Chapter 5. Zero Point Energy of the Physical Vacuum.

In this chapter the relation between the cosmic background radiation and the ideal gas constant R_g will be shown. They both are experimentally measured physical parameters. Relying on the derived relation, the determination of the size of the proton (and neutron) become possible by cross-related analysis provided in Chapter 6 (section 6.12.2), using the derived in Chapter 3 (section 3.13) mass equation.

The suggested model of the physical vacuum automatically leads to a conclusion that the CL space is able to contain a distributed Zero Point Energy (ZPE). In fact we may distinguish two kinds of distributed ZPE in every point of the observable space: a static energy (ZPE-S) and dynamic energy (ZPE-D). The ZPE-S is the energy that keeps the internode distance of CL space. This energy is quite big, because it involves the interaction forces between the two types of nodes formed of quite dense twisted prisms. The ZPE-D is the vibrational energy contributed by the CL nodes oscillations. Characteristic parameters of ZPE-D are the resonance node frequency and SPM frequency (equal to the Compton frequency). Their relations to the permeability and permittivity of free space were demonstrated in section 2.11.3. The ZPE-D is also related to the discussed in Chapter 2 zero point waves. The ZPE-S is related to the Static pressure, while ZPE-D is related to the Dynamic pressure of the CL space as discussed in section 3.13. The Static pressure is directly related to the Newtonian mass of the elementary particles, while the Dynamic pressure is related to the magnetic and partly to the electrical interactions. Presently the Modern physics identifies a zero point energy related only to the magnetic and electrical interaction. Obviously this ZPE corresponds to ZPE-D according to BSM concept. The ZPE-S part, now, is out of the vision of the Modern Physics. Some specific experiments show a signature of ZPE-S, but it is either ignored or dismissed as contradictable to the presently formulated by the Modern physics laws of physics. The well-known infinities in Feynman diagrams in the particle collider experiments is a manifestation of ZPE-S energy. Some experiments with cold plasma (for instance artificial light balls) also exhibit a signature of ZPE-S.

The huge difference between ZPE-D and ZPE-S could be understood if using an analogy with the energy in the ocean. The ZPE-D is analogous to the energy of the ocean waves carried by a layer with a small thickness in comparison to its depth and normalized to unit surface area. The ZPE-S is analogous to the potential energy of the column of water under the same unit area. If a zunamy wave is invoked by an Earth quake (a very strong interaction) its enormous energy should analogically corresponds to a ZPE-S energy disturbance of the physical vacuum.

5.1 Zero point energy of CL space and its relation to the Cosmic Background Radiation

According to the BSM theory, the cosmic background radiation, known also as a relict radiation, does not come from the past, but originates from the rarefied gas distributed in the deep space. The gas molecules or atoms in such conditions are in dynamic equilibrium with the surrounding CL nodes, the carriers of the dynamic type of Zero Point Energy (ZPE-D). This equilibrium involves absorption of zero order waves, from the gas molecules or atoms and emission of photons, while the total energy balance of the system including the gas particles and surrounding CL space is preserved. The most abundant interstellar gas is an atomic and molecular Hydrogen. This fact facilitates the estimation of the ZPE and determination of one important parameter of the proton - the volume of its envelope. This parameter, is later used in Chapter 6, for determination of the dimension of the proton with its substructures by cross calculations with other experimentally determined parameters.

5.2 Derivation of expressions about the CL space background temperature.

The method of calculation is based on two fundamental expressions: the equation of the ideal gas and the equation of the CL dynamical pressure. The first one is well known in the Classical termodynamics, while the second one is a BSM equation derived in Chapter 3.

The equation for the ideal gas is

$$R_{ig} = \frac{PV_{\mu}}{T} \qquad (5.1)$$

where: R_{ig} = 8.31451 (J $kmol^{-1}$) - is the universal gas constant; V_{μ} is the molar volume at absolute temperature T.

The ideal gas constant is an experimentally measured physical parameter for gases in conditions when they behave as ideal gases.

