Cosmological Particle Creation and Baryon Number Violation in a Conformal Unified Theory

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Abstract

We consider a conformal unified theory as the basis of conformal-invariant cosmological model where the permanent rigid state of the universe is compatible with the primordial element abundance and supernova data. We show that the cosmological creation of vector Z and W bosons, in this case, is sufficient to explain the CMB temperature (2.7 K). The primordial bosons violate the baryon number in the standard model as a result of anomalous nonconservation of left-handed currents and a nonzero squeezed vacuum expectation value of the topological Chern-Simons functional.

1 Introduction

To explain the origin of the observable matter in the universe and the violation of baryon number are the urgent problems in modern cosmology. The latter is needed for the explanation of the baryon asymmetry in the universe in accordance with the three Sakharov conditions: CP-violation in weak interaction, nonstationary universe, and baryon asymmetry [1].

In the present paper, we try to explain the cosmological origin of the observable matter and the violation of the baryon number in a conformal-invariant version of the unified theory of gauge fields and gravitation given in a spacetime with the Weyl geometry of similarity [2,3]. This geometry allows us to measure the ratio of two intervals and leads to conformal cosmology [4,5]. In the conformal cosmology, the modern supernova data on the accelerating universe evolution [6] are compatible with the dominance of the rigid state [5]. The conformal version of the rigid state reproduces the z-history of chemical
evolution of the element abundance in standard cosmology, since we have, in conformal cosmology, the same square root dependence of the scale factor on the observable time in the rigid stage. At the beginning of the universe, conformal cosmology describes intensive creation of W and Z bosons from vacuum. The primordial bosons violate the baryon number due to their polarization of Dirac vacuum.

2 Model

We consider a conformal-invariant unified theory of gravitational, electroweak, and strong interactions: the Standard Model where the dimension parameter in the Higgs potential is replaced by the dilaton field \( w \) described by the Penrose-Chernikov-Tagirov action with the negative sign. The corresponding action takes the form

\[
W = \int d^4x \sqrt{-g} [L_{\Phi, w} + L_g + L_l + L_{\Phi} + ...],
\]

where the Lagrangian of dilaton and Higgs fields is given by

\[
L_{\Phi, w} = \frac{|\Phi|^2 - w^2}{6} R - \partial_\mu w \partial^\mu w + D^-_\mu \Phi (D^\mu - \Phi)^* - \lambda \left( |\Phi|^2 - y_\nu^2 w^2 \right)^2,
\]

where \( \Phi = \begin{pmatrix} \Phi^+ \\ \Phi^- \end{pmatrix} \) is the Higgs field doublet, \( D^-_\mu \Phi = (\partial_\mu - ig^{a}_2 A_\mu^a - \frac{i}{2} g' B_\mu) \Phi \), and \( |\Phi|^2 = \Phi^+ \Phi^- + \Phi^- \Phi^- \). The Lagrangian of the gauge fields is

\[
L_g = -\frac{1}{4} \left( \partial_\mu A^a_\nu - \partial_\nu A^a_\mu + g \varepsilon_{abc} A^b_\mu A^c_\nu \right)^2 - \frac{1}{4} (\partial_\mu B_\nu - \partial_\nu B_\mu)^2
\]

whereas that of the leptons is

\[
L_l = i \bar{L} \gamma^\mu D^+_\mu L + i \bar{e}_R \gamma^\mu \left(D^F_\mu + ig' B_\mu \right) e_R + \bar{\nu}_R i \gamma^\mu \partial_\mu \nu_R
\]

with

\[
L = \begin{pmatrix} \nu_{\ell, L} \\ e_L \end{pmatrix}; \quad e_R, \nu_{\ell, R},
\]

\( D^F \) is the Fock derivative, \( D^+_\mu L = (D^F_\mu - ig^{a}_2 A_\mu^a + \frac{i}{2} g' B_\mu) L \).
The Lagrangian describing mass terms of leptons including that of the neutrino (if it has one) is

\[ L_{l\phi} = -y_e \left( e_R \Phi^+ L + \bar{L} \Phi e_R \right) - y_\nu \left( \bar{\nu}_R \Phi^+_C L + \bar{L} \Phi_C \nu_R \right), \quad (6) \]

where

\[ \Phi_C = i \tau_2 \Phi^+_C = \begin{pmatrix} \Phi_0 \\ -\Phi_- \end{pmatrix} \]

