}\text{g} = 2.38\times10^{84}\text{erg}$$

where M_V is the vacuum energy, or empty space energy.

3.4. General equation of state

The preceding arguments show a regularity between the mass scales with respect to the monodimensional space extension. This regularity can be represented in terms of the expansion

Planck State $\rightarrow$ Hydrogen Nucleous $\rightarrow$ Hydrogen Atom $\rightarrow$ Background Radiation $\rightarrow$ Cosmological Totality

The order of hierarchy established in this sequence, can be formalized quantitatively on basis of the paradigm of the "energy bubble", using Planck's Constant as a parameter. This universal constant marks the discontinuity of the energy and therefore, constrains both the mass and the spatial component, for the invariant product $h = \Delta p\Delta x$. Owing to the synchronism between the macroscopic space in expansion, and each of the unitary elements, the invariance remains from Planck's state, up to the microscopic elements observed at present time.

$$\hbar = m_{\rm Planck}\, c\,\lambda_{\rm Planck} = \frac{m_{\rm proton}\, c\,\lambda_{\rm compton}}{2\pi} = \frac{2m_{\rm elect}\, c\, r_n}{\alpha} = m_{\rm elect}\, c\, a_0\,\alpha = \frac{5\, m_{\rm CMB} c\,\lambda_{\rm CMB}}{2\pi} \tag{27}$$

Being $m_{\rm CMB} = kT_{\rm CMB}/c^2$; α: Sommerfeld constant

Table 1. The numerical results obtained from Eq. (32) show that the expansion rate is c when the radius of the Universe is $R_G = 1.032$ mps. Making use of this scale, the expansion rate progresively decreases up to the present value of 78 Km s^{-1}.(1.032 Mps)$^{-1}$ or 75.5 Km s^{-1} Mps^{-1}.

m_Λ/m_M	$R_U(R_G^{-1}$ unit)	$H(\mathrm{Km\,s^{-1}}R_G^{-1})$	z	Temp.(°K)
3,930	1	3.0×10^5	3,840	10,500
1,965	2	1.5×10^5	1,920	5,250
1,310	3	1.0×10^5	1,280	3,350
983	4	1.5×10^4	960	2,625
—	—	—	—	—
7.86	500	600	7.68	21.00
6.55	600	500	6.40	17.50
5.63	700	528	5.55	15.00
4.90	800	375	4.80	13.10
—	—	—	—	—
1.025	3,840	78	0	2.73

4. The Hubble constant

4.1. Kinematics implications of H_0

Theorically, the Hubble constant is defined as a parameter established by the speed of the cosmological expansion within a scale unit (Misner *et at* 1972).

$$H = \frac{\dot{R}}{R}$$

Starting from this constant, the following parameters can be deduced: a) Linear recession law: $v/dl/dt = \dot{l} = \dot{R}l/R$ being l, the mean distance between two referential physical points (*i.e.* galaxies). b) Hubble time $t_H = l/v = H^{-1}$ where t_H is the time from the present referential position, extrapolated to zero distance between galaxies moving at the recession rate observed today. c) Hubble length $L_H = c/H$, where L_H is the top distance, which is attained by use of the linear recession law when v is extrapolated to c.

4.2. The origin of H_0

One microsecond of paralax, given by the diameter of the terrestrial orbit around the Sun, is an anthropic scale unit, and physically unmeaning by itself. On the other hand, if this unit is replaced by the radius of the gravitational collapse, it may allow us the acquisitions of physical implications which are comparative to the atomic referential radius as unit of scale (*i.e.* a_0 or r_n Sect. 2-3).

When the Universe radius was 3.185×10^{24} cm $= 1.032\,\mathrm{Mps} = R_G$ with a Planck's blackbody distribution curve corresponding to a temperature of $\sim 10,500$°K, there still existed a fraction of photons in a thermic state equivalent to $\sim 352,000$°K, whose number was the same as the whole population of baryons (Sect. 6-1).

Starting from these conditions, the collapse of gravitation is produced; all the matter, and radiation which up to that epoch was in an undiferenciated state, undergoes a 3-d granular packing condensation. The development of these lumps is a fundamental point of reference: the history of the cosmological expansion begins with the withdrawal of these formations, in order to mark the initial time of H_0^{-1}.(Sect. 5.3)

Since kilometer and megaparsec are units of distance, the dimensions km s^{-1}.Mps^{-1} means second^{-1}; then, as the cosmological space progresses, the Hubble expansion rate will decrease continuously, until it reaches the present time value of $H_0 = 75.4$ $\mathrm{Km\,s^{-1}}$ $\mathrm{Mps}^{-1} = 77.9$ $\mathrm{Km\,s^{-1}}$ $(1.032\,\mathrm{Mps})^{-1}$.(Table 1).

4.3. Dynamic implications of H_0

Taking into account the Cosmological Principle, and considering H_0 for a simultaneous time (unobservable) for any point in all the extension of the space, we may establish the dynamic state of the Universe, from the radiative transition, to barionic, up to present time. Thus, for the extremes $R_G = 1.032$ Mps (gravitational collapse) and R_U^0 (present time radius) we have

$$H_0 = \frac{c}{(z+1)R_G} = \frac{v}{R_G} = 2.45 \times 10^{-18}\mathrm{s}^{-1} \tag{28}$$

Table 2. Because of the continuous contribution of energy transferred to the space in expansion from the stretching of the $N\gamma$ photons of the CMB radiation, the mass of the cosmological component $m\Lambda$ attains its maximum value up to R_G. Whereas the gravitation collapses at R_G, it provokes a progressive depression on this cosmological component (Sect. 5-1)

v(cm/s)	R(cm)	m_M(g)	m_Λ(g)	$z+1$
3×10^{10}	3.2×10^{24}	6.70×10^{59}	2.64×10^{63}	1
3×10^{9}	3.2×10^{25}	6.70×10^{58}	2.64×10^{61}	10
3×10^{8}	3.2×10^{26}	6.70×10^{57}	2.64×10^{59}	100
3×10^{7}	3.2×10^{27}	6.70×10^{56}	2.64×10^{57}	1,000
7.8×10^{6}	1.23×10^{28}	1.54×10^{56}	1.78×10^{56}	3,841*
3×10^{5}	3.2×10^{28}	6.70×10^{55}	2.64×10^{55}	10,000
3×10^{4}	3.2×10^{29}	6.70×10^{54}	2.64×10^{53}	100,000

* Present age

being $v = 7.8 \times 10^6$ cm s^{-1} ; $R_G = 3.19 \times 10^{24}$ cm

$$H_0 = \frac{c}{R_U^0} = 2.45 \times 10^{-18}\ \mathrm{s}^{-1} \tag{29}$$

where $R_U^0 = 1.225 \times 10^{28}$cm

Equalizing (28) with (29) and reordering, we find the following adimensional scale

$$\frac{v}{c} = \frac{1}{z+1} = \frac{v}{H_0 R_U^0} = \frac{R_G}{R_U^0} \tag{30}$$

Any value from the linear recession law is comparable to whatever intensive property of a system *i.e.* it is similar to the absolute temperature used universally as an indicator of the thermic state, or as a measure of energy for any system.

Then

$$\frac{v}{c} = \frac{T_G}{T} \tag{31}$$

Since H_0^{-1} defines the present time expansion rate, and H defines a value of the Hubble constant at different epoch, we may extend (30) in the following way:

$$\frac{v}{c} = \frac{1}{z+1} = \frac{v}{HR_U} = \frac{R_G}{R_U} = \frac{T}{T_G} = \left(\frac{m_\Lambda}{M_V}\right)^{1/2} \tag{32}$$

Raising to square all this adimensional terms, and reordering, we find

$$m_\Lambda = \frac{M_V v^2}{c^2} = \frac{M_V}{(z+1)^2} = \frac{M_V v^2}{H^2 R_U^2} = \frac{M_V R_G^2}{R_U^2} = \frac{M_V T^2}{T_G^2} \tag{33}$$

These proportions express the dynamic state of the Universe unquestionably. The term $M_V v^2/c^2$, the same as the other terms, represents the relativistic m_Λ mass-energy equivalence of the space in expansion.

Despite of the different methods for the determination of the Hubble constant , and the implications of the Universe age, for us, H_0^{-1} as well as t_0, are not independent quantities, since we consider for H_0 a clear point of departure. This $R_G = 1.032$ Mps referential point, is coincident with the withdrawal of the protogalaxies after gravitational collapses.

Hubble time is an indicator of the cosmological age through the expansion rate in relation with the R_G referential interval of distance. Hence, the present value of H_0^{-1} means the duration of the expansion from R_G until now. For this reason, the $t_0 =$ age, determined on the basis of the antiquity of the oldest objects, plus its time of formation, is the same as $t_0 \simeq H_0^{-1}$, as likewise $H_0 t_0 \simeq 1$. Table 1 and 2 illustrate theses properties.

5. The extension of the cosmological space

5.1. Energy constraint

All terms of the Eq. (33) determine the main implication of the Hubble parameter, because it establishes the dynamic index (scale factor) of the relativistic kinetic energy of the global expansion, prevaling for any point in space in a simultaneous time (Cosmological Principle).

In the initial evolutive process, because of $E_T > E_G$ and $m_\Lambda > m_M$, the Universe was hegemoneously expansive. Up to the $R_G \sim 1.032$ mps, the gravitation collapses, and as it implies a force exerted, this makes a continuous decrease of $m_\Lambda = M_V v^2/c^2$. Thus, the space expansion range can be established by means of the ratio between the expansive and the restrained force (Planck, 1926).

