A Possible Universal Model without Singularity and its Explanation for Evolution of the Universe

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Abstract

The new hypotheses are proposed that there are $s$ - particles and $v$ - particles which are symmetric and mutually repulsive, there are $S$ - space and $V$ - space whose essential difference is only that their expectation values of the Higgs fields are different. In $S$ - space the $S$ - $SU(5)$ symmetry is broken into $S$ - $SU(3)$ $XU (1)$ , and $V$ - $SU(5)$ symmetry still holds. As a consequence, $s$ - particles get their masses determined by the $SU(5)$ GUT and form the $S$ - world, and $v$ - particles are all massless and form $SU(5)$ colour-single states which are identified with dark energy.

The following results are obtained. There is no spacetime singularity, and there is the highest temperature in the universe. The creating process of one world is just the annihilating process of the other world in the highest temperature. A formula which well describes the luminous distance and redshift is obtained. The results of the Guth’s inflationary scenario are obtained. Decelerated expanding early stage and accelerated expanding now stage of the universe are explained. New predictions are follows. Some huge cavities in $V$ - space are not empty, in which there is $s$ - matter with larger density, and are equivalent to huge concave lenses. The given characters of some huge cavities are well explained. The gravitation between two galaxies distant enough will lesser than that predicted by the conventional theory. A possible explanation for the big redshift of quasi-stellar objects is presented. Huge redshifts of quasars are mass redshifts. The universe is composed of infinite universal islands. It is possible that there is a new annihilating mode of black holes with their very huge masses, and there are very huge white holes which are different from that predicted by conventional theory.

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I. INTRODUCTION

As is now well known, there is space-time singularity under certain conditions\textsuperscript{[1]}. These conditions fall into three categories. First, there is the requirement that gravity shall be attractive. Secondly, there is the requirement that there is enough matter present in some region to prevent anything escaping from that region. The third requirement is that there should be causality violations. The recent astronomical observations show that the universe expanded with a deceleration early and is expanding with an acceleration now. This implies that there is dark energy. 0.73 of the total energy of the universe is dark energy\textsuperscript{[2]}. What is dark energy? Many possible answers have been given. One possible interpretation is in terms of the effective cosmological constant \( \lambda_{eff} = \lambda + E_0 \), here \( \lambda \) and \( E_0 \) are respectively the Einstein’s cosmological constant and the zero-point energy of the vacuum. But \( \lambda_{eff} \) cannot been derived from basic theory \textsuperscript{[3]} and \( E_0 \gg \lambda_{eff} \). Hence the interpretation is unsatisfactory. Alternatively, dark energy is associated with the dynamics of scalar field \( \phi(t) \) that is uniform in space\textsuperscript{[4]}. This is a seesaw cosmology\textsuperscript{[5]}. This implies that the conventional theory is still unsatisfied and the issue of the cosmological constant is still unsolved.

We hope to solve the two problems above on the premise \( E_0 = \lambda = 0 \). We suppose \( \lambda_{eff} = 0 \). On the premise and the basis of a new conjecture we try to solve the problems of space-time singularity and the universe expanding with an acceleration. In fact, a sort of quantum field theory has been constructed in which there is no divergence, and \( E_0 = 0 \)\textsuperscript{[6]}. But the present model is not on the basis of the quantum field theory without divergence. Hence we suppose \( \lambda_{eff} = 0 \). The other premise of the present model is the conventional \( SU(5) \) grand unified theory (\textit{GUT}) But it is easily seen that the present model does not rely the especial \textit{GUT} model. In fact, provided there are the \textit{GUT} model, and when the symmetry strictly hold water, there are the glue-balls corresponding to symmetry, the present model can hold water. As is well known, although the glue-balls corresponding to \( SU(3) \) are not founded for a time, the \( SU(3) \) theory have proven that there can be the \( SU(3) \) glue-balls
whose masses are not zero.

According to the present model there are two sorts of matter which are called \( s \)-\textit{matter} and \( v \)-\textit{matter} and which are repulsive and symmetric each other, hence one condition of the space-time singularity theorems is violated. Consequently, there is no the space-time singularity. One of both sorts of matter (\( s \)-\textit{matter}) can be identified with the conventional matter forming the given world, and other sort (\( v \)-\textit{matter}) can be identified with the so-called dark energy. The results of the Guth’s inflationary scenario are obtained. That the universe expanded with a deceleration early and is expanding with an acceleration now is explained are explained. The present model have the following new predictions. There is the highest temperature in the universe, hence there is no space-time singularity. That \( S \)-\textit{world} come into being follows that \( V \)-\textit{world} disappears at the highest temperature. There are the repulsion red-shifts and the mass red-shifts which are essentially different from the given red-shifts. Some \( s \)-\textit{huge} cavities in \( S \)-\textit{world} are not empty, but there is \( v \)-\textit{matter} in them, their effects are similar to that of huge concave lens. Because there must be \( v \)-\textit{matter} between two \( s \)-galaxies when the distant between both is large enough, the gravitation between both will lesser than that predicted by the conventional theory. According to the model, the universe is composed of infinite universal islands. From this we give a possible explanation to the very large red-shift of a quasar. The huge redshifts of quasars are the mass redshifts. It is possible that a \( v \)-\textit{black} hole with its mass big enough can transform into \( s \)-\textit{huge} white hole which cannot be observed by a \( v \)-\textit{observer} except by its repulsion effects, and the \( s \)-\textit{cosmic} island neighboring on a \( v \)-\textit{cosmic} island transforms into a \( v \)-\textit{cosmic} island after it contraction. In this case, a \( v \)-\textit{observer} in the \( v \)-\textit{cosmic} island must observe a very huge \( v \)-\textit{huge} white holes which are different from that predicted by conventional theory.

Before inflating occurs, the \( s \)-\textit{world} is in thermal equilibrating state. If there is no \( v \)-\textit{matter}, because of contraction by gravitation, the \( s \)-\textit{world} would become a thermal equilibrating singular point, i.e., the \( s \)-\textit{world} would be in the hot death state. As seen, it is necessary that there are both \( s \)-\textit{matter} and \( v \)-\textit{matter} and both \( S \)-\textit{space} and \( V \)-\textit{space}. 


II. ACTION, ENERGY-MOMENTUM TENSOR AND EQUATIONS OF MOTION

In order to solve the two problems of singular point and dark energy, we propose the following conjectures.

**Conjecture 1:** There are two sorts of matter which are respectively called solid – matter \((s - \text{matter})\) and void – matter \((v - \text{matter})\). \(s - \text{matter}\) and \(v - \text{matter}\) are symmetric; Contribution of \(s - \text{matter}\) to the Einstein tensor is opposite to that of \(v - \text{matter}\); There is no other interaction between both except there is the interaction described by (13) between \(s - \text{Higgs fields}\) and \(v - \text{Higgs fields}\).

Matter determines properties of spacetime. Different breaking modes of Higgs fields correspond to different ground states. The Higgs fields in the present model have two sorts of breaking modes different in essence. One sort is that the vacuum expectations of the \(s - \text{Higgs fields}\) are not zero and all the vacuum expectations of the \(v - \text{Higgs fields}\) are zero. In the case, space is called Solid – space \((S - \text{space})\). The other sort is that all the vacuum expectations of the \(s - \text{Higgs fields}\) are zero and the vacuum expectations of the \(v - \text{Higgs fields}\) are not zero. In the case, space is called Void – space \((V - \text{space})\).

We will see that in the \(S - \text{space}\) \(s - \text{particles}\) can get their masses and the masses of all \(v - \text{particles}\) are zero (hence, \(v - \text{particles}\) are identified with dark energy in \(S - \text{space}\)) , in the \(V - \text{space}\) \(v - \text{particles}\) can get their masses and the masses of all \(s - \text{particles}\) are zero (hence, \(s - \text{particles}\) are identified with dark energy in the \(V - \text{space}\)), and one sort of space can transform into the other as changing of breaking modes of Higgs fields.