and \( y_f \) are dimensionless parameters. This theory is invariant with respect to conformal transformations, and it is given in the Weyl space of similarity with the relative standard of measurement of intervals as the ratio of two intervals of the Riemannian space \([7]\). The space of similarity is the manifold of Riemannian spaces connected by the conformal transformations. This relation depends on nine metric components and allows us to use the Lichnerowicz conformal-invariant variables \([8]\) and measurable conformal-invariant space-time interval

\[ (ds^L)^2 = g^L_{\mu\nu} dx^\mu dx^\nu, \quad g^L_{\mu\nu} = g_{\mu\nu} |^{(3)} g |^{-1/3}, \quad |^{(3)} g^L | = 1. \quad (8) \]

The principle of equivalence of inertial and gravitational masses is incorporated into the conformal-invariant Higgs mechanism through the dilaton-Higgs mixing \([9]\) \( w^L = \phi \cosh \chi, \Phi^L = \phi \, n_i \sinh \chi, \, |\Phi^L|^2 - (w^L)^2 = -\phi^2, \, nn^+ = 1, \) so that the action (1) takes the form

\[ L = -\frac{\phi^2}{6} R - \partial_\mu \phi \partial^\mu \phi + \phi^2 \partial_\mu \chi \partial^\mu \chi + L_{\text{Higgs}} + y_e \phi \sinh \chi \bar{e} e + ..., \]

where the Higgs Lagrangian

\[ L_{\text{Higgs}} = -\lambda \left( |\Phi^L|^2 - y_h^2 (w^L)^2 \right)^2 = -\lambda \phi^4 \left[ \sinh^2 \chi - y_h^2 \cosh^2 \chi \right]^2 \]

describes the conformal-invariant Higgs effect of the spontaneous SU(2) symmetry breaking

\[ \frac{\partial L_{\text{Higgs}}}{\partial \chi} = 0 \Rightarrow \chi_1 = 0, \quad \sinh \chi_{2,3} = \pm \frac{y_h}{\sqrt{1 - y_h^2}} \sim 10^{-17}. \]

The present-day value of the dilaton in the region far from heavy masses distinguishes the scale of the Planck mass \( \phi(t_0, x) \simeq M_{\text{Planck}} \sqrt{3/(8\pi)}. \) This
fact is revealed by energy-constrained perturbation theory [3,10].

3 Method

The lowest order of energy-constrained perturbation theory is formed by linearization of all equations of motion in the class of functions with nonzero Fourier harmonics (i.e., the "local" class of functions) in the flat conformal space-time

\[ ds^2_L = d\eta^2 - dx_i^2, \quad d\eta = N_0(t)dt, \quad N_0 = [g^0_0]^{-1/2}. \]  \hspace{1cm} (9)

Part of these local equations are constraints that form the projection operators. These operators remove all superfluous degrees of freedom of massless and massive local fields. In particular, four local constraints as the equations for \( g_{\mu\nu}=0 \) remove three longitudinal components of gravitons and all nonzero Fourier harmonics of the dilaton. However, the local constraints could not remove the zero Fourier component of the dilaton \( \varphi(t) = \int d^3x \dot{\varphi}(t, x)/\int d^3x \).

The infrared interaction of the complete set of local independent variables \( \{f\} \) with this dilaton zero mode \( \varphi(t) \) is taken into account exactly. The lowest order of the considered linearized perturbation theory is described by the Hamiltonian form of the action (1) in this approximation

\[ S_0 = \int_{t_1}^{t_2} dt \int d^3x \left( \sum_f p_f \dot{f} - P\varphi \dot{\varphi} - N_0 \left[ -\frac{P^2}{4} + \rho(\varphi) \right] \right), \quad \dot{f} = \frac{\partial f}{\partial t}, \]

where \( \rho(\varphi) \) is the global energy density that generates all the above-mentioned linear equations for independent degrees of freedom. This energy-constrained theory contains the Friedmann-like equation for the conformal time (9)

\[ \eta(\varphi_0, \varphi_i) = \pm \int_{\varphi_i}^{\varphi_0} \frac{d\varphi}{\sqrt{\rho(\varphi)}} \]  \hspace{1cm} (10)

as a consequence of the energy constraint \(-P\dot{\varphi}/4 + \rho_F = 0\) and the equation for the dilaton momentum \( P_\varphi \)

\[ \frac{d\varphi}{d\eta} = \frac{P_\varphi}{2} = \pm \sqrt{\rho(\varphi)}. \]