Slightly modifying the mechanical equivalent of heat , we have:

$$\text{Expansive energy} = F_{\text{grav}} L_{\max} \tag{34}$$

As $F_{\text{grav}} L_{\max}$ is the potential energy U, it determines that the expansive energy (kinetic K) be depressed continuously up to the equilibrium limit given by the virial $2K = U$, which constraints the Universe extension ($L_{\max}$).

$$L_{\max} = \frac{M_V v^2 R_U^2}{G {m_U^0}^2} = \frac{M_V c^2 R_U^2}{G {m_U^0}^2 (z+1)^2} \tag{35}$$

Since $2K = -m_\Lambda = -M_V v^2/c^2$ (vacuum mass) and $U = m_M = G {m_U^0}^2 / c^2 R_U$ (gravitational mass), we have

$$L_{\max} = \frac{(-m_\Lambda)}{m_M} R_U \tag{36}$$

If we make $m_\Lambda / m_U^0 = \Omega_\Lambda$ and $m_M / m_U^0 = \Omega_M$

$$L_{\max} = \frac{\Omega_\Lambda}{\Omega_M} R_U \tag{37}$$

For any historic value of R_U the results are always $L_{\max} = 1.32 \times 10^{10}$Ly.

5.2. Physical meaning of the cosmological term

The expansive energy (repulsive) reaches its top limit for $R_U = L_{\max}$, when it is the same as the potential energy. This state of equilibrium, may be modified in its formal expression of Eq. (35) by multiplying and dividing the second term by $4\pi R_U^0/3$. Consequently, we have:

$$L_{\max}^2 = \frac{3 M_V v^2}{4\pi G m_U^0 \rho_M} = \frac{3 m_\Lambda c^2}{4\pi G m_U^0 \rho_M} \tag{38}$$

Because of these equilibrium conditions, the kinetic energy K is related to its potential energy U by the virial $2K = U$, which means

$$2K = M_V \frac{v^2}{c^2} = -m_\Lambda (\text{vacuum mass-energy}) \tag{39}$$

As at these conditions: $U = \left| m_U^0 \right| = 2K = |-m_\Lambda|$ and therefore reordering (38) we have $\rho_M = \rho_\Lambda$

$$\frac{1}{L^2} = \frac{-\Lambda}{3c^2} = \frac{4\pi G \rho_M}{3c^2} \qquad (\text{"cosmological term"}) \tag{40}$$

Since $c^2/L_{\max}^2 = H_0^2$ we obtain:

$$H_0^2 = \frac{4\pi G \rho_M}{3} \tag{41}$$

The results shown in the Eq. (40) differ from the standard expression $\Lambda/3c^2 = 8\pi G\rho/3c^2$ used in all models with a cosmological constant. This difference is due to the fact that the physical formalism in the original static solution, the system, is an isotropic and homogeneous fluid under hydrostatic conditions (Einstein, 1922; Tolman, 1934). Then, because the pressure is avoidable, since it is the radiation pressure, the cosmological terms were simply added to the final result as an integration constant, and equalized to the density of energy. Therefore, the standard cosmological term lacks of virialization.

In accordance with Eq. (40) the term $-3c^2/\Lambda = L_{\max}^2$, means a superior expansion limit,which is gaugered by the ratio between the expansive energy, with respect to the attractive force exerted by the mass density ρ_M.

As the expansive energy ($-m_\Lambda$) acts only on the space itself, but not on the matter, this exclusively repulsive effect does not gravitate. Then, in an Einstein static scenario, Ω_Λ must be equal to Ω_M(*i.e.* $\Omega_\Lambda = \Omega_M = 0.5$).

It is worth mentioning the accomplishment of Eq.(40) from Eq.(20) by multiplying and dividing it by N_b

$$L = \frac{8\pi^2 r_n^2 N_b c^2}{G N_b m_{\text{p}}} = \frac{L^2 c^2}{G m_U^0}$$

By multiplying the first and the last term by $4\pi L/3$ and reordering we get

$$\frac{-\Lambda}{3c^2} = \frac{1}{L^2} = \frac{4\pi G \rho_M}{3c^2}$$

5.3. Structure Formation

A gaseous homogeneous system with a certain temperature is gravitationally merged from a plasma state and forms a condensation of matter when the gravitational potential energy rises over the internal thermic energy $E_G > E_T$ (Jeans, 1902). Specifically a proof particle confined in a gravitational field shows the formation of clumps of radius R when:

$$\begin{aligned} \text{Gravitational Potential Energy} &= \text{Expansive Energy} \\ R \times \text{Attractive Force} &= \text{Expansive Energy} \end{aligned} \tag{42}$$

At this epoch, despite of the hegemonic expansion of the cosmological space, the first structures can be formed by means of the attractive potential. Since the cosmological expansion is only related with the space itself, the expansion does not annul the gravitational attractive effect associated with the matter. Therefore, the initial gravitational interaction makes the begining of the baryonic era.

The three principal plasma components (protons, electrons and photons) are found in thermic equilibrium ($E_{\mathrm{Tp}} = E_{\mathrm{Te}} = E_{\mathrm{T}\gamma}$). If the gravitational collapse is resolved in function of the proton mass as proff particle, the gravitational field intensity on the electrons would be $\sim 2,000$ times lesser. These conditions ($E_{\mathrm{Te}} >> E_{\mathrm{Ge}}$) are untenable, since they determine a fractionation due to escape of the electrons from the clump contour, likewise this would produce a strong repulsive effect by means of the protons excess.

On the other hand, when the gravitational effect is fixed on the basis of the electron mass, the acceleration on the formed clumps, can sustain just as much the protons as the electrons, and the Parity Principle is carried.

Finally, the photons even by far, they are the least massives of all components, but because of their great number, they represent together with the electrons the extremes entities which mark the limiting temperature for the formation of these clumps.

Consequently, both for the electrons and the photons, the expansive energy is

$$\frac{1}{2} m_{\mathrm{e}} \overline{v}^2 = \frac{3}{2} kT \tag{43}$$

For an electron, the translation energy for degree of freedom on the zero point is $3kT/2$. Likewise, for the same electron, the attractive force within a clump contour is

$$F_{\mathrm{a}} = \frac{G M_L m_{\mathrm{e}}}{R_L^2} \tag{44}$$

being M_L: clump mass and R_L: clump radius. Combining Eq.(43) and (44) in (42) we have

$$R_L = \frac{2 G M_L m e}{3kT} = \frac{2 G N_L (m_{\mathrm{p}} + m_{\mathrm{e}}) m_{\mathrm{e}}}{3kT} \tag{45}$$

where N_L is the particles pair number. If we multiply both members by $4\pi R_L^2/3$ and reordering, we have Eq.(45) in terms of the average density $\overline{\rho}$

$$R_L = \left(\frac{9kT}{8\pi G m_{\mathrm{e}} \overline{\rho}} \right)^{1/2} \tag{46}$$

Although the formalism of the big bang has the significance of the realization of a generalized expansion process, once the lumps are formed they will not dissipate, but the opossite occurs: within their contour they can collapse to produce minor structures (stars) as well as they can associate among themselves to form new conjunts (cumulus). In both cases, when these new structures originate, and due to the simultaneous effect produced by the progressive expansion, the rarefiying increases in the surrounding, which makes the process not fully efficient, and a significative mass remains in a dark (baryonic) form.

5.4. Numerical calculation

For the formation of a clump of gas (protogalaxy) in a fluid with a mass density of $\overline{\rho} = 1.26 \times 10^{-18}$g cm^{-3}, the mean kinetic energy of a proof plasma particle (*i.e.* an electron) corresponds to the thermic state determined by a Planck's distribution curve. As in the fluid, the number of photons is about $10^8 : 1$ times the number of nucleus and electrons, when the temperature is $\sim 10,500$°K, yet there exist as many photons in a thermic state corresponding to $352,000$°K as the whole population of free electrons. That is the reason why the gravitational fusion or gravitational collapse (Sect. 6-1) starts just when the Universe has a radius of 1.032 mps and $E_G >> E_T$.

Using Eq. (46) we may obtain the lumps radius in the fluid fluctuation. The result is

$R_L = 4.8 \times 10^{20}$ cm

The mass of this lump may be calculated by equating and reordering Eq.(44) and Eq.(45)

$$M_L = \left(\frac{3}{4\pi\overline{\rho}}\right)^{1/2}\left(\frac{3kT}{2Gm_{\mathrm{e}}}\right)^{3/2} = 5.7 \times 10^{44} \text{ g} \tag{47}$$

The mass of this protogalaxy coincides with the mean galaxy mass at present time. Owing to the physical constraint imposed by the Eq. (46) and the restriction of space within its general contour (1.032 Mps) the three dimensional (3-d) close packing makes an individual size considerably inferior (1/100) than the present one. Since the galaxies do not increase their extension in synchrony with the generalized cosmological expansion of the space, they will reach their normal size when the dynamic equilibrium is accomplished, after the stars formation, up to the present time.