Because contribution of \(s - \text{matter}\) to the Einstein tensor is opposite to that of \(v - \text{matter}\) and there is no other interaction, there is only repulsion between \(s - \text{matter}\) and \(v - \text{matter}\). Thus, it is obvious that \(s - \text{objects} (v - \text{objects})\) is composed of only \(s - \text{particles}\) (only \(v - \text{particles}\)). If both sorts of matter exist in the same form (e.g., both exist as atoms) and simultaneously exist in the same region, the hypothesis will be in contradiction with given observations. But this is impossible because one of both must be identified with dark energy which cannot be observed and the other must be identified with matter in the given world. Thus the hypothesis is not in contradiction with all given experiments and astronomical observations.

Of course, in fact, only there is one sort of space and one sort of metric tensors \(g_{\mu\nu}\) describing the structure of the space. In order to emphasize the important significance of
the vacuum expectations of the Higgs fields, we define $S$–space and $V$–space. The essential difference of $S$–space and $V$–space is that the vacuum expectations of the Higgs fields in $S$–space are different from those in $V$–space. Consequently the existing forms of matter and the metric tensors in $S$–space must be different from those in $V$–space.

Because the interaction between the $s$–matter and the $v$–matter is repulsive each other, one condition of the space-time singularity theorems is violated. Consequently, there is no space-time singularity according to the present model.

We denote physical quantities in $S$–space (in $V$–space) by subscript ‘$S$’ (‘$V$’), and denote physical quantities determined by $s$–matter ($v$–matter) by subscript ‘$s$’ (‘$v$’). But it is possible that the subscripts $S$ and $V$ are not marked, if there is no confusion.

On the basis of the conjecture above the actions should be written as two forms, $I_S$ in the $S$–space and $I_V$ in the $V$–space, respectively, at the 0-temperature.

$$I_S = \int d^4x_S \sqrt{-g_S} \mathcal{L}_S = \int d^4x_V \sqrt{-g_V} \mathcal{L}_V = I_V, \quad (1)$$

$$\mathcal{L}_S = \frac{1}{16\pi G} R_S + s\mathcal{L}_{Ss} + v\mathcal{L}_{Sv} + \frac{1}{2}(v + s) V_{Ssv}, \quad (2)$$

$$\mathcal{L}_{Ss} = \mathcal{L}_{sm}(\Psi_s(x_S), g_s(x_S), g_s(x_S)_\mu) + V_s(\omega_s(x_S)) + V_0, \quad (3)$$

$$\mathcal{L}_{Sv} = \mathcal{L}_{vm}(\Psi_v(x_S), g_s(x_S), g_s(x_S)_\mu) + V_v(\omega_v(x_S)), \quad (4)$$

$$V_{Ssv} = V_{nv}((\omega_s(x_S), \omega_v(x_S))), \quad (5)$$

$$\mathcal{L}_V = \frac{1}{16\pi G} R_V + v\mathcal{L}_{Vs} + s\mathcal{L}_{Vv} + \frac{1}{2}(v + s) V_{Vsv}, \quad (6)$$

$$\mathcal{L}_{Vs} = \mathcal{L}_{sm}(\Psi_s(x_V), g_v(x_V), g_v(x_V)_\mu) + V_s(\omega_s(x_V)), \quad (7)$$

$$\mathcal{L}_{Vv} = \mathcal{L}_{vm}(\Psi_v(x_V), g_v(x_V), g_v(x_V)_\mu) + V_v(\omega_v(x_V)) + V_0, \quad (8)$$

$$V_{Vsv} = V_{nv}((\omega_s(x_V), \omega_v(x_V))), \quad (9)$$

$$\omega_s \equiv \Omega_s, \Phi_s, \chi_s; \quad \omega_v \equiv \Omega_v, \Phi_v, \chi_v, \quad (10)$$

where the meanings of the symbols are follows. $g = \det(g_{\mu\nu}), g_{\mu\nu} = \text{diag}(-1,1,1,1)$ in flat space. $g = g_S$ or $g_V$. $R_S$ and $R_V$ are respectively the scalar curvatures in $S$–space and $V$–space. $s$ and $v$ are two parameters and we finally take $s = -v = 1$. $V_0$ is a parameter which is so taken that $(V_s(\omega_s(x_S)) + V_0)_{\text{min}} = (V_v(\omega_v(x_V)) + V_0)_{\text{min}} = 0$ at the 0-temperature. $\mathcal{L}_{sm}$ ($\mathcal{L}_{vm}$) is the Lagrangian density of all $s$–fields ($v$–fields) and their couplings of the $SU(5)$ GUT except the Higgs potentials $V_s, V_v$ and $V_{sv}$. $\Psi_s$ and $\Psi_v$
represents all \(s - fields\) and all \(v - fields\), respectively. \(\mathcal{L}_s\) and \(\mathcal{L}_s\) do not contain the contribution of the gravitational and repulsive fields. It is seen from \((2) - (9)\) that provided the subscripts \(S\) and \(V\) in \((2) - (5)\) are interchanged, \((6) - (9)\) are obtained. \(\mathcal{L}_{Ss}\) and \(\mathcal{L}_{Vs}\) are different denoting modes of the same Lagrangian density in different spaces.

\[
V_s = -\frac{1}{2} \mu^2 \Omega_s^2 + \frac{1}{4} \lambda \Omega_s^4 - \frac{1}{2} \eta \Omega_s^2 T \Phi_s^2 + \frac{1}{4} a (T \Phi_s^2)^2 + \frac{1}{2} b T (\Phi_s^4) - \frac{1}{2} \xi \Omega_s^2 \chi_s^+ \chi_s + \frac{1}{4} \xi (\chi_s^+ \chi_s)^2,
\]

\[
V_v = -\frac{1}{2} \mu^2 \Omega_v^2 + \frac{1}{4} \lambda \Omega_v^4 - \frac{1}{2} \eta \Omega_v^2 T \Phi_v^2 + \frac{1}{4} a (T \Phi_v^2)^2 + \frac{1}{2} b T (\Phi_v^4) - \frac{1}{2} \xi \Omega_v^2 \chi_v^+ \chi_v + \frac{1}{4} \xi (\chi_v^+ \chi_v)^2,
\]

\[
V_{sv} = \frac{1}{2} \lambda \Omega_s^2 \Omega_v^2 + \frac{1}{2} \eta \Omega_s^2 \Omega_v^2 T \Phi_s^2 + \frac{1}{2} \beta \Omega_s^2 \chi_v^+ \chi_v + \frac{1}{2} \beta \Omega_v^2 \chi_s^+ \chi_s,
\]

where \(\Omega_s\) and \(\Omega_v\), \(\Phi_s = \sum_{i=1}^{24} \sqrt{2} \phi_i\) and \(\Phi_v, \chi_s\) and \(\chi_v\) are respectively \(\frac{1}{24}\), \(24\) and \(5\) dimensional representations of the \(SU(5)\) group, here the couplings of \(\Phi_s\) and \(\chi_s\) \((\Phi_v\) and \(\chi_v\)) are ignored for short[7].

We will see that the present model takes \(SU(5)\) \(GUT\) only as an example. In fact, the consequences of the present model is not dependent on specific model, provided a model contains such Higgs couplings as \((11) - (13)\).