The CL dynamical pressure, P_D , is given by Eq (3.61) (Chapter 3).

$$P_D = \frac{h\nu_c}{cS_e} = \frac{h\nu_c}{4\pi^2 cR_c r_e} \quad \left[\frac{N}{m^2Hz}\right] \qquad (5.2)$$

where: h - is a Plank's constant, ν_c - is a Compton frequency, c - is alight velocity, R_c is the Compton radius, r_e is the small electrons structure radius.

In conditions of dynamical equilibrium, the hydrogen atom gets momentum from the cosmic lattice in a form of dynamical pressure on the proton envelope. The surface of the proton envelope is given by the envelope of the proton circumference $2\pi(R_c + r_p)$ and its axial length L_{pc}.

$$S_p = 2\pi(R + r_p)L_{pc} \qquad (5.3)$$

The dynamical force exercised by the CL space on the proton surface is

$$F_D = P_D S_p = \frac{h\nu_c(R_c + r_p)L_{pc}}{2\pi cR_c r_e} \qquad (5.4)$$

The pressure unit in SI system is [N/m^2]. This means that the resultant total force should be referenced to a unit surface of 1 m^2. In such case the pressure can be regarded as a sum of bouncing individual forces from a large number of protons while the resultant force is reference to a virtual wall with area $S_W = 1\ m^2$.

The number of protons in one molar volume of atomic hydrogen is given by the Avogadro number N_A. Then the resultant force on a virtual wall from N_A number of protons is $\Sigma F_D = N_A F_D$. Normalizing the resultant force to a virtual wall with unite area of 1 m^2, we get the exercised pressure:

$$P = \frac{\Sigma F_D}{S_W} = \frac{N_A F_D}{S_W} = \frac{N_A h\nu_c(R_c + r_p)L_{pc}}{2\pi cR_c r_e} \qquad (5.5)$$

Let consider one *mol* of neutral Hydrogen atoms in a deep space that is in a dynamical equilibrium with the ZPE-D. This equilibrium could be estimated by the dynamical CL pressure exercised on the proton. It has been mentioned, that the dynamical CL pressure is caused by the zero point waves, responsible for ZPE equalization, that means a background temperature uniformity of CL space. The dynamical equilibrium means, that the hydrogen atom gets energy from the zero point waves, but it also should radiate some energy back into the space. Obviously, the radiated energy should be contributed by level transitions. It is performed by small amount of atoms distributed in the space so the optical depth is quite large. This conditions are ideal in order to consider the behaviour of the hydrogen atoms existing in the deep space as an ideal gas. The distance between atoms is large enough to eliminate the collision effect. The background temperature also is very low, so we may consider that the photon energy exchange is negligible. In such conditions the probability of the hydrogen electron to be in a ground state is quite high. But the electron could never stop its motion in the quantum orbits. So it will have a continuous interaction with CL space by its magnetic moment. This means that the Hydrogen atom will have some finite velocity different than zero. The physical effect of such motion is some small but finite pressure. In order to estimate this pressure we need to define a finite volume. Such volume could be the molar volume. It could be defined as:

$$V_{\mu} = V_H N_A \qquad (5.6)$$

where: N_A - is the Avogadro number

V_H - is the Hydrogen volume, considered as a neutral in the interaction with the zero point waves (related to ZPE-D).

The Hydrogen volume should be some volume around the proton core where the interaction will take place. It is very probable this to be the volume enclosed in the Bohr surface, so in the outside volume the atom behaves as a neutral. (the system of proton and orbiting electron appears externally neutral). Then comparing such described system of Hydrogen (possessing the mentioned hydrogen volume connected to the Avogadro number) with a similar volume defined for a single neutron we see, that they both exhibit the following common features:

- they appear as a neutral in the far field
- in the near field they exhibit magnetic field

- the proximity electrical field of the neutron is locked by the IG(CP) forces due to the symmetrical spatial configuration

- the proximity field of the proton in the Hydrogen is locked inside the Bohr surface due to the proximity coupling with the electrical field of the orbiting electron in a quantum quasishrink space (see Chapter 7 and Chapter 9).