Adjusting the Eq. (21) we can get the present radius

$$R_L = \frac{32\pi^2 N r_n^2 v^2}{GNm_{\mathrm{p}}}$$

If $N = 3.5 \times 10^{68}$; $v = 2.85 \times 10^7$ cm s^{-1}; ${R_L}^2 = 32\pi^2 N r_n^2$

$$R_L = \frac{GM_{\mathrm{L}}}{v^2} = 4.7 \times 10^{22}\,\text{cm}$$

6. The start of the Baryonic age

6.1. Energy and Temperature

The temperature for a fixed number of N particles in a certain volume is a measure of their (kinetic) energy. That is the reason why the energy for a certain quantity is always an extensive property. On the other hand, the absolute temperature for degree of freedom, similarly pressure and density are intensive properties and independent of the mass. Thus, the Boltzmann constant k, for a Kelvin degree determines the mass or energy of 1°K for one freedom degree (particle or photon).If $m = kT/c^2$, and $T = 1$°K, result $m_\gamma = 1.533 \times 10^{-37}$ g (fd)$^{-1}$.

This means that the average of energy for each freedom degree, multiplied by the total number of photons or particles, will allow us to establish the energy of whole system. Then, N elements are required for producing an equivalent behavior between the gravitational potential of the matter in bulk and the coulombic potential of the individual atoms (See Appendix A).

For a universe with a Hubble constant $H_0 = 75.4$ Km s^{-1}Mps^{-1}, the mean mass of all the photons is equal to the critical gravitational mass when $T = 352,000$°K and $R_U = 9.5 \times 10^{22}$ cm.

$$T = \frac{m_U^0 c^2}{kN_\gamma} = 352,000°\text{K}$$

Being $m_U^0 = 1.7 \times 10^{56}$g and $N_\gamma = 3.15 \times 10^{87}$. In order to calculate the effective temperature in which the begining of the baryonic age is produced, the scales established in Eq.(32) and (33) are used.

$$2.73°\text{K}.R_U^0 = T_G 1.032\text{Mps} \qquad \text{or} \qquad \left(\frac{T_G}{2.73}\right)^2 = \frac{M_V}{m_\Lambda}$$

since $R_U^0 = 1.225 \times 10^{28}$ cm, $m_\Lambda = 1.78 \times 10^{56}$ g and $M_V = 2.64 \times 10^{63}$ g, $T_G = 10,500$°K. (Table 2)

The discordance between the initial baryonic radius $R_G = 9.5 \times 10^{22}$ cm for $T = 352,000$°K and $R_G = 3.19 \times 10^{24}$ cm $= 1.032$ Mps for $T_G = 10,500$°K takes place, because in the plasma there is a great excess of photons with respect to the number of baryons ($\sim 10^8 : 1$) and this determine that the baryonic age was produced considerably later.

This model of begining of the gravitational era may be interpreted considering the relativistic equivalence of energy, which allows us to use the generalization of the First Thermodynamic Principle: the same as the energy may be specified and identified according to its origins, this does not happen as regards the observation of the effects.

7. Equivalence between the gravitational and electrical potencial

7.1. Saha Equation Generalization

The Saha equation is an extension of the Nernst formula, adapted to the thermoionization process of the atoms which are found in a gaseous state. The chemical potential which comes into play, is represented by the potential of the interacting components: free atoms, ions, electrons, and photons. E.g. for the hydrogen, each one of these components behave as a monoatomic gas, in accordance with the following process:

$$H^{+} + e^{-} + \gamma \rightleftarrows H^{\cdot} + \gamma \tag{48}$$

For certain temperature, this process has a degree of displacement or ionization degree $(1-x)/x^2$ that may be described as a constant. The ionization potential (quantity of energy) does not distinguish intrinsically the material species or the quality of the intervining component. This potential is only characterized by its energy value, which depends on the temperature and the ionization degree.

When the Universe is in a stage inmediatly preceding ($T \sim 10,000°$K) the hydrogen recombination, or negative thermoionizations process ($T \sim 4,000°$K) the plasma thermodynamic conditions are slightly different. Nevertheless this small difference already established the conditions in order to produce first, the gravitational collapse which marks the beginning of the Hubble Law.

Taking into account, first of all, that the observation of the cosmos makes it possible to detect the galaxies and to establish their dynamic mass through the stars movement. Secondly, the galaxies are the final product of a process, which, from lumps formation, remains quasi stable in time, and has a mass distribution with little dispersion. Therefore, from this important temporal invariance of the fraction registered it has galaxies, as well as from the remaining dark mass, a kind of equilibrium between both mass can be deduced. This "dissoaciation degree"can be expressed by the ratio between the visible dynamic mass (Ω_L) and the dark matter (Ω_d).

Finally, according to these arguments, it may be said that the component Ω_d of "dark" matter is formed by a rarefied plasma of H^{+},H_{e}^{+} and free electrons, which dates from the gravitational collapse.

$$\text{plasma}\left\{\begin{array}{c}\text{photons}\\ \text{protons}\\ \text{electrons}\end{array}\right\} \begin{array}{c}\longrightarrow\\ \text{Gravitational}\\ \text{Collapse}\\ \longleftarrow\end{array} \left\{\begin{array}{l}\text{photons }(\Omega_\gamma)\\ \text{clumps }(\Omega_L)\\ \text{dark matter }(\Omega_d)\end{array}\right.$$

If we consider the equivalence between the gravitational and the coulombic potential, giving to it the same thermodynamics implications, we can determine by this way the transition from the radiative epoch to the baryonic era (Appendix A). To account for it, it is only necessary to know the escape potential (binding energy) of an electron from a spherical lump, the temperature of the Universe when it has a radius of 1.032 Mps (R_G) and the η constant (proton to photon ratio).

The coulombic binding energy of N_L pairs of opposites charges in N_L isolated hydrogen atoms, are equivalent to the gravitational energy for the same N_L elements of mass within a spherical contour. Hence, the dissociation degree can be accomplished by means of the Saha equation. By reordering Eq.(45).

$$E = \frac{N_L e^2}{2a_0} \simeq \frac{2GN_L m_{\mathrm{p}} N_L m_{\mathrm{e}}}{3R_L}$$

or

$$\frac{e^2}{2a_0} \simeq \frac{2GN_L(m_{\mathrm{p}}+m_{\mathrm{e}})m_{\mathrm{e}}}{3R_L}$$

The "dissociation degree", is the result of the thermodynamic interplay of all the AN_L elements of mass confined in the gravitational potential of the Jeans condensation, in relation to the potential of all remaining isolated elements of mass (dark matter).

Thus, this equlibrium state may be described as

$$N_{\mathrm{p}} + N_{\mathrm{e}} \rightleftarrows AM_L \qquad \text{because}\,(N_{\mathrm{p}} = N_{\mathrm{e}} = N_{\mathrm{b}})$$

where $M_L = N_L(m_{\mathrm{p}} + m_{\mathrm{e}})$ and A is the clumps number; then, this equilibrium state is the same as

$$X + X \rightleftarrows 1 - X$$

$$\Omega_{m_{\mathrm{p}}} + \Omega_{m_{\mathrm{e}}} \rightleftarrows \Omega_{\mathrm{d}}$$

Since $\Omega_{\rm d} = 1 - \Omega_L$, when the gravitational collapse is accomplished, the dissociation degree is

$$K = \frac{1-X}{X^2} \simeq \frac{\Omega_L}{\Omega_{\rm d}^2} \tag{49}$$

An expression of the Saha equation for the hydrogen thermoionization (Bernstein 1988) is

$$\frac{1-X}{X^2} = n_{\rm p} \left(\frac{2\pi\hbar^2}{m_{\rm e}kT}\right)^{3/2} \exp\left(\frac{B}{kT}\right) \tag{50}$$

Extending this equation to the gravitational collapse, we can adjust it by making use of Eq. B.3

$$n_{\rm p} = n_{\rm e} = \eta n_\gamma = \frac{3\eta}{4\pi}\left(\frac{kT}{\hbar c}\right)^3 \tag{51}$$

Replacing (51) in Eq. (50) results

$$\frac{1-X}{X^2} = \frac{\Omega_L}{\Omega_d^2} = \frac{3\eta}{4\pi}\left(\frac{2\pi kT}{m_{\rm e}c^2}\right)^{3/2} \exp\left(\frac{E}{kT}\right) = \frac{3\eta}{4\pi}\left(\frac{2\pi T_s}{T_e}\right)^{3/2} \exp\left(\frac{T}{T_s}\right) \tag{52}$$

This equation is an equilibrium relationship between free particles and those bound by an attractive field, where E is the thermal dissociation potential for an electron respect to the gravitational potential of a clump; T_s: surrounding temperature and T: escape temperature. Since $E = 2Gm_{\rm e}M_L/3R_L = 4.86 \times 10^{-11}$ erg, $\eta = 3.2 \times 10^{-8}$ and $T_s = 10,500$°K, we find $\Omega_L/\Omega_d^2 = 0.10$, being $\Omega_L = 0.084$ and $\Omega_d = 0.916$. Introducing the cosmological component m_Λ, we can normalize these densities as $\Omega_\Lambda \simeq 0.51$; $\Omega_{\rm d} \simeq 0.447$; $\Omega_{\rm b} \simeq 0.043$.

Deeper into space, and farther into the past, most of the Universe is made of gas rather than galaxies, and most of the ionized baryonic matter that permeates the clusters of galaxies is observed in hot gas form. Likewise, a substantial amount of intergalactic matter outside of the clusters of galaxies could be formed by voids of ionized gas and Rydberg atoms.

Observational data however, is subordinated with respect to nucleosynthesis constraint, and it imposses $0.02 \le \Omega_b h^2 \le 0.036$, so in the standard model, the mayority of matter must be presented in an unknown mysterious non-baryonic form. Therefore, we may say that it would be very unusual that the thermodynamic process of galaxies formation was so efficient, that almost all the baryonic materials corresponding to the upper limit derived from calculus of the primordial nucleosynthesis, were condensed near and into galaxies.