From \((1)\) the energy-momentum tensor densities which do not contain the energy-momentum tensor of gravitational and repulsive fields can be defined as

\[
T_{S\mu\nu} = \frac{2}{\sqrt{g_s}} \left( \frac{\partial}{\partial s} + \frac{\partial}{\partial v} \right) \left[ \frac{\partial (\sqrt{-g_s} \mathcal{L}_s)}{\partial g_s^{\mu\nu}} - \left( \frac{\partial (\sqrt{-g_s} \mathcal{L}_s)}{\partial g_s^{\mu\nu}} \right) \right]_{\sigma} \\
\equiv T_{Ss\mu\nu} + T_{Sv\mu\nu} + T_{Ssv\mu\nu},
\]

\[
T_{Ss\mu\nu} = T_{Ssm\mu\nu} + T_{Ssv\mu\nu} = \frac{2}{\sqrt{g_s}} \left[ \frac{\partial (\sqrt{-g_s} \mathcal{L}_{sm})}{\partial g_s^{\mu\nu}} - \left( \frac{\partial (\sqrt{-g_s} \mathcal{L}_{sm})}{\partial g_s^{\mu\nu}} \right) \right]_{\sigma}
- g_s^{\mu\nu} (V_s + V_0),
\]

\[
T_{Sv\mu\nu} = T_{Svm\mu\nu} + T_{Ssv\mu\nu} = \frac{2}{\sqrt{g_s}} \left[ \frac{\partial (\sqrt{-g_s} \mathcal{L}_{vm})}{\partial g_s^{\mu\nu}} - \left( \frac{\partial (\sqrt{-g_s} \mathcal{L}_{vm})}{\partial g_s^{\mu\nu}} \right) \right]_{\sigma}
- g_s^{\mu\nu} (V_v + V_0),
\]

\[
T_{Ssv\mu\nu} = \frac{2}{\sqrt{g_s}} \left[ \frac{\partial (\sqrt{-g_s} \mathcal{L}_{sv})}{\partial g_s^{\mu\nu}} - \left( \frac{\partial (\sqrt{-g_s} \mathcal{L}_{sv})}{\partial g_s^{\mu\nu}} \right) \right]_{\sigma}
- g_s^{\mu\nu} (V_{sv} + V_{0v}),
\]
\[ T_{sv\mu\nu} = T_{svm\mu\nu} - T_{svv\mu\nu} = \frac{2}{\sqrt{-g}} \left[ \frac{\partial (\sqrt{-g} S L_{vm})}{\partial g^{\mu\nu}} - \left( \frac{\partial (\sqrt{-g} S L_{vm})}{\partial g^{\sigma\nu}_{S}} \right)_{\sigma} \right] - g_{s\mu\nu} V_v, \]

(16)

\[ T_{sv\mu\nu} = -g_{s\mu\nu} V_v \]

(17)

Interchanging the subscripts \( S \) and \( V \) and the subscripts \( s \) and \( v \) in (14) – (17), we get \( T_{V\mu\nu}, T_{Vsm\mu\nu}, T_{Vvm\mu\nu}, T_{Vsv\mu\nu}, T_{Vv\mu\nu}, T_{Vs\mu\nu}. \)

(18)

Einstein’s equation of gravitation field can be derived from (1)

\[ R_{S\mu\nu} - \frac{1}{2} g_{s\mu\nu} R_S = -8\pi G (T_{S\mu\nu} - T_{Ssv\mu\nu}), \]

(19)

\[ R_{V\mu\nu} - \frac{1}{2} g_{v\mu\nu} R_V = -8\pi G (T_{V\mu\nu} - T_{Vsv\mu\nu}). \]

(20)

It must be emphasized that the equations (19)+ (20) or \( T_{S\mu\nu} + T_{V\mu\nu} \) are all nonsensical, since \( R_{S\mu\nu} \) and \( R_{V\mu\nu} \) are respectively the curvature tensors in the two different spaces, \( T_{S\mu\nu} \) and \( T_{V\mu\nu} \) are physical quantities in the two different spaces, respectively, and both \( S - space \) and \( V - space \) cannot simultaneously exist. Only one of the equations (19) and (20) corresponds to real space and is applicable. Similarly, only one of \( I_S \) and \( I_V \) is applicable. It should be noticed from (19) – (20) and (14) – (18) that the potential energy \( V_{sv} \) is different from other energies in essence, \( V_{sv} \) does not influence \( R_{S\mu\nu} \) and \( R_{V\mu\nu} \), i.e., there is no gravitation and repulsion of the potential energy \( V_{sv} \). But this does not cause any contradiction with all given experiments and astronomical observations since \( V_{sv} = 0 \) when \( \langle \omega_s \rangle_0 = 0 \) in the \( V - space \) or \( \langle \omega_v \rangle_0 = 0 \) in the \( S - space \).

It is proven that the necessary and sufficient condition of \( T_{\mu\nu}^{\mu\nu} = 0 \) is \( I_M \) to be a scalar quantity\(^8\). Form (1) – (18) we see that \( I_S \) and \( I_V \) are all scalar quantities, hence when the energy-momentum tensors of the gravitational field and repulsive field are not considered,

\[ (T_{S\mu\nu}^{S\mu\nu} + T_{sv\mu\nu}^{sv\mu\nu})_{,\nu} = (T_{V\mu\nu}^{V\mu\nu} + T_{Vsv\mu\nu}^{Vsv\mu\nu})_{,\nu} = 0. \]

Because there is repulsive interaction between both \( s - matter \) and \( v - matter \), the motional law of \( v - matter \) must be different from the motional law of \( s - matter \) in the same gravitational fields. According to the general relativity, it is obtained from (19) the motional equation of \( s - matter \) in \( S - space \) to be

\[ \frac{d^2 x^\mu_S}{d\sigma^2} + \Gamma^\mu_{S\alpha\beta} \frac{dx^\alpha_S}{d\sigma} \frac{dx^\beta_S}{d\sigma} = 0, \]

(21)
where $\sigma$ is a scalar parameter satisfying a proper equation. In contrast with $s$–matter, the motional equation of $v$–matter in $S$–space will be

$$-\frac{d^2x^\mu_S}{d\sigma^2} + \Gamma_{S\alpha\beta}^\mu \frac{dx^\alpha_S}{d\sigma} \frac{dx^\beta_S}{d\sigma} = 0. \tag{22}$$

Analogously, we obtain the motional equation of $v$–matter in $V$–space to be

$$-\frac{d^2x^\mu_V}{d\sigma^2} + \Gamma_{V\alpha\beta}^\mu \frac{dx^\alpha_V}{d\sigma} \frac{dx^\beta_V}{d\sigma} = 0, \tag{23}$$

and the motional equation of $s$–matter in $V$–space to be

$$-\frac{d^2x^\mu_V}{d\sigma^2} + \Gamma_{V\alpha\beta}^\mu \frac{dx^\alpha_V}{d\sigma} \frac{dx^\beta_V}{d\sigma} = 0. \tag{24}$$

### III. SPONTANEOUS BREAKING OF SYMMETRY

Ignoring the couplings of $\Phi$ and $\chi$ and suitably choosing the parameters of the Higgs potential, analogously to [7] and [9] we can prove from (11) – (13) that there are the following vacuum expectation values,

$$\langle 0 | \Omega_v | 0 \rangle = \overline{\Omega}_v = \langle 0 | \Phi_v | 0 \rangle = \overline{\Phi}_v = \langle 0 | \chi_v | 0 \rangle = \overline{\chi}_v = 0, \tag{25}$$

$$\langle 0 | \Omega_s | 0 \rangle = \overline{\Omega}_s, \tag{26}$$

$$\langle 0 | \Phi_s | 0 \rangle = \overline{\Phi}_s = Diagonal \left( 1, 1, 1, -\frac{3}{2}, -\frac{3}{2} \right) \nu_{\Phi_0}. \tag{27}$$

$$\langle 0 | \chi_s | 0 \rangle^+ = \overline{\chi}_s = \frac{\nu_{\chi_0}}{\sqrt{2}}(0, 0, 0, 0, 1), \tag{28}$$

$$\nu_{\Omega_0}^2 = \frac{\mu^2}{f}, \quad f \equiv \lambda - \frac{15\eta^2}{15a + 7b} - \frac{\zeta^2}{\xi} \tag{29}$$

$$\nu_{\Phi_0}^2 = \frac{2\eta}{15a + 7b} \nu_{\Omega_0}^2, \tag{30}$$

$$\nu_{\chi_0}^2 = \frac{2\zeta}{\xi} \nu_{\Omega_0}^2. \tag{31}$$
where $\lambda > 15\eta^2/(15a + 7b) + \xi^2/\xi$. Such space in which the vacuum expectation values of the Higgs fields take the forms (25) – (31) is called $S$ – space. In $S$ – space the $S – SU(5)$ symmetry is finally broken into $SU(3) \times U(1)$, $s – particles$ can get their masses of the $SU(5) GUT$ and form the $s – world$ described $SU(5) GUT$, the $V – SU(5)$ symmetry still holds, all $v – gauge bosons$ and $v – fermions$ are massless. From (12) and (13) it can be proved that all $v – Higgs bosons$ can get their masses big enough. The masses of the Higgs particles except the $\Phi_s – particles$ and the $\chi_s – particles$ are respectively

$$m^2(\Omega_s) = 2\mu^2,$$  \hspace{1cm} (32)  

$$m^2(\Omega_v) = \Lambda v_{100}^2 - \mu^2;$$  \hspace{1cm} (33)  

$$m^2(\Phi_v) = \frac{1}{2}\alpha v_{100}^2,$$  \hspace{1cm} (34)  

$$m^2(\chi_v) = \beta v_{100}^2.$$  \hspace{1cm} (35)  