The cosmic evolution of dilaton masses leads to the redshift of energy levels of star atoms [4] with the energy density \( \rho(\varphi) \) and the Hubble parameter
\[ H_0 = \frac{\dot{\varphi}}{\varphi}(\eta_0) \], which gives the present-day value of the dilaton

\[ \varphi(\eta_0) = \varphi_0 = \frac{\sqrt{\rho_0}}{H_0} = \Omega_0^{1/2} M_{\text{Planck}} \sqrt{\frac{3}{8\pi}}, \quad \Omega_0 \equiv \frac{\rho_0}{\varphi_0^2 H_0^2} = 1. \]

Therefore, the Planck scale is distinguished as a current (present-day) value of the dilaton, rather than the fundamental parameter that can be shifted to the beginning of the universe. The energy-constrained theory solves also the problem of horizon by perturbation theory in conformal space (9). If we introduce "particles" as holomorphic field variables

\[ f(t, \vec{x}) = \sum_{k, \sigma} \frac{C_f(\varphi) \exp(ik_i x_i)}{V_0^{3/2}} \sqrt{2 \omega_f(\varphi, k)} \left( a_\sigma^+(-k, t) \epsilon_\sigma(-k) + a_\sigma(k, t) \epsilon_\sigma(k) \right), \]

where

\[ C_h(\varphi) = \frac{\sqrt{12}}{\varphi}, \quad C_v(\varphi) = \frac{\omega_v}{g_v \varphi}, \quad C_{\gamma}(\varphi) = C_s(\varphi) = C_\perp(\varphi) = 1, \]

then the energy density can be represented in the diagonal form

\[ \hat{\rho}(\varphi) = \sum_{\varsigma} \omega_f(\varphi, k) \hat{N}_\varsigma \quad \text{(where } \omega_f(\varphi, k) = (k^2 + y_f^2 \varphi^2)^{1/2} \text{ is the one-particle energy; } \hat{N}_\varsigma = \frac{1}{2} (a_\varsigma^+ a_\varsigma + a_\varsigma a_\varsigma^+) \text{ is the number of particles; } \varsigma \text{ include momenta } k_i, \text{ species } f = h, \gamma, v, s, \text{ spins } \sigma). \]

At the same time, the canonical differential form in the action acquires nondiagonal terms as sources of cosmic creation of particles

\[ \left[ \int \frac{d^3x}{V_0} \sum_f p_f f \right]_B = \sum_{(k, f, \sigma)} \frac{i}{2} (a_\varsigma^+ \dot{a}_\varsigma - a_\varsigma \dot{a}_\varsigma^+) - \sum_{\varsigma} \frac{i}{2} (a_\varsigma^+ a_\varsigma^+ - a_\varsigma a_\varsigma) \hat{\Delta}_\varsigma(\varphi). \]

The number of created particles is calculated by diagonalization of the equations of motion by the Bogoliubov transformation

\[ b_\varsigma = \cosh(r_\varsigma) e^{i\theta_\varsigma} a_\varsigma + i \sinh(r_\varsigma) e^{-i\theta_\varsigma} a_\varsigma^+. \quad (11) \]

The equations for the Bogoliubov coefficients

\[ [\omega_\varsigma - \theta_\varsigma'] \sinh(2r_\varsigma) = \Delta_\varsigma' \cos(2\theta_\varsigma) \cosh(2r_\varsigma), \quad r_\varsigma' = -\Delta_\varsigma' \sin(2\theta_\varsigma) \]

determine the number of particles \[ N_\varsigma^{(B)}(\eta) = \langle 0 | \hat{N}_\varsigma^{(B)} | 0 \rangle_{sq} - 1/2 = \sinh^2 r_\varsigma(\eta) \] created during the time \( \eta \) from squeezed vacuum: \( b_\varsigma | 0 \rangle_{sq} = 0 \) and the evolution
of the density $\rho(\varphi) = \varphi^2 = \sum_\varsigma \omega_\varsigma(\varphi) \langle 0 | \hat{N}_\varsigma | 0 \rangle$. The set of nondiagonal terms in SM

$$\Delta_h(\varphi) = \ln(\varphi/\varphi_I), \quad \Delta_\bot(\varphi) = \frac{1}{2} \ln(\omega_\bot/\omega_I), \quad \Delta_{||}(\varphi) = \Delta_h(\varphi) - \Delta_\bot(\varphi),$$

where $\varphi_I$ and $\omega_I$ are initial values, contains the zero-mass singularity [11,12] that plays an important role in the explanation of the longitudinal vector bosons and the origin of the cosmic microwave background (CMB) radiation.