7.2. Implications related to the recombination

In general, the thermoionization spectrum is originated by atoms, whose initial state is the fundamental or ground state. Therefore, the inverse thermoionization or "recombination" implies a transition of electrons proceeding from the plasma state, to be solely accomplished in the ground state.

On the other hand, the emission spectrum is the result of electronic transition from the plasma state - or any quantum superior state - to any other inferior quantum state. This property makes it feasible to produce all other possible transitions. Because of this, there is a major number of emissions series and spectral lines as in the absortion spectrums.

Therefore, we can deduce that the misunderstanding "recombination" is nothing else but an inverse emission process, which ocurred when the Universe temperature was $\sim 4,000$°K. In these conditions, when the photon number per cm^3 is $\sim 1.3 \times 10^{12}$, and an empty space density of $\sim 1.1 \times 10^{-12}$ g cm^{-3}, the cosmic gas undergoes a transition from the plasma state to an upper $n = 6$ or $n = 7$ eigenstates. This quantum structuration with levels superior to the ground state is a normal physical property of the emission process in these particular equilibrium conditions.

At the same time as the Universe expands, the recombining hydrogen atoms evolve progressively to higher rarefiying conditions. Since these atoms were in a generalized reversible equilibrium state with the CMB radiation, they emit and absorb radiation with the same energy. Consequently, these atoms can be continuously excited, as soon as they reach the highest Rydberg quantum states, *i.e.* $n \sim 220 - 240$ at 2.73°K.

Given these conditions, we can assert that there is no physical reason for this ionized gas, as well as the highly excited Rydberg hydrogen atoms could constitute the "dark" or "not observable" matter represented by the Ω_d component.

Hence, the following observations are congruent with the preceding arguments:

a - Before the recombination, there was a predominant number of free electrons which by scattering maintained the thermal equilibrium between radiation and matter. This phenomenon produces the energy spectrum of the CMB radiation which shows an isotropic distribution frame-work.

b - Despite of an almost perfect CMB radiation distribution curve, there even remains faint anisotropies, which were originated from the structure formation through the gravitational instability.

c - The conservation of these anisotropies, and the scale invariance in all directions in the expansion process expresses the existence of a critical mass as a single cause to produce the planarity registered in the BOOMERANG sky maps (De Bernardis *et al.*2000; Melchiori *et al.* 2000).

Consequently, the intergalactic and intercluster undetectable dark matter may be formed by ionized and highly excited hydrogen atoms. For example, each Rydberg hydrogen atom at $\sim n = 240$ eigenstate is ionized and recombined at the same energy as the photon energy of the present CMB radiation.

$$E_H = \frac{m_e}{2}\left(\frac{\alpha}{n}\right)^2 = 4.21 \times 10^{-37}\ \mathrm{g} \qquad (n = 240)$$

$$E_\gamma = \frac{kT}{c^2} = 4.19 \times 10^{-37}\ \mathrm{g} \qquad (T = 2.73^\circ\mathrm{K})$$

Furthermore, in the empty Rydberg contour, the density of energy is the same as in the cosmological empty space. This balance is sustained through all the expansion process (Equation E.6). E.g. for $n = 6$ and $4,000^\circ$K, the density in the empty atomic contour is $\sim 1.0 \times 10^{-12}\mathrm{g\,cm^{-3}}$.

7.3. Gamow's time-temperature relationship

One of the great successes of the standard big-bang model is the prediction of a nucleosynthesis phenomena which supposedly occured in the first seconds of the history of the Universe. This mechanism was developed ~ 50 years ago (Gamow 1946, 1948; Alpher & Herman 1948; Alpher, Bethe & Gamow 1948; Alpher, Follin, Herman 1953) and the succesive investigation was repeated essentially with the same procedures with more precise neutron lifetime and more refined constraints of barion-to-photon ratio.

In the theoretical development of this nucleosynthesis process, the deuterium formation starts one subsequent chain of reactions which are highly dependable on an adjusted time-temperature correlation, and to accomplish it, the Gamow's formulae are still used. These formulae, despite of their unquestionable precursory value to describe the thermic history of the Universe, are basically misleading, since the cosmological time is an extensive property, therefore, it is dependent of the total photons number $N_\gamma/2$ of the CMB radiation.

The space-time equivalence, is not reciprocal along all the cosmological history. Certainly, the objects (particles plus photons) operate in the space, as likewise, these objects create the events, due to the fact that the space is the locus where the events take place. Also, the space-time irreversibility is fundamental since the objects history cannot be subordinated to time in itself as a causal factual. The elements of the objetive reality and the sequence in which the events occurs creates the time.

Going back in terms of z from a temperature superior of $10,500^\circ$K, the physical conditions of the Universe were preliminar to the gravitational collapse and the recombination. In this scenario there is no structure or referential point existence, and the homogeneity is total. As in the radiative era, the expansion is hegemonic, the whole baryonic mass and the photons do not gravitate. In consequence, any expression which relates time and temperature must be connected with an objective element as the mean wavelength, or the frequency of the CMB radiation. The frequency, as the temperature for one particle or photon, can't be other than the same in correspondence to a gaussian distribution of all the N_b particles as the N_γ photons in a generalized contour (the cosmological vacuum energy bubble).

This repulsive energy bubble, is represented by a spherical space or volume of vacuum energy full of microwave radiation. As during all the expansion, the N_γ photon number remains invariant, the universal age is implicit in the mean photon frequency of the CMB radiation. Whereas, if the origin of the $\frac{1}{2}N_\gamma$ photons is simultaneous to neutrons formation, consequently the "nucleosynthesis epoch" is the same as the elapsed time in such epoch for these photons of the CMB radiation.

In the standard model of nucleosynthesis, the timescale is crucially dependable on (53) illusive equation, which gives us only correct dimensional results, but it does not reveal the physical reality. Likewise, by means of Eq. (54), in these highly hegemonic expansive conditions at $10^9{}^\circ$K, the radiation cannot be related by any gravitational dependent scheme, which resembles the physics of the stars (Appendix D)

$$T = \left(\frac{3}{32\pi G a}\right)^{1/4} \frac{1}{t^{1/2}} = \frac{1.52 \times 10^{10}{}^\circ\mathrm{K}}{t^{1/2}}\mathrm{s}^{1/2} \qquad (Gamow) \tag{53}$$

being a the Stephan-Boltzmann radiation density ($8.4 \times 10^{-36}\mathrm{g\,cm^{-3}\,{}^\circ K^{-4}}$)

$$\rho_{\mathrm{rad}} = \frac{3}{32\pi G t^2} \tag{54}$$

Table 3. The results expressed in this table are come Gamow's equation. R_U is deduced from c.t.

Temp.(°K)	time(s)	R_U(cm)	$\rho_{\rm rad}$(g cm^{-3})	N_γ mass (g)	N_γ
2.73	3.10×10^{19}	9.3×10^{29}	4.66×10^{-34}	1.51×10^{57}	3.61×10^{93}
4,000	1.44×10^{13}	4.33×10^{23}	2.16×10^{-21}	7.34×10^{50}	1.18×10^{84}
10,500	2.10×10^{12}	6.30×10^{22}	1.02×10^{-19}	1.04×10^{50}	6.46×10^{82}
10^9	2.31×10^2	6.93×10^{12}	8.34	1.16×10^{40}	7.56×10^{67}
2.0×10^{12}	5.80×10^{-5}	1.65×10^6	1.48×10^{14}(a)	2.78×10^{33}(a)	9.66×10^{57} (a)
1.4×10^{32}	1.18×10^{-44}	3.43×10^{-34}	3.38×10^{93}(b)	6.28×10^{-6}(b)	~ 1(b)

(a)neutrons, (b)one Planck particle

In the time-temperature extrapolation by these equations, there is no consideration of phase transition in the time evolution from now, to Planck's conditions. Moreover, this extrapolation does not take into account the temperature influence in direct connection with the number of photons of the CMB radiation as far as it attains the threshold temperature $\sim 2 \times 10^{12}$°K corresponding to the matter-antimatter transition (See Appendix C).

$$p^- + e^+ + \overline{\nu} \rightarrow n^0$$

$$p^+ + e^- + \nu \rightarrow n^0$$

This transition means that all the polarized pairs of photons increase their mass, owing to the energy intake from the empty space or "vacuum" in collapse. Given theses conditions, the equations which relates temperature and time from present epoch to the proton-antiproton threshold temperature are:

$$t_\gamma = \frac{h}{5kT}\left(\frac{N_\gamma}{2}\right)^{1/3} = \frac{\lambda_{\rm CMB}}{c}\left(\frac{N_\gamma}{2}\right)^{1/3} = \frac{1}{\gamma_{\rm CMB}}\left(\frac{N_\gamma}{2}\right)^{1/3} \qquad ; T : 2.73°{\rm K \ to} \sim 10^{13}°{\rm K} \tag{55}$$

$$t_{n^0} = \frac{h}{kT}\left(\frac{N_{n^0}}{2}\right)^{1/3} = \frac{r_{n^0}}{c}\left(\frac{N_{n^0}}{2}\right)^{1/3} \qquad ; T \sim 10^{13}°{\rm K} \tag{56}$$

The preceding extrapolation process initially shows two well differentiated components: the first one, the CMB radiation and the other is the physical contour where this radiation is confined. This means that, such contour is the space itself or the vacuum contour (M_V component).