We can choose such parameters so that

$$m(\Omega_s) \simeq m(\Omega_v) \gg m(\varphi_s) \gg m(\chi_s),$$ \hspace{1cm} (36)  

e.g., $m(\Omega_s) \sim 10^{19} Gev$, $m(\varphi_s) \sim 10^{15} Gev$ and $m(\chi_s) \sim 10^2 Gev$. When radiative corrections are considered, the results above still qualitatively hold. It is easily seen from (32) – (35) that all real components of $\Phi_v$ have the same mass $m(\Phi_v)$, all real components of $\chi_v$ have the same mass $m(\chi_v)$ in $S – space$.

Because $s – matter$ and $v – matter$ are symmetric, $S – space$ and $V – space$ are symmetric as well, when the subscripts $s$ and $v$ in formulas (25) – (35) are interchanged and the subscripts $S$ and $V$ in (25) – (35) are interchanged as well, i.e., $s \rightleftharpoons v$ and $S \rightleftharpoons V$, the formulas still hold water. Such space in which the vacuum expectation values of the Higgs fields take the forms (25) – (31) in which the subscripts $s$ and $v$ are interchanged is called $V – space$.

It is seen from the above mentioned that properties of space are determined by breaking mode of the Higgs fields. Because breaking mode of the Higgs fields, i.e., expectation values of the Higgs fields, can vary with temperature, the properties of space will vary with
temperature as well. We will see that when temperature $T \rightarrow T_{\text{max}}$, $S$-space can transform into $V$-space, consequently $s$-world can transform into $v$-world, and vice versa.

When the Higgs potentials do not considered, we have that the energy density of the vacuum state $E_0 = 0^{[6]}$. Considering the potential energy densities $V_S (\varpi_s, \varpi_v)$ in $S$-space to be,

$$V_S (\varpi_s, \varpi_v) = V_s (\varpi_s) + V_v (\varpi_v) + V_{sv} (\varpi_s, \varpi_v).$$  \(37\)

Taking $V_0 = -V_{s \min}$ at the 0-temperature, considering $V_{v \min} = V_{sv \min} = 0$, we get energy densities of the vacuum state $E_{S0}$ in $S$-space at the 0-temperature to be

$$E_{S0} = E_0 + V_{S \min} = E_0 + (V_s + V_v + V_{sv})_{\min} + V_0 = 0, \ \ (38)$$

Similarly, we have

$$E_{V0} = E_0 + V_{V \min} = E_0 + (V_s + V_v + V_{sv})_{\min} + V_0 = 0. \ \ (39)$$

IV. EVOLUTION OF SPACE

A. Evolving equations

Provided the cosmological principle holds, the metric tensor is the Robertson-Walker metric which can be written

$$(ds)^2 = -(dt)^2 + R^2(t) \left\{ \frac{(dr)^2}{1 - kr^2} + (rd\theta)^2 + (r \sin \theta d\varphi)^2 \right\}, \ \ (40)$$

where $k$ is a real constant describing curve of space.

Matter in the universe may approximately be regarded as ideal gas to evenly distribute in whole space. The energy-momentum tensor densities of the ideal gas are

$$T_{A s \mu \nu} = (\rho_{As} + p_{As}) U_{As \mu} U_{As \nu} + p_{As} g_{A \mu \nu}, \ \ (41)$$

$$T_{A v \mu \nu} = (\rho_{Av} + p_{Av}) U_{Av \mu} U_{Av \nu} + p_{Av} g_{A \mu \nu}, \ \ (42)$$

where $A = S, V$, $\rho_A$ and $p_A$ are the density and pressure of a medium, respectively, and $U_{A \mu}$ is a 4-velocity. Considering the potential energy densities in (15) – (16) and (18), we can rewrite (41) – (42) as

$$T_{S s \mu \nu} = [\tilde{\rho}_{Ss} + \tilde{p}_{Ss}] U_{S \mu} U_{S \nu} + \tilde{p}_{Ss} g_{S \mu \nu}, \ \ (43)$$
\[ \tilde{\rho}_{Ss} = \rho_{Ss} + (V_s(\varpi_s) + V_0), \quad \tilde{p}_{Ss} = p_{Ss} - (V_s(\varpi_s) + V_0), \quad (44) \]

\[ T_{S\mu\nu} = [\tilde{\rho}_{Ss} + \tilde{p}_{Ss}] U_{S\mu} U_{S\nu} + \tilde{p}_{Ss} g_{S\mu\nu}, \quad (45) \]

\[ \tilde{\rho}_{Sv} = \rho_{Sv} + V_v(\varpi_v), \quad \tilde{p}_{Sv} = p_{Sv} - V_v(\varpi_v), \quad (46) \]

\[ T_{V\mu\nu} = [\tilde{\rho}_{Vv} + \tilde{p}_{Vv}] U_{V\mu} U_{V\nu} + \tilde{p}_{Vv} g_{V\mu\nu}, \quad (47) \]

\[ \tilde{\rho}_{Vv} = \rho_{Vv} + (V_v(\varpi_v) + V_0), \quad \tilde{p}_{Vv} = p_{Vv} - (V_v(\varpi_v) + V_0), \quad (50) \]

where \( \rho_{Aa} \) and \( p_{Aa} \) (\( a = s, v \)) are respectively the motional mass and the momentum current densities corresponding to \( \mathcal{L}_{sm} \) and \( \mathcal{L}_{vm} \) in (15), (16) and (18). The difference between \( \rho_{Ss} \) and \( \rho_{Vv} \) is that \( \rho_{Ss} \) is given common matter density in \( S - space \) and \( \rho_{Vv} \) is the dark energy density in \( V - space \).

Substituting (43) – (46) and the Robertson-Walker metric into (19) and considering \( U_{S\mu} = (1, 0, 0, 0) \) which implies that a medium move only as expanding of the universe, we get the generalized Freedman equations

\[ \frac{\ddot{R}_S(t_S)}{R_S^2(t_S)} + \frac{k_S}{R_S^2(t_S)} = \eta [\tilde{\rho}_s - \tilde{p}_v] = \eta [(\rho_s + V_s(\varpi_s) + V_0) - (\rho_v + V_v(\varpi_v))], \quad (51) \]

where \( \eta \equiv 8\pi G/3, \)

\[ \frac{\dddot{R}_S(t_S)}{R_S(t_S)} = -\frac{1}{2} \eta [(\tilde{\rho}_s + 3\tilde{p}_s) - (\tilde{p}_v + 3\tilde{p}_v)] = -\frac{1}{2} \eta [(\rho_s + 3p_s) - 2 (V_s(\varpi_s) + V_0) - (\rho_v + 3p_v) + 2V_v(\varpi_v)]. \quad (52) \]