The above features provides a possibility to replace the magnetic interaction (with CL space) of the moving neutral Hydrogen by the magnetic interaction of the neutron. So we can use some of the neutron's parameters and more specifically its magnetic moment as a dynamical interaction with the CL space.

Let examine firstly, could the following relation be correct: $V_H/V_p = m_p/m_e$, where V_H is the above defined volume, V_p - is the volume of the proton envelop, m_p and m_e - the proton's and electron's masses. From well known relation $m_p/m_e = \mu_e/\mu_p$, where μ_e and μ_p are respectively the magnetic moments of the electron and the proton we arrive to $V_H/V_p = \mu_e/\mu_p$ While the left side of this relation is a volume ratio between a neutral (hydrogen) and a charged particle (proton) the right side is a magnetic moment ratio between two charge particles (electron and proton). We may replace one of the magnetic moment in the right side ratio with the magnetic moment of a neutral particle, or μ_p with μ_n. This matches the considerations in the above paragraph. The we arrive to the relation:

$$\frac{V_H}{V_P} = \frac{\mu_e}{\mu_n} \qquad (5.6.a)$$

The envelope volume of the proton structure (whose surface is expressed by Eq. (5.2)) is:

$$V_p = \pi(R_c + r_p)^2 L_{pc} \qquad (5.6.b)$$

Combining Eqs. (5.6), (5.6.a) and (5.6.b) we may express the interaction molar volume of the hydrogen as:

$$V_\mu = \left(\frac{\mu_e}{\mu_n}\right)\pi(R + r_p)^2 L_{pc} N_A \qquad (5.7)$$

Substituting (5.5) and (5.7) in Eq. (5.1) we obtain the equation of the CL background temperature.

$$T = \frac{N_A^2 h\nu_c (R_c + r_p)^3 L_{pc}^2}{S_W \, 2cR_c r_e R_{ig}}\left(\frac{\mu_e}{\mu_n}\right) \quad [K] \qquad (5.8)$$

where: $S_W = 1$ (m^2) - is a reference wall area

The proton core length L_{pc}, obtained directly from Eq. (5.8) is:

$$L_{pc} = \frac{1}{N_A}\left(\frac{2cR_c r_e T S_W R_{ig}}{h\nu_c (R_c + r_p)^3}\frac{\mu_n}{\mu_e}\right)^{1/2} \quad [m] \qquad (5.9)$$

The measured background temperature by COBE experiment is:

$$T_{exp} = 2.726 \pm 0.01 \quad [K] \qquad (5.10)$$

Then from Eq.(5.7) we obtain

$L_{pc} = 1.6429 \times 10^{-10}$ (m), but this is approximate value. In §6.12.2.1 (Chapter 6), the accurate value is obtained by strobing the approximate value with some of the experimentally parameters of some elementary particles. The obtained accurate value for the proton core length is

$$L_{pc} = 1.6277 \times 10^{-10} \quad [m] \qquad (5.11)$$

This value is extensively used in number of expressions, especially in Chapter 9 and 10 and matches quite well to the theoretical results and the experimental data.

The calculated background temperature for this value of L_{pc} is: $T = 2.6758$ [K] (5.12)

The difference between the estimated temperature by BSM and the experimentally measured one is only 1.8%.

The CMB (cosmic microwave background) temperature is measured by a satellite looking in a deep space, while the universal gas constant is measured in Earth conditions. Some difference may exist between the ZPE-D of the deep space and the Earth local filed, that could be a result of the Earth gravitation influence on the CL density. This is kind of General relativistic effect.