From the matter-antimatter collapse, the Universe has a single phase and only one component. Whereas, as the collapse process is moving forward to Planck's state, the energy does not proceed from the "vacuum", instead it comes from the mass itself, which collapse on itself. In advance, $N_{n^0} = N_\gamma$ ceases as a constant, and diminishes gradually at the same time as the temperature increases. This makes necessary another equation for the description of this last extrapolation.

$$N = \frac{N_\gamma T_{n^0}}{2T} \qquad {\rm for}\ T > T_{n^0} \tag{57}$$

$$N_{\rm PL} = \frac{N_\gamma T_{n^0}}{2T_{\rm PL}} = 1.29 \times 10^{68} \tag{58}$$

$$t_{\rm UPL} = \frac{\lambda_{\rm PL}}{c}\left(\frac{N_{\rm PL}}{2}\right)^{1/3} \tag{59}$$

where $T_{n^0} = 2.95 \times 10^{12}$°K, $T_{\rm PL} = 1.42 \times 10^{32}$°K, $\lambda_{\rm PL} = 1.62 \times 10^{-33}$ cm.

The density can be calculated from the number of photons per cubic centimeter given in Eq.(B.3), multiplying it by the photon mass.

$$\rho_{\rm rad} = \frac{3}{4\pi}\frac{(kT)^4}{\hbar^3 c^5} \tag{60}$$

or

$$\rho_{\rm rad} = \frac{3N_\gamma kT}{4\pi R_U^3 c^2} = \frac{3N_\gamma kT}{4\pi t^3 c^5} \tag{61}$$

$$\rho_{\rm PL} = \frac{3N_{\rm PL} kT_{\rm PL}}{4\pi R_{U\,PL}^{\,3} c^2} \tag{62}$$

Table 4. The numerical values expressed in this table result from the Equations (55) to (62).

Temp.(°K)	time(s)	R_U(cm)	$\rho_{\rm rad}$(g cm^{-3})	N_γ mass (g)	N_γ
2.73	4.08×10^{17}	1.23×10^{28}	1.72×10^{-34}	1.32×10^{51}	3.16×10^{87}
4,000	2.79×10^{14}	8.36×10^{24}	7.90×10^{-22}	1.93×10^{54}	3.16×10^{87}
10,500	1.07×10^{14}	3.19×10^{24}	3.72×10^{-20}	5.06×10^{54}	3.16×10^{87}
10^9	1.12×10^9	3.35×10^{19}	3.04	4.80×10^{59}	3.16×10^{87}
2.0×10^{12}	5.58×10^5	1.67×10^{16}	1.40×10^{14}(a)	2.64×10^{63}(a)	3.16×10^{87}
1.4×10^{32}	2.13×10^{-21}	6.38×10^{-11}	2.40×10^{93}(b)	2.64×10^{63}(b)	1.20×10^{68}

(a)Correspond N_{n^0}, (b)Correspond N_{PL}

In a cyclic, or periodic Universe, the Planck state was not an initial *ex-nihilo* big bang starting point, instead, it was a crossing point for a new cycle. As at this point, there is not a preexistent surface, the Universe does not rebound on it, but it passes across itself, and expands toward any 3d points of space. Then, the former inward gravitational implosive falling energy was shifted to an opposite outward acceleration. This accelerative expansion, in fact, was simultaneously cancelled by an equal attractive gravitational field ($g = 0$).

Both opposite interactions were still unchanged until the gravitational baryonic collapse, which started at 1.032 Mps (Sect. 5-1) This dynamics makes the expansion in the initial stages of the universe evolution to be hegemonically performed by the kinetic component (Eq, 55 to 62 and Appendix D).

7.4. Nucleosynthesis

The standard nucleosynthesis is highly dependable on the parameters barion-to-photon ratio η, the Gamow's cosmological time, and the neutron half life. Our model is free of these parameters, and is only dependent on the initial neutron-to-proton ratio from $\sim 1.2 \times 10^{10}$ °K ($2m_e c^2 = 1.022 M_{\rm ev}$. Under these conditions, a great number of positrons and electrons collapse in pairs of polarized photons ($e^- + e^+ \rightleftarrows \gamma + \overline{\gamma}$). This $N \sim 1.6 \times 10^{87}$ leptons maintains the equilibrium in whole relativistic form ($2m_{\rm e}c^2 = kT$). Thus, such interactions do not alter the thermic state of the system.

In this epoch, the following reaction takes place

$$\begin{array}{lllll}
(a) & e^- + p^+ & \rightarrow & n + \gamma & 0.27 M_{\rm ev} \\
(b) & \overline{\nu} + p^+ & \rightarrow & n + e^+ & 1.29 M_{\rm ev} \\
(c) & n & \rightarrow & p + e^- + \gamma & -0.27 M_{\rm ev}
\end{array}$$

The ratio between neutrons and protons can be determined in terms of Boltzmann distribution energy of the (endothermic) neutrons $Q = (m_n - m_p)c^2$, with respect to the energy of the surrounding $1.022\, M_{\rm ev}$. In our scheme, the system operates in a near isothermic state, since one degree of temperature depletion means $\sim 6 \times 10^{-2}$ s (Eq.55).

The number of photons, are two times the number of positrons, but not with respect to the electrons, because there is a tight excess of electrons ($10^{-8} : 1$). In these conditions, there is a continuous regimen of production of neutrons, until reaching the "end point" at $\sim 0.0635 M_{\rm ev}$. At this state, almost all the positrons are destroyed, and $N_{\rm e} \simeq N_{\rm p}$

Then, the neutron-to-proton balance is controled on the basis of the reaction (b).

$$\frac{n}{p} = e^{-\frac{Q}{kT}} = 0.282 \qquad Q = 1.2934\, M_{\rm ev}\,;\; kT = 1.022\, M_{\rm EV}$$

Later, deuterium is produced in continuous form by a high rate of neutron capture

$$(d) \qquad n + p \rightarrow D + \gamma \qquad -2.23\, M_{\rm EV}$$

Departing from this deuterium production, an efficient sequence of highly exothermic chain of nuclear reaction continues. This sequence comprehends a set of nine possible steps of stability superior to $3\, M_{\rm ev}$.

$$\begin{array}{lllll}
(e) & D + D & \rightarrow & {}^3H_{\rm e} + n + \gamma & -3.25\, M_{\rm ev} \\
(f) & D + D & \rightarrow & {}^3H + p + \gamma & -4.05\, M_{\rm ev} \\
(g) & D + p & \rightarrow & {}^3H_{\rm e} + \gamma & -5.49\, M_{\rm ev} \\
(h) & D + n & \rightarrow & {}^3H + \gamma & -6.26\, M_{\rm ev} \\
(i) & {}^3H_{\rm e} + {}^3H_{\rm e} & \rightarrow & {}^4H_{\rm e} + 2p & -12.85\, M_{\rm ev} \\
(j) & {}^3H + D & \rightarrow & {}^4H_{\rm e} + n + \gamma & -17.60\, M_{\rm ev} \\
(k) & {}^3H_{\rm e} + D & \rightarrow & {}^4H_{\rm e} + p + \gamma & -18.86\, M_{\rm ev}
\end{array}$$

Table 5. The numerical results are attained by making use of Eqts. (63) and (64)

$kT(M_{ev})$	η	n/p	${}^4H_e/H$	space density (g cm^{-3})	Time (s)
1.022	9.4×10^{-2}	0.28		2.84×10^7	9.40×10^7
0.500	7.4×10^{-2}	0.28		3.30×10^6	1.90×10^8
0.100	2.6×10^{-5}	0.28		2.73×10^4	9.60×10^8
0.0635	3.2×10^{-8}	0.28	0.082	6.82×10^3	1.51×10^9
0.050	3.2×10^{-8}	1.6×10^{-3}	0.082	3.29×10^3	1.92×10^9
0.010	3.2×10^{-8}	2.1×10^{-47}	0.082	2.63×10^1	9.60×10^9

$(l)\ \ {}^3H + p \ \rightarrow\ {}^4H_e + \gamma \qquad -19.81\, M_{ev}$
$(m)\ {}^3H_e + n \ \rightarrow\ {}^4H_e + \gamma \qquad -20.60\, M_{ev}$

(The energies of all these reactions, were calculated based on Wapstra & Audi, 1985 tables). Operating on all the preceding reactions, plus the inverse of (d), the following algebraic result is obtained.

$(n)\ 2n + 2p = 2D = {}^4H_e$

In this regimen the result (n) indicates that from (d) through all the linked reactions, there is a net capture of two protons for each nucleus of helium.

Because $0.282 = 4/14.18$, it means that the final ${}^4H_e$ abundance is

$$Y_p = \frac{4}{14.18+2} = \frac{4}{12.18+4} = 0.247 \qquad \text{or} \qquad Y_p = \frac{4n-2n+2p}{12.18p+2p+2n} = \frac{H_e}{12.18H+H_e} = 0.247$$

Clearly 0.282 is a key adimensional number, which has the significance of the initial departure and the final point in the accomplishment of a thermodynamic equilibrium. The nucleosynthesis is stopped at $\sim 7.4 \times 10^8\,{}^\circ$K ($0.0635 M_{ev}$), or 1.5×10^9 sec, when almost the whole of the electrons and positrons were transformed in photons, as likewise, the half life of ${}^3H$ ($\sim 3.9 \times 10^8$sec) is exceeded. A remainder part of $\sim 10^{80}$ electrons and nuclides (including D; ${}^3H_e$;${}^4H_e$ and minutes traces of ${}^7Li$) stays until the present time.