Analogously, from (46) – (49), (40) and (20), we get

\[ \frac{\ddot{R}_V(t_v)}{R_V^2(t_v)} + \frac{k_V}{R_V^2(t_v)} = \eta [\tilde{\rho}_v - \tilde{p}_s] = \eta [(\rho_v + V_v(\varpi_v) + V_0 - \rho_s - V_s(\varpi_s))], \quad (53) \]
\[
\frac{\ddot{R}_V(t_V)}{R_V(t_V)} = -\frac{1}{2} \eta [\tilde{\rho}_v + 3\tilde{\rho}_v - (\tilde{\rho}_s + 3\tilde{\rho}_s)] \\
= -\frac{1}{2} \eta [(\rho_v + 3p_v) - 2(V_v(\overline{\omega}_v) + V_0) - (\rho_s + 3p_s) + 2V_s(\overline{\omega}_s)].
\] (54)

Because of the coupling term \( V_{sv} \), the expectation values of the Higgs fields can only take the following forms. \( \langle \omega_s \rangle \neq 0 \) and \( \langle \omega_v \rangle = 0 \) or \( \langle \omega_s \rangle = 0 \) and \( \langle \omega_v \rangle \neq 0 \) when temperature is low. Hence space is only \( S - space \) in which only (51) – (52) applies, or only \( V - space \) in which only (53) – (54) applies. It is possible that \( \langle \omega_s \rangle = \langle \omega_v \rangle = 0 \) when temperature is high enough \( (T \sim T_{\text{max}}) \). Such space in which \( \langle \omega_s \rangle = \langle \omega_v \rangle = 0 \) is called transiting space. In the case, \( s - matter \) and \( v - matter \) is completely symmetric, and both (51) – (52) and (53) – (54) can describe evolution of transiting space, i.e., transiting space can transform into \( S - space \) or \( V - space \). This is because a physical quantity or an equation has its meanings only when it is relative to a definite physics vacuum.

For example, let a state be the vacuum of \( S - space \), i.e., \( \rho_a = p_a = V_v(\overline{\omega}_v) = 0 \), and \( V_s(\overline{\omega}_s) = -\mu^2/4f \). Substituting the parameters into (51) – (52) and taking \( k_s = 0 \), we get
\[
\ddot{R}_S(t_s) = \dot{R}_S(t_s) = 0, \quad R_S(t_s) = R_S(0),
\]
i.e., \( S - space \) is invariant. Oppositely, if substituting the parameters into (53) – (54) and taking \( k_V = 0 \), we get
\[
\frac{\ddot{R}_V(t_V)}{R_V(t_V)} = \eta V_0, \quad \frac{R^2_V(t_V)}{R^2_V(0)} = \eta V_0, \quad R_V(t_V) = R_V(0) \exp t_V\sqrt{\eta V_0} \text{ or } 0.
\]
This result is obviously difficult to understand it. Appearance of the result is because the state above is not the ground state of \( V - space \). There are similar examples in physics. For example, for Higgs field with single constituent, if the state were regarded as the ground state in which \( \langle \varphi \rangle = 0 \) \( (V(0) = V_{\text{max}}(\varphi)) \), the ‘mass’ of \( \varphi - particle \) would be a virtual and thereby \( \varphi - particle \) would move in a greater velocity than photon velocity. Of course, this is not right.

Because of the coupling term (13), the direct transformation, \( \langle \omega_s \rangle \neq 0 \) and \( \langle \omega_v \rangle = 0 \rightarrow \langle \omega_s \rangle = 0 \) and \( \langle \omega_v \rangle \neq 0 \), is impossible, i.e., \( S - space \) cannot directly transform into \( V - space \). But the transformation
\[
\langle \omega_s \rangle \neq 0, \quad \langle \omega_v \rangle = 0 \rightarrow \langle \omega_s \rangle = \langle \omega_v \rangle = 0 \rightarrow \langle \omega_s \rangle = 0, \quad \langle \omega_v \rangle \neq 0 \quad (55)
\]
is possible, i.e., $S$–space can transform into $V$–space via transiting space as temperature rises to the highest temperature (see the following).

Considering (38), $\tilde{\rho}_a = \rho_a$, $\tilde{p}_a = p_a$, $a = s, v$, from (51) – (52) we obtain

$$d \left[ (\rho_s - \rho_v) R_S^3 \right] = - (p_s - p_v) dR_S^3. \quad (56)$$

When temperature is low so that the pressures $p_s$ and $p_v$ may be ignored. Thus (56) become

$$(\rho_s - \rho_v) R_S^3 = C_S, \quad (57)$$
in $S$–space, here $C_S$ is a constant. In contrast to the conventional theory, it is possible $C_S > 0$, $C_S = 0$ or $C_S < 0$. Analogously, we have

$$(\rho_v - \rho_s) R_V^3 = C_V, \quad (58)$$
in $V$–space.

For photon-like gases in heat balance, $p_a = \rho_a/3$, we have

$$(\rho_s - \rho_v) R_S^4 = C'_S, \quad (59)$$
in $S$–space, and

$$(\rho_v - \rho_s) R_V^4 = C'_V, \quad (60)$$
in $V$–space.

When the approximations (57) and (58) are taken, i.e., temperature is low, the equations (51) – (54) become

$$\dot{R}_S(t_S) = -k_S + \eta (\rho_s - \rho_v) R_S^2, \quad (61)$$
$$\ddot{R}_S(t_S) = -\frac{\eta}{2} (\rho_s - \rho_v) R_S, \quad (62)$$
$$\ddot{R}_V(t_V) = -k_V + \eta (\rho_v - \rho_s) R_V^2, \quad (63)$$
$$\ddot{R}_V(t_V) = -\frac{\eta}{2} (\rho_v - \rho_s) R_V. \quad (64)$$

B. Two sorts of temperature

Because there is no interaction except the repulsion between $s$–matter and $v$–matter and the masses of the Higgs-particles are all big enough at low temperature, the Higgs
bosons are hardly produced. Consequently there is no thermal equilibrium between the \( v - particles \) and the \( s - particles \). Thus at low temperature, we should use two sorts of temperature \( T_v \) and \( T_s \) respectively to describe the thermal equilibrium of \( v - matter \) and the thermal equilibrium of \( s - matter \). In general case, \( T_v \neq T_s \). When temperature \( T_s \) is so high that \( \langle \Omega_s \rangle \rightarrow 0 \) in \( S - space \), the masses of Higgs bosons tend to zero. On the other hand, because \( \langle \Omega_v \rangle = 0 \) in \( s - space \), \( m(\Omega_v), m(\Phi_v) \) and \( m(\chi_v) \) tend to zero as \( \langle \Omega_s \rangle \) tends to zero as well. Consequently \( \Omega_s, \Phi_s \) and \( \chi_s \) can be enormously produced and easily transform into \( \Omega_v, \Phi_v \) and \( \chi_v \) by the couplings in (13). Other \( v - particles \) can be easily produced by the couplings of \( V - SU(5) \) as well. Consequently there is thermal equilibrium between the \( v - particles \) and the \( s - particles \) when \( T_s \sim T_v \sim T_{\text{max}} \). In the case, contraction of space will stop and inflating must occur. Thus the temperature \( T > T_{\text{max}} \) cannot appear in fact.