4 Creation of vector bosons

We consider the rigid state in the conformal version $\rho/\rho_0 = \Omega_{\text{rigid}}(z+1)^2$ with the conformal-invariant equation for the dilaton

$$\varphi^2(\eta) = \varphi_I^2 [1 + 2H_I\eta] = \frac{\varphi_0^2}{(1+z)^2}, \quad H(z) = \frac{\varphi'}{\varphi} = H_0(1+z)^2,$$

where $\varphi_I, H_I$ are primordial data. At the point of coincidence of the Hubble parameter with the mass of vector bosons $m_v(z) \sim H(z)$, there occurs the intensive creation of longitudinal bosons [2].

The numerical solutions of the Bogoliubov equations for the time dependence of the vector boson distribution functions $N_{||}(k,\eta)$ and $N_\bot(k,\eta)$ are given in Fig. 1 (left panels) for the momentum $k = 1.25H_I$. We can see that the longitudinal function is noticeably greater than the transversal one. The momentum dependence of these functions at the beginning of the universe is given on the right panels of Fig.1. The upper panel shows us the intensive cosmological creation of the longitudinal bosons in comparison with the transversal ones. This fact is in agreement with the mass singularity of the longitudinal vector bosons discussed in [11,12]. One of the features of this intensive creation is a high momentum tail of the momentum distribution of longitudinal bosons which leads to a divergence of the density of created particles defined as [13]

$$n_v(\eta) = \frac{1}{2\pi^2} \int_0^\infty dk k^2 \left[ N_{||}(k,\eta) + 2N_\bot(k,\eta) \right]. \quad (12)$$

The divergence is a defect of our approximation where we neglected all interactions of vector bosons that form the collision integral in the kinetic equation for the distribution functions. In order to obtain a finite result for the density,
Fig. 1. Time dependence for the dimensionless momentum $x = k/H_I = 1.25$ (left panels) and momentum dependence, at the dimensionless lifetime $\tau = (2\eta H_I) = 14$, (right panels) of the transverse (lower panels) and longitudinal (upper panels) components of the vector-boson distribution function.

we suggest multiplying the primordial distributions $N^\parallel_v(k, \eta_L)$ and $N^\perp_v(k, \eta_L)$ with the Bose - Einstein distribution ($k_B = 1$)

$$F_v(k, \eta) = \left\{ \exp \left( \frac{\omega_v(\tau) - m_v(\eta)}{T} \right) - 1 \right\}^{-1},$$

(13)

where $T$ is considered as a regularization parameter.

Our calculation of this density presented in Fig.1 signals that the density (12) is established very quickly in comparison with the lifetime of bosons, and in the equilibrium there is a weak dependence of the density on the time (or $z$-factor). This means that the initial Hubble parameter $H_I$ almost coincides with the Hubble parameter at the point of saturation $H_s$.

For example, we have calculated the values of integrals (12) for the regularization parameter $T = m_v(z_I) = H_I$. The result of the calculation is

$$\frac{n_v}{T^3} = \frac{1}{2\pi^2} \left\{ [1.877]^\parallel + 2[0.277]^\perp = 2.432 \right\}.$$  

(14)
The final product of the decay of the primordial bosons includes photons. If one photon comes from the annihilation of the products of the decay of $W^\pm$ bosons and another from $Z$ bosons, we can expect the density of photons in the conformal cosmology with the constant temperature and the static universe [5] to be

$$\frac{n_\gamma}{T^3} = \frac{1}{\pi^2} \{2.432\}. \quad (15)$$

Comparing this value with the present-day density of the cosmic microwave radiation

$$\frac{n_\gamma^{\text{obs}}}{T_{\text{CMB}}^3} = \frac{1}{\pi^2} \{2\zeta(3) = 2.402\} \quad (16)$$