7.5. Numerical calculation of D; ${}^3H_e$ and ${}^7Li$ abundances

Although the intention of this article does not deals specifically with this subject, some remarks are valuable with respect to the abundances of the light isotopes of cosmological origin.

The potential of all the preceding nucleosynthesis reactions is connected with the same ground constant: $2m_ec^2 = e^2/r_n = kT$. Clearly, the first two terms are equivalent, and express a fundamental unit of nuclear binding energy. Consequently, nucleosynthesis basically means the collapse of the strong nuclear interaction.

Initially, $2m_ec^2$ is equal to kT. During such epoch, as the number of electrons, plus the positrons, are almost the same as the photons number, the n/p ratio can be determined by a Boltzmannian distribution. Next, at the same time as T decreases, there is a progressive increase of photons, as consequence of the electrons-positrons destruction. During this interval, the n/p balance is sustained by the Saha equation, and its results are invariable for more than one order of magnitude with respect to the decreasing of T (Table 5).

$$\frac{n}{p} = \frac{4\pi}{3\eta}\left(\frac{0.511M_{ev}}{2\pi kT}\right)^{3/2} e^{-\frac{1.29M_{ev}}{kT}} \tag{63}$$

$$\eta = \frac{N_e}{N_\gamma} \tag{64}$$

Just as the n/p regime defines completely the ${}^4H_e$ abundance, the abundances of the other linked light isotopes (D, ${}^3H_e$, and ${}^7Li$) can be defined in the same way.

The long time of nucleosynthesis evolution, the reaction (g) by itself is unable to depress D more and more, until its extintion. The limit is impossed by the higher potential of the surviving reaction (k). Likewise, this key reaction of stable isotopes is derived from the combination of the nuclear processes of lesser energy (g) and (i).

Consequently, given the final thermodynamic values of the ${}^4H_e$ nucleosynthesis, the composite abundances of ${}^3H_e$ and D can be calculated by use of the inverse equation (k) including the gamma energy (0.511 M_{ev}).

$$K = e^{-\frac{Q}{kt}} = \frac{D/H \times {}^3H_e/H}{{}^4H_e \times p/H \times \gamma/H} = 9.66 \times 10^{-9}$$

Taking into account $kT = 1.022M_{\mathrm{ev}}$, ${}^4H_{\mathrm{e}}/H = 0.082$, $\gamma/H = 1$ and $p/H = 1$ we have

$D/H \times {}^3H_{\mathrm{e}}/H = 7.92 \times 10^{-10}$

If we employ the upper observational results, e.g. $D/H = 6.76 - 3.98 \times 10^{-5}$ (Kirkman *et. al.* 2000-2003) we get ${}^3H_{\mathrm{e}}/H = 1.2 - 2.0 \times 10^{-5}$, being acceptable values, considering such origin as primordial.

Some isotopes of ${}^7Li$ could be produced by the reaction

$(o)\, {}^4H_{\mathrm{e}} + {}^3H \rightarrow {}^7Li + \gamma \qquad - 2.47\, M_{\mathrm{ev}}$

Or they could be formed later, by the following chain of reactions

$(p)\, {}^4H_{\mathrm{e}} + {}^3H_{\mathrm{e}} \rightarrow {}^7B_{\mathrm{e}} + \gamma \qquad - 1.59\, M_{\mathrm{ev}}$

$(q) \quad {}^7B_{\mathrm{e}} + e \rightarrow {}^7Li + \overline{\nu} \qquad - 2.19\, M_{\mathrm{ev}}$

In the initial time of the nucleosynthesis, this lateral reaction has a very weak potential, in competition with the strongly exothermic energies evolved in the principal chain by D, ${}^3H_{\mathrm{e}}$ and ${}^3H$ nuclei.

Consequently, if these reactions were produced at the end of the nucleosynthesis in a surrounding of large excess of protons, most of the scarces${}^7Li$ nucleus are destroyed by the highly exothermic reaction:

$(r)\ {}^7Li + p \rightarrow 2^4\, H_{\mathrm{e}} + \gamma \qquad - 17.85\, M_{\mathrm{ev}}$

Then, in accordance with the inverse of this reaction, the ${}^7Li$ abundance is

$$K = \frac{{}^7Li \times p}{{}^4H_{\mathrm{e}}^2 \times \gamma} = e^{-\frac{Q}{kT}} = 2.60 \times 10^{-8}$$

As ${}^4H_{\mathrm{e}}/H = 0.082$, $p/H = 1$, $\gamma/H = 1$ and $kT = 1.022M_{\mathrm{ev}}$

$Li/H = 1.75 \times 10^{-10}$

The preceding results signify that Y_p =constant, D has an exclusively cosmological origin, and this isotope is solely depleted by astrophysical means. On the other hand, undefined amounts of ${}^3H_{\mathrm{e}}$ and ${}^7Li$ can be produced, or destroyed by astrophysical means.

In this sense ${}^7Li$ shows very dispersed experimental values. In recent observations of the most primitives stars, this isotope gives a significative underabundance (Frebel et al, 2005). Oppositely, there is an extensive discussion about several categories of non-neglegible astrophysical ${}^7Li$ producers by Romano *et.al.*2001.

Finally, our numerical values are not restricted to the observable fraction $\Omega_{\mathrm{b}} = 0.043$, which for us, is the site where the astrophysical phenomena take place. Instead, we extend the location of the light metals within all the huge cosmological component $\Omega_{\mathrm{M}} = 0.49$, therefore, we do not make use of any diffuse constant, or adjusted variables in the obtainment of the results.

8. Conclusions

In natural sciences, particularly in any branch of physics, it is extremely hard to construct a scientific framework on the basis of a generalized hypothetical unknown matter. Hence, it is very unusual, as in the cosmological standard model is considered as a natural fact that $\sim 95\%$ of the matter-energy (near the whole) is in an unknown hidden form.

Cosmology requires particles, radiation, space and energy, as likewise, the physics of the particles requires the same components. Since the atomic physics does not make use of any hidden form of matter-energy, therefore, the theoretical cosmology must be free of these artifices.

Because the cosmological space expands by itself, it acts as an entity. This means that the empty space is nothing, and it must be something.

The analysis of some unspecific details from oustanding experiments, reveals us implications as valuables as the direct observation of the phenomena. Then, from not explicit deductions of the Millikan's experiment, we infer that the coulombic interaction of an electron charge in the atomic space contour is equivalent to the electron mass in a Newtonian macrospace interaction within a Jeans contour (Appendix A). Likewise, from unspecific implications of H.B. Chan and coworkers experiment (Appendix E) we deduce the energy of the empty space as the physical cause of cosmological order for the Cassimir effect.

Departing from the begining of the big-bang, the Universe is an energetic homogeneus bubble of hegemonically expansive nature, with a constant baryonic mass as well as the photons number of the CMB radiation. When this reached the size of $R_G \sim 1$ Mps the conditions which produced the gravitational collapse were originated. From them onwards two opposite actions emerge:

1. the gravitation proceeding by the always attractive mass m_M
2. the always expansive empty space energy m_Λ

Taking into account that m_M decreases less rapidly than m_Λ, the equlibrium will be reached when m_Λ (expansive) is equal to m_M (attractive). Likewise, the existence of a density nearly equal to the critical is allowed by the registered value of the Hubble constant at the present epoch. For a flat Universe, the extreme values for this constant lead to the following physical alternatives:

1a.- A low value for H_0 (say 50km s^{-1} Mps^{-1}) determines a strong empty space energy component m_Λ which makes the Universe not only massive and big, but also very extensive in time.

2a.- A high value for H_0 (*e.g.* 100 Kms^{-1} Mps^{-1}) shows a weak space energy component (m_Λ) which determines a Universe with less gravitational critical mass, relatively small and too young.

Two other possible extremes are:

1b.- An open Universe, *i.e.* a Universe with a gravitational mass m_M smaller than the critical one(say $0.25\Omega_M$ and $0.75\Omega_\Lambda$) which determines that the starting point in the gravitational collapse, or R_G radius, must be$\sim$ 3 Mps and $T \sim 3,500°$K. Following the theoretical context of this article, this means that in order to reach the present value of $H_0 \sim 75$ Kms^{-1}Mps^{-1}, the Universe would be very big in size (x3) and age (x3) which makes a CMB radiation of 2.73°K/3.

2b.- Finally for a Universe with a gravitational mass m_M higher than the critical one (say $0.75\Omega_M$ and $0.25\Omega_\Lambda$) the crushing would have begun when $H_0 = 225$ Kms^{-1}Mps^{-1} and $T = 3 \times 2.73°$K. Thus, for a similar age to ours ($\sim 4.07 \times 10^{17}$ s) the Hubble current would turn backwards to the blue. In the same way, the CMB radiation temperature for a hypothetical contemporary observer would be $6 \times 2.73°$K.

.

From all of this, we may conclude that the existence of a final critical mass (euclidian Universe) is the only possible alternative with a physical foundation. It is impossible to maintain that a comparatively small and decisively limiting Ω_M mass within the empty space contours of high mass-energy contents ($M_V \sim 2.6 \times 10^{63}$ g) may fit into any mass value with a specific gravitational effect. Since the H_0 constant is connected principally to dynamic factors, the Universe only has an age and a size assigned by the available mass and energy from the very begining of the big-bang, which cannot be other than a critical mass-energy for an expansive-implosive cyclic framework. This oscillating scenario is possible due to the reversible equilibrium between the blackbody spectrum of the CMB radiation and the Rydberg atoms of the dark matter. Moreover, in the expansive-compressive cycles, the energy density of the empty space of any of the Rydberg atoms is the same as the density of energy of the cosmological empty space. In this completely reversible evolution, the mass-energy variation of all the N quantum unities (Appendix C) is proceeding from the empty space, and does not make a net increase of entropy from cycle to cycle.