C. Temperature effect

The influences of finite temperature on the Higgs potential in the present model are consistent with the conventional theory. For

\[
V(\Omega_s) = -\frac{\mu^2}{2} \Omega_s^2 + \frac{\lambda}{4} \Omega_s^4,
\]

to ignore the terms proportional \( \lambda^n, n > 1 \), the effective potential approximate to 1-loop at finite temperature and in flat space is \(^9\)

\[
V^{(1)}_{\text{eff}}(\Omega_s, T_s) = -\left(\frac{\mu^2}{2} - \frac{\lambda T_s^2}{8}\right) \Omega_s^2 + \frac{\lambda}{4} \Omega_s^4 - \frac{\pi^2}{90} T_s^4 + \frac{\mu^2}{24} T_s^2,
\]

(65)

It is seen from the term \( \lambda T_s^2 \Omega_s^2 / 8 \) that the expectation value \( \Omega_s \) can be strikingly altered at high temperature. When \( T_s > \sqrt{4\mu^2/\lambda}, \Omega_s = 0 \). For

\[
V(\Phi_s) = -\frac{1}{2} \kappa \Omega_s^2 Tr\Phi_s^2 + \frac{1}{4} a(Tr\Phi_s^2)^2 + \frac{1}{2} b Tr\Phi_s^4,
\]

going ignoring the contributions of Higgs fields and fermion fields with one loop correction and only considering the contribution of the gauge fields with loop correction, when \( \varphi_s \ll kT, k \) is the Boltzmann constant, the effective potential approximate to 1-loop at finite temperature and in flat space is \(^10\)

\[
V^{(1)}_{\text{eff}}(\Phi_s, T_s) = V(\Phi_s) + B\varphi_s^4 \left( \ln \frac{\varphi_s^2}{\sigma^2} - \frac{25}{6} \right) + \frac{75}{16} (kgT)^2 \varphi_s^2 - \frac{\pi^2}{15} (kT)^4,
\]

(66)
where $B = (5625/1024\pi^2)g^4$, $\sigma = \langle \varphi_s \rangle \sim 10^{15}\text{Gev.}$

Taking the place of the subscript $s$ by $v$ in (65) and (66), we get $V^{(1)}_{\text{eff}}(\overline{\varphi}_v, T_v)$ and $V^{(1)}_{\text{eff}}(\overline{\Phi}_v, T_v)$. The effective potential approximate to 1-loop at finite temperature and in flat space can be written as

$$V^{(1)}_{\text{eff}}(\overline{\varphi}_s, T_s, \overline{\varphi}_v, T_v) = (V^{(1)}_{\text{eff}}(\overline{\varphi}_s, T_s) + V_0) + V^{(1)}_{\text{eff}}(\overline{\varphi}_v, T_v) + V_{sv}(\overline{\varphi}_s, \overline{\varphi}_v). \quad (67)$$

For short, we only consider influence of temperature on $\Omega_s$ and $\Omega_v$ and ignore the couplings of $\Omega_s$ and $\Omega_v$ with other fields. Considering $V^{(1)}_{\text{Seff}}$ in $S-space$ and $\Lambda > \lambda$, ignoring the terms irrelative to $\Omega_s$ and $\Omega_v$, we have

$$V^{(1)}_{\text{Seff}}(\overline{\Phi}_s, T_s, \overline{\Phi}_v, T_v) = \left[ -\frac{1}{2} (\mu^2 - \lambda T_s^2/4) \overline{\Omega}_s^2 + \frac{1}{4} \lambda \overline{\Omega}_s^4 + V_0 \right]$$

$$+ \left[ -\frac{1}{2} (\mu^2 - \lambda T_v^2/4) \overline{\Omega}_v^2 + \frac{1}{4} \lambda \overline{\Omega}_v^4 \right] + \frac{1}{2} \Lambda \overline{\Omega}_s^2 \overline{\Omega}_v^2. \quad (68)$$

From (66) and (68) we see the absolute values of the expectation values of the Higgs fields will decrease as the temperature $T_s$ rises, consequently $V^{(1)}_{\text{eff}}(\overline{\varphi}_s, T_s, \overline{\varphi}_v, T_v)$ must increase. From (68) we get when $\mu^2 - \lambda T_s^2/4 \geq 0$

$$m^2(\Omega_s, T_s) = 2 \left( \mu^2 - \frac{1}{4} \lambda T_s^2 \right) \geq 0, \quad (69)$$

and when

$$\frac{\Lambda}{\lambda} \left( \mu^2 - \frac{1}{4} \lambda T_s^2 \right) - \left( \mu^2 - \frac{\lambda}{4} T_v^2 \right) \geq 0,$$

$$m^2(\Omega_v, T_s, T_v) = \frac{\Lambda}{\lambda} \left( \mu^2 - \frac{1}{4} \lambda T_s^2 \right) - \left( \mu^2 - \frac{\lambda}{4} T_v^2 \right) \geq 0, \quad (70)$$

$$\overline{\Omega}_s^2(T_s) = (\mu^2 - \lambda T_s^2/4) / \lambda, \quad \overline{\Omega}_v(T_v) = 0. \quad (71)$$

Because $\Lambda > \lambda$, when $T_s \sim T_v \sim 0$, $m^2(\Omega_v, T_s, T_v) > 0$. As $T_s$ and $T_v$ rise, $m^2(\Omega_s, T_s)$ and $m^2(\Omega_v, T_s, T_v)$ will decrease. From (68)-(70) we see it is necessary that when $\mu^2 - \lambda T_s^2/4 \rightarrow 0$, $m(\Omega_v) \sim m(\Omega_s) \rightarrow 0$. In the case, $s-Higgs$ particles can easily transform into $v-Higgs$ particles by the coupling (13) so that the thermal equilibrium between $s-matter$ and $v-matter$ will come into being, $T_v \sim T_s$ and $\rho_s \simeq \rho_v$. Thus contraction of $s-space$ must stop and inflation of $v-space$ will occur (see following).

In fact, when the energy density $\rho_s - \rho_v$ is large and $T_v < T_s \lesssim T_{\text{max}}$, it is possible that $S-space$ can contract so swiftly that the temperature rises to $T_{\text{max}}$ before the potential
reduces to

\[
V_{veff_{\min}}^{(1)}(\varpi_s, \varpi_v, T_{\text{max}}) = V_{seff_{\min}}^{(1)}(\varpi_s, T_{\text{max}}) + (V_0 + V_{veff_{\min}}^{(1)}(\varpi_v, T_v)) + V_{veff_{\min}}^{(1)}(\varpi_s, \varpi_v)
\]

\[
= V_0 + V_{veff_{\min}}^{(1)}(\varpi_v, T_v) > 0,
\]

here \(V_{veff_{\min}}^{(1)}\) is the potential energy corresponding to \((\Lambda/\lambda)(\mu^2 - \frac{1}{4} \lambda T_s^2) - (\mu^2 - T_v^2/4) < 0\). In this case, we have still \(\langle \omega_s \rangle = \langle \omega_v \rangle = 0, m(\omega_s) = m(\omega_s) = 0\), s – Higgs particles and \(v – Higgs\) particles can transform from one to other, consequently the thermal equilibrium can come into being by the couplings in (13), i.e., \(T_s = T_v\) and \(\rho_s = \rho_v\). Thus the inflation of the universe still occurs. The state with \(V_{S_{\min}}(\varpi_s, \varpi_v, T_s, T_v)\) is a steady state at \(T_s\). The process is called \textbf{super-heating process} in which the temperature of a system rises to \(T\) before the potential energy \(V(T)\) decrease to corresponding \(V_{\min}(T)\). The contracting process is a \textbf{super-heating process}.

Considering \(\Phi_s, \chi_s, \Phi_v, \chi_v\), the conclusions above still hold water.

D. Contraction of space, the highest temperature and transiting space

1. Contraction of space and the highest temperature

In contrast with the conventional cosmological model, the present model can explain the “big bang” of the universe, but there is no singularity.

In \(S – space\), \(V – SU(5)\) does not break so that all \(v – gauge\) bosons and \(v – fermions\) are massless and they form \(V – SU(5)\) colour single states with their masses in low temperature, and \(S – SU(5)\) breaks into \(S – SU(3) \times U(1)\) so that \(s – particles\) gets their masses and can form \(s – galaxies\). In \(S – space\), let \(\tilde{\rho}_s - \tilde{\rho}_v > 0, (\tilde{\rho}_s + 3\tilde{\rho}_s) - (\tilde{\rho}_v + 3\tilde{\rho}_v) > 0\) and \(k = 1\). From (51)-(52) or (61)-(62) we see that \(S – space\) will contract, consequently temperature \(T_s\) will rise, and \(V_s\) can increase as \(T_s\) rises since the expectation values of the \(S – Higgs fields\) can vary with \(T_s\).