we can estimate the regularization parameter $T$. One can see that this parameter is of the order the temperature of the cosmic microwave background $T = T_{\text{CMB}} = 2.73$ K. We can speak about thermal equilibrium for the primordial bosons with the temperature $T_{\text{eq}}$, if the inverse relaxation time [14] $\tau_{\text{rel}}^{-1}(z_I) = \sigma_{\text{scat}} n_v(T_{\text{eq}})$, where the scattering cross-section of bosons in the considered region proportional to the inverse of their squared mass $\sigma_{\text{scat}} = \gamma_{\text{scat}}/m_v^2(z)$ is greater than the primordial Hubble parameter $H_I$. This means that the thermal equilibrium will be maintained, if

$$\gamma_{\text{scat}} n_v(T_{\text{eq}}) = \frac{2.4}{2\pi^2} \frac{\gamma_{\text{scat}} T_{\text{eq}}^3}{H(z_I)m_v^2(z_I)} > H(z_I) m_v^2(z_I). \quad (17)$$

The right-hand side of this formula is an integral of motion for the evolution of the universe in the rigid state. The estimation of this integral from the present values of the Hubble parameter and boson mass gives the value

$$\left[ m_W^2(z_I) H(z_I) \right]^{1/3} = \left[ m_W^2(0) H_0 \right]^{1/3} = 2.76 \text{ K.} \quad (18)$$

justified, when for the coefficient $\gamma_{\text{scat}} > 8.5$ holds.

Thus, we conclude that the assumption of a quickly established thermal equilibrium in the primordial vector boson system may be justified, since $T \sim T_{\text{eq}}$. The temperature of the photon background emerging after annihilation and decay processes of $W^\pm$ and $Z$ bosons is invariant in the conformal cosmology and the simple estimate performed above gives a value surprisingly close to that of the observed CMB radiation.
5 Nonconservation of fermion quantum numbers

The interaction of primordial W and Z bosons with left-handed fermions leads to nonconservation of the fermion quantum numbers. It is well known that the gauge-invariant current of each doublet is conserved at the classical level, but not the quantum one [15]. At the quantum level, we have the anomalous current

\[ j^{(i)}_L = \bar{\psi}^{(i)}_L \gamma_\mu \psi^{(i)}_L, \]

\[ \partial_\mu j^{(i)}_L = -\frac{\text{Tr} F_{\mu\nu}^* F_{\mu\nu}}{16\pi^2}, \quad F_{\mu\nu} = -\frac{ig_{\tau_a}}{2} F^a_{\mu\nu} \langle \text{p.t.} \rangle, \quad F^a_{\mu\nu} \langle \text{p.t.} \rangle = \partial_\mu A^a_\nu - \partial_\nu A^a_\mu. \]

If we take the integral over four-dimensional conformal space-time confined between three-dimensional hyperplanes \( \eta = 0 \) and \( \eta = \eta_L \), we find that the number of left fermions \( N(\eta_L) \) is equal to the difference of Chern-Simons numbers

\[ \Delta N_{CS}(\eta_L) = N_{CS}(\eta_L) - N_{CS}(0) \]

where \( \tau_L = \eta_L / \eta_I \) is the lifetime of bosons. To estimate this time \( \eta_L \), we use the lifetime of W-bosons in the Standard Model at this moment

\[ \eta_I + (\eta_I + 1) = \frac{\sin^2 \theta_W}{m_W(z_L) \alpha_{QED}}, \]

where \( \theta_W \) is the Weinberg angle, \( \alpha_{QED} = 1/137 \), and \( z_L \) is the z-factor at this time. Using the equation of the rigid state [2] and the equality \( \eta_I m_W(z_L) = (z_I + 1)/(2[z_L + 1]) \), we rewrite the previous equation in terms of the z-factor

\[ \tau_L + 1 = \frac{(z_I + 1)^2}{(z_L + 1)^2} = \frac{(z_L + 1) 2 \sin^2 \theta_W}{(z_I + 1) \alpha_{QED}}. \]  

The solution of this equation is \( \tau_L + 1 = (2 \sin^2 \theta_W / \alpha_{QED})^{2/3} \simeq 15 \), and for the lifetime of created bosons we have \( \tau_L = \eta_L / \eta_I \simeq 14 \).