References

Alpher, R.A., Herman, R.C., 1949, Phys. Rev. 75, 1089.
Alpher, R.A., Bethe, H., Gamow, G., 1948, Phys. Rev. 73, 803
Alpher, R.A., Follin, J.W., Herman, R.C., 1953, Phys. Rev. 92, 1347
Bernstein, J., 1988, Kinetic Theory of the Expanding Universe, Cambridge University Press, p.73
Bohr, N., 1913 Phil. Mag. 26,1,10, 476,587
Bohr, N., Wheeler, J.A., 1939, Phys. Rev. 56, 426
Chan, H.B., Aksyoub, R.N., Kleiman, D.J., et al., 2001, Science 291, 1941
De Bernardis, P., Ade, P.A.R., Bock J.J., et al., 2000, Nature 404, 955
Dicke, R.H., 1965, Nature 397, 303-306
Dirac, P.A.M., 1938, Proc. Roy. Soc. A, 165, 199
Eddignton, A.S., 1936 Theory of Photons and Electrons, Cambridge Univ. Press
Einstein, A., 1922 The Meaning of Relativity, Princenton Univ. Press
Frebel, A., Aoiki, W. Cristieb, N. et al., 2005, Nature L, 419, 871
Freedman, W.L., et al, 2001, Ap. J., 553, 47
Gamow, G., 1946, Phys. Rev. L. 70, 572
Gamow, G., 1948, Phys. Rev. L. 74, 505
Gamow, G., 1952, The Creation of the Universe, The Viking Press, Appendix
Jeans, J.L., 1902, Phil. Trans. Roy. Soc. London, 199, I
Jordan, P., 1955 Schwerlaff und Weltall, Branunchwerg
Kirkman, D., Tytler D., et al, 2000, Ap. J. 529, 655.
Kirkman, D., Tytler D., Suzuki, N et al, 2003, Ap. J.S, 1.
Madore, B.F., Freedman, W.L., Silvermann, N., et al, 1999, Ap. J. 515, 29

Melchiori, A., Ade, P.A.R., De Bernardis, P., et al, 1999, Ap. J.L. 536, 2, 63
Millikan, R.A., 1913, Phys. Rev. 2, 109-143
Mishra, Subodha, 2007, arXiv:physics/0703175 V3
Misner Thorne Wheler, 1973, Gravitation, Freedman, p.709
Ohanian, H., Ruffini, R., 1994, Gravitation and Spacetime, Norton & Co., p.594
Planck, M., 1926, Treatise on Thermodynamics, Dover Publ. p44
Romano, D., Matteucci, F., et al, 2001, A&A, 352, 117
Tolman, R.C., 1934, Relativity, Thermodinamics and Cosmology, Dover Publ. p333, p405
Wapstra, A.H., Audi, G., 1985, The atomic mass evaluation II. Nuclear-reaction and separation energies. Nuclear Physics A 432, 55
Weyl, H., 1919, Annalen der Physic 59, 101-133
Wilczek, F., 1999, Nature 397, 303-306

Appendix A: Subjacent implications in the Millikan experiment

The Millikan experiment (Millikan 1913) consists of the execution of several experiments systematically integrated to only one instrument.

To carry out this experiment in atmospheric pressure does not mean any failure, since in the vacuum it would be impossible to carry it out. In the same way, when the bouyance and the viscous force are substracted this led to a vacuum formal situation.

$$0 = F_{\rm grav} + F_{\rm elect} + F_{\rm visc} + F_{\rm bouy} \tag{A.1}$$

Hence, in a superposed way the charged droplet is subjected to the terrestrial gravitational field, and an electrical field. As both fields are of constant intensity, and opposites in direction, the minutes drops proceed in discontinuous rinses or falling speeds change , as likewise they can be in static balance.

The electron mass, the same as the charges, does not modify the gravitational potential. Also, the electron mass, as the droplet mass does not alter the electrical potential, which means that both interactions are independent.

If we suppose that a droplet of mass $m_{\rm d}$ is restrained unmovable from both condenser plates whose potential is $E\,{\rm volt\,cm^{-1}}$, also, unlike the Millikan experimental intentions, if we use the electron charge e as a knowable date, the equilibrium state can be defined by

$$m_{\rm d} g = \frac{GM_\oplus m_{\rm d}}{R_\oplus^2} = E\,e \tag{A.2}$$

This shows that the gravitational potential on the droplet mass is equivalent to the electrical potential on the droplet weight.

Despite the fact that it appears as a matter of unmeaning physical value, we can deduce the radius, or the terrestrial mass, as well as the gravitational constant from (A.2).

By opposite extrapolations toward both extremes of the micro and macroworld, the droplet mass ($\sim 8.10\times10^{-11}$ g) becomes unnecessary as an experimental artifice. In this new context, we consider an equilibrium state between the mass of a single electron as a poof particle in a gravitational field. If this field of mass M and radius R is balanced with respect to the coulombic potential of an isolated Bohr's hydrogen atom, we have

$$\frac{e^2}{2a_0} \simeq \frac{GMm_{\rm e}}{R} = 2.2\times10^{-11}\ {\rm erg}$$

where $M \simeq 2.5\times10^{44}$ g; $R \simeq 7\times10^{20}$ cm; $e = 4.8\times10^{-10}$ ${\rm cm^{3/2}g^{1/2}s^{-1}}$ and $a_0 = 5.29\times10^{-9}$ cm.

This equality for the electron charge within an electrical field, in relation to the electron mass within a gravitational field, is an expression of equivalence. Therefore, we consider the pertinence of the Saha formula in clump formation, and its micro and macrophysical implications.

Appendix B: Density of photons number of the CMB radiation

The number of photons per cm^3 of the microwave radiation may be easily calculated[4] if we take into account the first and sixth terms of the Eq. (27)

$$\hbar = \frac{5}{2\pi} m_{\rm CMB} c\,\lambda \tag{B.1}$$

[4] The standard method to obtain this result is carried out through a long and complex calculus procedure *e.g.* (Ohanian & Ruffini 1994)

being $m_{\rm CMB} = kT_{\rm CMB}/c^2$.

Reordering (B.1) and multiplying both terms by R_U, the Universe photon number N_γ may be obtained by raising to the cubic power.

$$N_\gamma = \left(\frac{2\pi R_U}{5\lambda_{\rm CMB}}\right)^3 = \left(\frac{kT_{\rm CMB} R_U}{\hbar c}\right)^3 \tag{B.2}$$

This equality shows the invariance of N_γ through any kind of extrapolation between an inferior extreme to a superior one, which may be very far from each other in the evolution of R_U.

In order to obtain the number of photons in a cubic centimeter unit, it is only necessary to divide both terms of Eq. (B.2) by the spheric volume of the Universe

$$n_\gamma = \frac{N_\gamma}{V} = \frac{6\pi^2}{(5\lambda_{\rm CMB})^3} = \frac{3}{4\pi}\left(\frac{kT_{\rm CMB}}{\hbar c}\right)^3 \tag{B.3}$$

e.g. for $T = 2.7315°$K, $n_\gamma = 407$ photons cm^{-3}.

Appendix C: Phase transitions in the N photons of the CMB radiation

All the photons of the CMB radiation vibrate in all possible directions through a symmetric axis. But, as they have their origin in the annihilation of almost the same quantity of matter-antimatter, they are formed from $N_\gamma/2$ pairs of polarized waves. This polarization still remains after the inverse thermoionization (recombination) because the recombinant electron also collapses in atoms with two possible quantum states. Likewise, the electrons of the hydrogen atoms and He too, show two equal quantum states and emit polarized photons in both pairs.

Because the great supremacy of the $N_\gamma/2$ pairs of polarized waves, and despite of the perturbations provoked by the $N_{\rm b}$ baryons, this scheme remains invariant through all the cosmological evolution. Therefore, from the present conditions, if we fix an inverse sequential order towards a collapse on the space itself(gravitational implosion), it will show the following phases:

a - When the temperature is higher than $4,000°$K the electrons and the hydrogen nucleous, will still be at the plasma state. The N_γ photons of the CMB radiation keep their polarity, taking into account that they are $1/2N_\gamma(-)$ and $1/2N\gamma(+)$.

b - For the electrons' threshold temperature $T \sim 6\times10^{9}°$K and $R_U \sim 2.6\times10^{19}$ cm, 1/4 photons (-) and 1/4 photons (+) collapses as 1/4 electrons and 1/4 positrons.

c - When $R_U \sim 1.6\times10^{16}$ cm and $T > 2\times10^{12}°$K (neutron's threshold temperature) other 1/4 photons (+) plus 1/4 photons (-) collapse as 1/4 protons and 1/4 antiprotons, their final result being $N/2$ neutrons.
$$\left.\begin{cases} 1/4N(p^+ + e^- + \nu_{\rm neutrino} \to n^0) \\ 1/4N(p^- + e^+ + \nu_{\rm antineutrino} \to n^0) \end{cases}\right\} N/2 \text{ neutrons}$$
Where $N/2 = 1.6\times10^{87}$ neutrons, and $M_V = 2.6\times10^{63}$ g is the mass intake from the empty space.

d - Finally, this $N/2$ neutrons coaleses to give $\sim 1.2\times10^{68}$ Planck's "particles" when $R_U = 6.4\times10^{-11}$ cm and $T = 1.62\times10^{32}$ °K.