From (69)-(70) we see when \(\lambda T_s^2/4 \sim \mu^2, m(\Omega_s) \sim m(\Omega_v) \sim 0\). In the case, the masses of \(\Omega_s, \varphi_s\) and \(\chi_s\) tend to zero, hence the \(s – fermions\) and the \(s – gauge\) bosons can easily transform into \(\chi_s, \varphi_s\) and \(\Omega_s\), and \(\Omega_s, \varphi_s\) and \(\chi_s\) can easily transform into \(\Omega_v, \varphi_v\) and \(\chi_v\) by the couplings in (13). As a consequence, we have

\[
T_s \sim T_v, \quad \rho_s \sim \rho_v.
\]

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In the case, \( p_s = \rho_s/3 \) and \( p_v = \rho_v/3 \), considering \( k = 1 \) for contracting \( S \)-space, from (51) – (52) we get

\[
\begin{align*}
\ddot{R}_S(t_S) &= -1 + \eta V_0 R_S^2(t_S), \\
\dot{R}_S(t_S) &= -\sqrt{-1 + \eta V_0 R_S^2(t_S)}, \\
\dddot{R}_S(t_S) &= \eta V_0 R_S(t_S) > 0.
\end{align*}
\] (73)

It is seen that in the case, \( S \)-space will contract with a deceleration and when

\[
R_S(t_S) \equiv R_S(t_{SF}) \equiv R_{\text{min}} = \sqrt{1/\eta V_0}, \\
\dot{R}_S(t_{SF}) = 0.
\] (74)

Consequently \( R_S(t_{SF}) \equiv R_{\text{min}} \) cannot continue to reduce, \( t_{SF} \) is the last moment of the \( S \)-world and the initial moment of the \( V \)-world, and \( T_s(t_{SF}) \) and \( \rho_s = \rho_v = \rho_{\text{max}} \) cannot continue to increase. The temperature \( T_s(t_{SL}) \equiv T_{\text{max}} \) corresponding to \( R_{\text{min}} \) is the highest temperature, \( \rho_{\text{max}} \) is the largest density and \( R_{\text{min}} \) is the minimum scale. Consequently, we see that according to the present model, there are the \( R_{\text{min}}, T_{\text{max}} \) and \( \rho_{\text{max}} \), and considering the case described by (72) – (73), there is no singularity in any case.

Considering \( \lambda \sim g^4, g \sim 4\pi/45 \) for \( SU(5) \) and \( m(\Omega_s) = \sqrt{2} \mu \), from (69) we see that \( T_{\text{max}} \) can be estimated,

\[
T_{\text{max}} \sim \frac{2\mu}{\sqrt{\lambda}} \sim \frac{2\mu}{g^2} \sim \frac{\sqrt{2}m(\Omega_s)}{4\pi/45} = 5m(\Omega_s).
\] (75)

As is well known, there is the singular point in the universe according to the conventional cosmological theory. This is because there is only one sort of matter and only one sort of space in the conventional cosmological theory. To consider the effective vacuum energy density \( \rho_{\text{vac}} \), the evolving equations of the universe are

\[
\frac{\ddot{R}}{R^2} + \frac{k}{R^2} = \frac{8\pi G}{3}(\rho + \rho_{\text{vac}}),
\]

\[
\frac{\ddot{R}}{R} = -\frac{8\pi G}{3}(\rho - \rho_{\text{vac}}).
\]

Because \( \rho_{\text{vac}} \) is a constant, we see that provided \( \rho \) is large enough, there must be singular point in the universe. Of course, in fact, the cosmological theory assumes now \( \rho(t_0) - \rho_{\text{vac}} < 0 \) and thereby explains expansion of the universe with an acceleration. But expansion of the universe must begin from a singular point.

In contrast with the conventional expansive model, there are the two sorts of matter and the two sorts of space. One condition of the space-time singularity theorems is violated,
consequently there is no the space-time singularity. As is mentioned above, no matter how large $\rho_s$ or $\rho_v$ is, when $T_s$ or $T_v \sim T_{\text{max}}$, the universe can no longer contract, and inflation must occur. Hence there is no singular point and there is the highest temperature $T_{\text{max}}$ in the universe.

2. Transiting space and selection of $k$

When $T_s \sim T_v \sim T_{\text{max}}$, $\varpi_s = \varpi_v = 0$ and $\rho_s \sim \rho_v \sim \rho_{\text{max}}$. In the case, $s - \text{matter}$ and $v - \text{matter}$ is completely symmetric and space cannot be regarded as $S - \text{space}$ neither $V - \text{space}$. space in the state may be called transiting space ($T - \text{space}$). $T - \text{space}$ is not stable and will continue to evolve as $V - \text{space}$ or $S - \text{space}$. $R_S \equiv R_{\text{min}}$ implies the $S - \text{world}$ have ended and a new world will begin. $k = 1$ for the contracting $S - \text{space}$. It is not necessary $k = 1$ for the new world and new space. We take $k = -1$. In fact, $k = 1, 0,$ or $-1$ is not important for $T - \text{space}$.

E. Inflating of space

From (73) – (74) we see that when $R_S \equiv R_{\text{min}}$, space begin to expand. Let transiting space transforms into $V - \text{space}$. From (53) – (54) we get the evolving equations of $V - \text{space}$ in the case,

$$\ddot{R}_V (t_V) = 1 + \eta V_0 R_v^2 (t_V), \quad \dot{R}_V (t_V) = \sqrt{1 + \eta V_0 R_v^2 (t_V)} \quad (76)$$

$$\dddot{R}_V (t_V) = \eta V_0 R_V (t_V). \quad (77)$$

(76) – (77) show that $V - \text{space}$ expands with an acceleration. Ignoring 1, from (76) – (77) we have

$$\dddot{R}_V (t_V) / R_V (t_V) = \sqrt{\eta V_0}, \quad R_V (t_V)$$

$$= R_V (t_{V1}) \exp \sqrt{\eta V_0} (t_V - t_{V1}) = R_V (0) \exp H t_V = R_V (0) \exp a T_{\text{max}}^2 t_V, \quad (78)$$

where $H \equiv \sqrt{\eta V_0} = a T_{\text{max}}^2$ is the Hubble constant at $t_{V1}, a \equiv \sqrt{\eta (\lambda / 8 \sqrt{J})}$.

The temperature will strikingly decrease in the process of inflation. But the potential energy $V (\varpi_s \sim \varpi_v \sim 0)$ cannot decrease to $V_{\text{min}} (\varpi_s, \varpi_v, T_v)$ at once. This is a super-
cooling process. From (78) we can get the expectant results by suitably choosing the parameters in (78).

From (78) we can get the expectant results by suitably choosing the parameters in (78). For example, taking \( \lambda/8\sqrt{f} \sim 1 \), considering \( \langle \omega_s \rangle = \langle \omega_v \rangle = 0 \) and consequently the \( SU(5) \) symmetry strictly holds water at \( T_{\text{max}} \), we can take \( T_{\text{max}} \) to be the temperature corresponding to \( GUT \), i.e., \( T_{\text{max}} \sim m(\Omega_s) \sim 10^{15}\text{Gev} \). Thus we can get the same result as the given inflation model. If the existing time of the super-cooling state (i.e., the sub-steady state with \( V (\varpi_s \sim \varpi_v \sim 0) \sim V_0 \)) is \( 10^{-33} \text{s} \) and to take \( T_{\text{max}} \sim 10^{15}\text{Gev}, \ H^{-1} \sim 10^{-35}\text{s} \), \( R_S (0) \) will increase \( \exp 100 \sim 10^{43} \) times. The result is consistent with the Guth’s inflation model\(^\text{[11]}\).