During their lifetime, transverse vector bosons are evolving so that the Chern-Simons functional is changed

\[ \Delta N_w = \frac{4\alpha_{QED}}{\sin^2 \theta_W} \int_0^{\eta_W} \eta \int \frac{d^3 x}{4\pi} \text{sq} \langle 0 | E_i^W B_i^W | 0 \rangle_{\text{sq}}, \]

where

\[ N_w = \frac{4\alpha_{QED}}{\sin^2 \theta_W} \int_0^{\eta_W} \eta \int \frac{d^3 x}{4\pi} \text{sq} \langle 0 | E_i^W B_i^W | 0 \rangle_{\text{sq}}. \]
where $E_i$ and $B_i$ are the electric and magnetic fields strengths. The squeezed vacuum and Bogoliubov transformations (11) give a nonzero value for these quantities

$$\int \frac{d^3 x}{4\pi} s_q(0|E_i^v B_i^v|0)_{sq} = -\frac{V_0}{2} \int_0^\infty dk |k|^3 \cos(2\theta_\zeta) \sinh(2r_\zeta),$$

where $\theta_\zeta$ and $r_\zeta$ are given by the equation for transverse bosons. Using the relation

$$\Delta N_Z = \frac{\alpha_{QED}}{\sin^2 \theta_W \cos^2 \theta_W} \int_0^{\eta_0^2} d\eta \int \frac{d^3 x}{4\pi} s_q(0|E_i^Z B_i^Z|0)_{sq},$$

we find the Chern-Simons functional for $Z$ bosons in a similar way. We estimate

$$\frac{(3\Delta B)}{V_0 T^3} = \frac{(\Delta N_W + \Delta N_Z)}{V_0 T^3} = \frac{\alpha_{QED}}{\sin^2 \theta_W} \left( 4 \times 1.44 + \frac{2.41}{\cos^2 \theta_W} \right)$$

for the lifetime of bosons $\tau_L^W \approx 15$, $\tau_L^Z \approx 30$, using the T-regularization (13).

The baryon asymmetry, which appeared as a consequence of three Sakharov conditions ($CP_{SM}$, $H_0 \neq 0$, $\Delta L = 3\Delta B = \Delta n_w + \Delta n_z$), is equal to $\Delta B/n_\gamma = X_{CP}/3$ where $X_{CP}$ is a factor determined by a superweak interaction of $d$ and $s$-quarks ($d + s \to s + d$) with CP-violation experimentally observed in decays of $K$ mesons [16].

It is worth emphasize that in the considered model of the conformal cosmology, the temperature is a constant. In conformal cosmology, we have the mass history

$$m_{era}(z_{era}) = \frac{m_{era}(0)}{(1 + z_{era})} = T_{eq},$$

with the constant temperature $T_{eq} = 2.73 \text{ K} = 2.35 \times 10^{-13} \text{ GeV}$ where $m_{era}(0)$ is characteristic energy (mass) of the era of the universe evolution, which begins at the redshift $z_{era}$.

Eq. (23) has the important consequence that all physical processes, which concern the chemical composition of the universe and depend basically on the Boltzmann factors with the argument $(m/T)$, cannot distinguish between the conformal cosmology and the standard cosmology due to the relations

$$\frac{m(z)}{T(0)} = \frac{m(0)}{(1 + z)T(0)} = \frac{m(0)}{T(z)}.$$
This formula makes it transparent that in this order of approximation a $z$-history of masses with invariant temperatures in the rigid state of conformal cosmology is equivalent to a $z$-history of temperatures with invariant masses in the radiation stage of the standard cosmology. We expect, therefore, that the conformal cosmology allows us to keep the scenarios developed in the standard cosmology in the radiation stage for, e.g. the neutron-proton ratio and primordial element abundances.

6 Conclusion

We have considered the unified theory of all interactions in the space-time with the Weyl relative standard of measurements. The conformal symmetry, reparametrization - invariant perturbation theory, and the mass-singularity of longitudinal components of vector bosons lead to the effect of intensive creation of these bosons with the temperature of an order of $(m_W^2 H_0)^{1/3} \sim 2.73$ K. Instead of the $z$-dependence of the temperature in an expanding universe with constant masses in the standard cosmology, in conformal cosmology, we have the $z$-history of masses in a non-expanding universe with an almost constant temperature of the photon background (with the same argument of the Boltzmann factors). Recall that the density resemble physical properties of the cosmic microwave background radiation. The primordial boson "radiation" created during a conformal time interval of $2 \times 10^{-12}$ sec violates the baryon number. The subsequent annihilation and decay of primordial bosons form all the matter in the universe in the rigid state. At the present-day stage, the evolution of the universe in the rigid state in the conformal cosmology does not contradict recent observational data on Supernova [6] and confirms the results on the abundance of chemical elements obtained in the Hot Scenario at the radiation stage [2].

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