Appendix D: Time - temperature relationship in an implosive - expansive cyclic Universe

a - According to a very explicit classical approach (Gamow 1952), the big-bang departs from an initial plasma state at $T \sim 10^{9}°$K$(\sim 0.511M_{ev})$.
The total energy is
$$E = KE + PE \tag{D.1}$$
Being
$$KE = \frac{4}{3}\pi\rho_\gamma H^2 R^5 \qquad and \quad PE = \frac{16}{15}\pi G\rho_\gamma R^5 \tag{D.2}$$
H: Hubble constant; R: distance, and $H\cdot R = c$

Since at this epoch, the cosmological space was extremely repulsive, as well as the gravitational interaction was irrelevant, it means that KE was largely dominant.
Then, relating KE in terms of the total photon numbers N_γ of the CMB radiation, we have:
$$KE = \frac{4}{3}\pi\rho_\gamma c^2 R^3 = m_\gamma c^2 N_\gamma \tag{D.3}$$

Replacing ρ_γ by Equation (60), we find the following time - temperature relationship

$$T = \frac{\hbar}{kt} {N_\gamma}^{\frac{1}{3}} \tag{D.4}$$

b - There is another way to illustrate the misleading of this key Gamow's cosmological equation, since it is possible to obtain the same result from the energy of a neutron star, which is described by the Mishra's equation (Mishra 2007). Here, there is a new *had-hoc* time-temperature scale for the big bang departure which is shifted back $(m_{n^\circ}/m_{\mathrm{e}})^{1/4}$ times to other stage, defined as a neutronic condensation.
The total energy of this system is

$$E_{(\lambda)} = KE_{(\lambda)} + PE_{(\lambda)} \qquad E_{(\lambda)} = \frac{12}{25\pi} \frac{\hbar^2}{m_{n^\circ}} \left(\frac{3\pi N_{n^\circ}}{16} \right)^{5/3} \frac{1}{\lambda^2} - \mathrm{g}^2 \frac{N^2_{n^\circ}}{16} \frac{1}{\lambda} \tag{D.5}$$

g means G ${m_{n^\circ}}^2$; λ is a parameter of distance.
If we consider the mass - energy of the kinetic term of this "neutron star" as a contour of matter-antimatter hypothetical big bang starting point (T $\sim$ 10^{12}°K), by expansion, as the temperature drops, the threshold matter-antimatter stability is surpassed, and these particles become photons. There are 2 spin states for each particle-antiparticle, and 2 polarized photons derived from them. Since, for each photon $g = 2$, the total contribution is $g = 4$

$$N_{n^\circ} \rightarrow \tfrac{1}{2}p^+ + \tfrac{1}{2}p^- + \tfrac{1}{2}e^- + \tfrac{1}{2}e^+ + \tfrac{1}{2}neutrinos + \tfrac{1}{2}antineutrinos \rightarrow 2N_\gamma$$

Therefore, at temperature bellow 10^9°K, these cosmological conditions were very repulsive. It signifies that the kinetic term of Eq(D.5) becomes largely hegemonic, and the use of the hamiltonian(D.5) is an unmeaning.

$$\frac{KE}{c^2} = N_\gamma m_\gamma = \frac{48}{25\pi} \frac{\hbar^2}{m_\gamma c^2} \left(\frac{3\pi N\gamma}{16} \right)^{\frac{5}{3}} \frac{1}{\lambda^2} \tag{D.6}$$

Since $R = 2\lambda$:

$$R = \left(\frac{192}{25\pi} \right)^{\frac{1}{2}} \left(\frac{3\pi}{16} \right)^{\frac{5}{6}} \frac{\hbar}{m_\gamma c} {N_\gamma}^{\frac{1}{3}}$$

Because the product of all the adimensional factors is $1.006 \simeq 1$, we have:

$$\frac{R}{c} = t = \frac{\hbar}{m_\gamma c^2} {N_\gamma}^{\frac{1}{3}} = \frac{\hbar}{kT} {N_\gamma}^{\frac{1}{3}} \tag{D.7}$$

c - Finally, for this black body contour full of radiation and a very repulsive-expansive cosmological bubble of energy, the ideal gas equation as a kinetic expression is a suitable tool to resolve this problem directly.

$$V = \frac{N_\gamma kT}{\rho_\gamma c^2} \tag{D.8}$$

As the relation volume to radius is

$$R = \left(\frac{3}{4\pi} V \right)^{\frac{1}{3}}$$

Substituting ρ_γ by Eq (60), and dividing by c

$$t = \frac{\hbar}{kT} {N_\gamma}^{\frac{1}{3}}$$

If $N_\gamma = 3.12 \times 10^{87}$, it means

$$T = 1.12 \times 10^{18} {}^\circ\mathrm{K} s t^{-1}. \tag{D.9}$$

Appendix E: Empty space energy density

The empty space is all energy. The source of this energy was originated from the initial conditions of the big-bang process, whose physical significance is related as an evolution of the space in expansion. This process was initiated from the annihilation of near the same matter-antimatter particles. At the present time development, the empty space density of energy is equivalent to

$$102(m_{\rm p}+m_{\overline{\rm p}}+m_{\rm e}+m_{\overline{\rm e}})c^2 = 0.31 \text{ erg cm}^{-3} \tag{E.1}$$

The pressure exerted by the empty space is hegemonic and isotropic, but experimentally elusive. However, recently this task was accomplished by a reliable method (Chan . *et al*, 2001). By means of a plane-spherical torsional electromicromachine, the Casimir attractive force was determined within a distance of 300 nm to 75.7 nm between surfaces.

Dimensionally, the energy density is equivalent to the pressure, and is possible to deduce it from the force equation for a plane-sphere system.

$$F = \frac{\pi^3 \hbar c R}{360 z^3} \tag{E.2}$$

where R is the radius of the spherical surface and z is the separation between surfaces.

Since the effective area is $2R^2$, the density of energy can be expressed in the following form

$$P = \rho_E = \frac{\text{Force}}{\text{Effective Area}} = \frac{\pi^3 \hbar c}{720 z^3 R} = 0.314 \text{ dyn cm}^{-2} = 0.314 \text{ erg cm}^{-3} \tag{E.3}$$

The attractive force on one side of the plate was measured by a torsional device. When this effect is expressed respect the approaching sphere per unit of area, the force is the same, but opposite to this sphere, and it indicates a pressure or energy density.

The torsion exerted by one side of the plate was gaugered electrostatically in terms of the separation distance z. When this z variable is 75.7 nm (point of closest approach), the Casimir curve intercepts the coulombic calibration curve. This referential point means that the pressure per area unit of the electrostatic field is the same as the energy density. At this point, as the electromagnetic modes between the reflecting areas are excluded, the Casimir pressure has the same intensity. Consequently, 0.31 erg.cm^{-3} is the energy density proceed from the proper nature of the empty space.

From (B.3) we consider the origin of the CMB radiation as matter-antimatter annihilation from N baryons- N antibaryons pairs: $\frac{1}{2}N_\gamma = N_{\rm p^+} + N_{\rm p^-}$ (Appendix C). Because of this, the energy density of the empty space is

$$\rho_{\rm E} = \frac{\pi^3 \hbar c}{720 z^3 R} \simeq \frac{3\pi^2 m_{p\pm} c^2}{(5\lambda_{\rm CMB})^3} = 0.31 \text{ erg cm}^{-3} \tag{E.4}$$

where $z = 7.57 \times 10^{-6}$ cm, $R = 0.01$ cm and $\lambda_{\rm CMB} = 0.105$ cm.

Substituting $\hbar$ by Eq.(B.1) and considering R and $\lambda_{\rm CMB}$ as constants, we can express (E.4)as follows:

$$\rho_E = \frac{3}{4\pi}\frac{m_{p\pm}c^2}{\lambda_{\rm CMB}^3} = \frac{9}{8\pi}\frac{m_{\rm CMB}c^2}{z^3} = \frac{3}{4\pi}\frac{m_{\rm CMB}c^2}{z_0^3} = 0.31 \text{ erg cm}^{-3} \tag{E.5}$$

Being z_0 the fitted electrostatic value: 6.7×10^{-6}cm

Which signifies that the energy density of the empty cosmological space, is equivalent to the vacuum energy density per quantum fd^{-1} in this z^3 MEMS void. If the density is extrapolated up to the present Universe volume, the result is the empty space mass-energy (Sect. 3.3).

$$M = \rho . V_U = \frac{4\pi R_U^3 \rho_{\rm E}}{3c^2} = 2.65 \times 10^{63} \text{ g}$$

Likewise, the density of energy within the empty contour of a hydrogen Rydberg atom at $n \simeq 240 - 220$ is the same as the density of energy of the cosmological empty space. Hence, the density of energy is

$$\rho_{240-220} = \frac{3e^2}{8\pi n^6 a_0^4} = \frac{3\alpha\hbar c}{8\pi n^6 a_0^4} = \frac{3,51 \times 10^{13}}{n^6} \text{ erg cm}^{-3} = (0.18 - 0.31) \text{ erg cm}^{-3} \tag{E.6}$$

The discrepancy of these results is because of the ellipticity of the Rydberg hydrogen atom. A quantum defect is produced by $r = n^2 a_0$, where r is the spherical radius, instead of the major elliptical axis. Moreover, our Rydberg spherical volume approach is n^6 sensitive respect to a_0^4.

Submission History (viXra.org; 0909.0015) v2 07 Mar 2008; v3 15 Jul 2010 ; v4 20 Jan 2011.