The concept applied for the Hydrogen in fact should be valid for any other simple molecule, because, the Zero point waves have very short wavetrain and could easy envelope around any molecule. Therefore, in conditions of dynamical equilibrium number of molecules contained in the deep space could be involved. The resultant spectrum obtained as a summation of their radiation may have an envelope approaching the theoretical curve of the blackbody radiation at the definite temperature. The "relict" temperature in fact is estimated by fitting of the measured spectrum to a blackbody function tuned at a proper temperature.

5.3 CL space background temperature expressed by the parameters of CL space.

The deep space background temperature is a pure CL space parameter existing in both conditions: a deep space and in a vicinity of a massive objects as well. The first option indicates that it could be expressed directly by some of the intrinsic parameters of CL space. In order to obtain such expression we must replace the proton and electron geometrical parameters in Eq. (5.6) with pure CL space parameters.

The proton length L_{pc} could be substitute by some length parameter of the quantum orbit. In Chapter 3 (73.12.3) it has been shown that the trace length of a quantum orbits is defined by the equation [(3.43.j)0

$$L_q(n) = \frac{2\pi a_o}{n} = \frac{\lambda_c}{n\alpha} = \frac{c}{n\alpha\nu_c} \qquad [(3.43.j)]$$

where: n - is the quantum number, defined by the subharmonic number of confined velocity motion of electron in CL space.

For a second subharmonic we have:

$$L_q(2) = 1.66246\times10^{-10} \text{ [m]} \qquad (5.13)$$

This value differs from L_{pc} only by 2%, so L_{pc} in Eq. (5.8) could be substituted. The parameters of the electron: R_c, r_e and r_p can be also expressed by α, c, g_e (electron gyromagnetic factor). Then we arrive to an equation in which the geometrical parameters of the electron and proton are eliminated.

$$T = \frac{N_A^2 hc^2 (3g_e\sqrt{1-\alpha^2} + 4\pi\alpha)^3}{864\alpha^3 \nu_c^2 \pi^2 g_e^2 (1-\alpha^2) R_{ig}} \frac{\mu_e}{\mu_n} \qquad (5.14)$$

It has been shown in Chapter 3 that the gyromagnetic factor of the electron (g_e) is defined by the interactions between the internal RL(T) structures and the CL space. The magnetic moment ratio μ_e/μ_n could be also considered defined by the CL space.

The provided analysis is correlated with the calculated mass budget of the proton and cross-correlated with the eta- particle mass, antiproton/proton stopping power ratio, and the high energy collision resonances (1.7778 GeV, 1.44 GeV, 80 GeV and 91.18 GeV) (See Chapter 6 of BSM).

5.4 Breakdown of the equivalence principle at internode range distance.

Problem for obtaining a theoretical expressions about the Zero Point Energy

It may seam that the ZPE-D could be theoretically estimated using the classical equation $E = 0.5I\omega^2$, if the moment of inertia, I, is estimated for the oscillating CL node, for which many parameters were identified. This equation, however, is valid with a presumption that the Newtonian gravitational mass is equal to the inertial mass (equivalent principle). Extensive analysis (including a quantitative, as well) from a point of view of BSM, however, indicates that equivalence principle breaks down when approaching the internode distance. This is understandable, also logically, when considering that the CL space could not exercise a static pressure on a particle object whose size is comparable with the internode distance. In this category are some types of neutrino particles.

5.5 Summary

- **The calculated background temperature is a CL space parameter related to the Zero Point Energy of that space. The coincidence of the calculated ZPE temperature with the CMB temperature is one of many proofs for the existence of gravitational lattice.**
- **Eq. (5.6) connects directly two experimentally measured constants: the ideal gas constant from one side and the CMB temperature from the other.**
- **Eq. (5.6) connects indirectly many experimentally measured constants: Plank constant, light velocity, Compton wavelength, fine structure constant (for r_e determination), muon to electron magnetic moment ratio, pion to muon mass ratio (for proton core length determination).**
- **The discovered relation between the CMB temperature and ZPE of the CL space, provides a physical meaning of the universal gas constant and the Boltzman constant, as parameters of CL space.**
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