F. The phase transition of the vacuum and the reheating process

After inflation, the temperature must strikingly descend, consequently the phase transition of the vacuum must occur. In \( T - \text{space} \), \( S - SU(5) \) and \( V - SU(5) \) symmetry strictly hold water and \( s - \text{matter} \) and \( v - \text{matter} \) are strictly symmetric. Transiting space can transform into either \( S - \text{space} \) or \( V - \text{space} \) by the phase transition of the vacuum. Let transiting space transform into \( V - \text{space} \) and \( k = -1 \) for \( V - \text{space} \). Thus the phase transition of the vacuum is follows,

\[
\varpi_v(T_{\text{max}}) = 0 \rightarrow \varpi_v(T_v \sim 0) = \varpi_{v0}, \quad \varpi_s(T_{\text{max}}) = 0 \rightarrow \varpi_s(T_s \sim 0) = 0, \\
V_v(\varpi_v = 0) + V_0 = V_0 \rightarrow V_v(\varpi_v = \varpi_{v0}) + V_0 = 0, \quad V_s(\varpi_s = 0) \rightarrow V_s(\varpi_s = 0) = 0.
\]

(79)

After the transition, \( V_v(\varpi_v = 0) - V_v(\varpi_v = \varpi_{v0}) = V_0 \) must directly transform into the energy of \( v - Higgs \) particles. \( V - Higgs \) particles can fast decay into \( v - \text{gauge} \) bosons and \( v - \text{fermions} \) by \( V - SU(5) \) couplings. On the other hand, because of \( m(\Omega_v) \sim m(\Omega_s) \gg m(\varphi_s) \gg m(\chi_s) \) and the couplings in (13), \( v - Higgs \) particles can transform into \( \Omega_s, \varphi_s \) and \( \chi_s \) as well. \( \Omega_s, \varphi_s \) and \( \chi_s \) will fast decay into \( s - \text{gauge} \) bosons and \( s - \text{fermions} \). Let \( \alpha V_0 \) transforms the \( v - \text{energy} \), then \( (1 - \alpha)V_0 \) transforms the \( s - \text{energy} \) and it is necessary \( \alpha > (1 - \alpha) \). Let before the transition, \( \rho'_v = \rho'_s \). Thus after inflation, it is necessary that

\[
\rho_v = \rho'_v + \alpha V_0 > \rho_s = \rho'_s + (1 - \alpha)V_0, .
\]

(80)

This is the reheating process. After the reheating process, the temperatures \( T_s \) and \( T_v \) rise higher, \( v - \text{particles} \) get their masses and form \( v - \text{atom} \) and \( v - \text{galaxies} \), but \( s - \text{gauge} \)
bosons and elementary \( s - fermions \) are still massless since \( S - SU(5) \) is not broken. The \( s - particles \) will form \( S - SU(5) \) colour single states analogous to the \( SU(3) \) glue-balls whose masses are not zero in low temperature.

After the phasic transition, \( v - particles \) form the \( v - world \), \( S - SU(5) \) colour single states are identified as dark energy in \( v - world \). After the reheating process, considering \( k = -1 \), in international unit (53) - (54) become

\[
\frac{R_v^2}{R_0^2} = c^2 + \eta [\rho_{\text{vm}} - \rho_{\text{sm}} + \rho_{\nu \gamma}] R_v^2 (t_v), \quad \text{or}
\]
\[
\ddot{a} = \frac{c^2}{R_0^2} \left[ 1 - \frac{H_0^2 R_0^2}{c^2} \left( \frac{\Omega_{\text{m}0}}{a} - \frac{\Omega_{\nu \gamma 0}}{a^2} \right) \right],
\]
\[
\ddot{R}_v (t_v) = -\frac{1}{2} \eta (\rho_{\text{vm}} - \rho_{\text{sm}} + 2 \rho_{\nu \gamma}), \quad \text{or} \quad \ddot{a} = \frac{1}{2} H_0^2 \left( \frac{\Omega_{\text{m}0}}{a^2} - 2 \frac{\Omega_{\nu \gamma 0}}{a^3} \right).
\]

where \( a = R (t) / R_0, \quad \dot{a} = H_0^2 = \eta \rho_c, \quad \Omega_{\text{m}0} = - (\rho_{\text{vm}0} - \rho_{\text{sm}0}) / \rho_c, \quad \Omega_{\nu \gamma 0} = \rho_{\nu \gamma 0} / \rho_c \), and we consider \( \rho_{\nu \gamma} = 0 \) in \( V - space \) and ignore \( p_{\text{vm}0} \) and \( p_{\text{sm}0} \). From (81) we have \( H_0^2 R_0^2 / c^2 = 1 / (\Omega_{\text{m}0} - \Omega_{\nu \gamma 0}) = 1 / (1 + \Omega_0) \), \( \Omega_0 = \Omega_{\text{m}0} - \Omega_{\nu \gamma 0} \). Thus (81) become

\[
\ddot{a} = H_0^2 (1 + \Omega_0) \left[ 1 - \frac{1}{(1 + \Omega_0)} \left( \frac{\Omega_{\text{m}0}}{a} - \frac{\Omega_{\nu \gamma 0}}{a^2} \right) \right].
\]

Because of (80), \( V - space \) will expand with a deceleration in the initial period.

G. Expansion of space

1. To determine \( a(t) \)

From (83) we have

\[
t = t_0 - \frac{1}{H_0 \sqrt{1 + \Omega_0}} \left\{ \sqrt{1 - M + \Gamma} - \sqrt{a^2 - Ma + \Gamma} + \frac{M}{2} \ln \frac{2 - M + 2 \sqrt{1 - M + \Gamma}}{2a - M + 2 \sqrt{a^2 - Ma + \Gamma}} \right\},
\]

where \( M = \Omega_{\text{m}0} / (1 + \Omega_0) \), \( \Gamma = \Omega_{\nu \gamma 0} / (1 + \Omega_0) \).

As mentioned above, we suppose that \( T - space \) transforms \( V - space \), i.e., \( \langle \omega_v \rangle = 0 \longrightarrow \omega_{v0} \neq 0 \) and \( \langle \omega_s \rangle = 0 \longrightarrow 0 \). Hence the Higgs potential energy \( V_0 \) must first transform into \( \rho_\nu' = \alpha V_0 \). On the other hand, because \( m(\omega_v) \sim 0 \) and \( m(\omega_s) \sim 0 \) when \( T_v \sim T_s \sim T_{\text{max}} \), \( v - Higgs \) particles \( \omega_v \) can transform into \( s - Higgs \) particles \( \omega_s \) by the coupling (13), i.e., a part of \( V_0 \) finally transform into \( s - Higgs \) particles \( \omega_s \). Let \( \rho_\nu' \sim (1 - \alpha) V_0 \equiv \beta V \). It is necessary \( \alpha > \beta \).
V - matter can exist in many forms, e.g., v - visible matter and v - dark matter, v - particles with their large masses and v - particles without mass or very small mass (e.g., neutrino). It is possible there are some v - dark particles without mass or with very small mass. Here ρ_vγ contains all (visible and dark) v - particles whose masses are zero or very small. Because we cannot completely understand dark matter now, we cannot determine ρ_vγ. In contrast with v - matter, s - matter exists in only one form, i.e., SU(5) colour single states whose masses are not zero. Consequently, although ρ_v = ρ_vm + ρ_vγ > ρ_s = ρ_sm, it is possible ρ_sm > ρ_vm and ρ_sm > ρ_s when R is big enough.

Taking Ω_vγ0 = 0.001, Ω_m0 = 0.3Ω_vγ0 + 2√Ω_vγ0, H_0^{-1} = 9.7776 × 10^9 h^{-1} yr \[12\] and h = 0.8, we get the a(t) which showed by the curve B in the figure 1 and describes evolution of the cosmos from 14 × 10^9 yr ago to now; Taking Ω_vγ0 = 0.05, Ω_m0 = 2√Ω_vγ0 we get the a(t) which showed by the curve A in the figure 1 and describes evolution of the cosmos from 13.7 × 10^9 yr ago to now. Provided Ω_m0 < 2Ω_vγ0 + 2√Ω_vγ0 (the condition a^2 > 0), we can get a curve of a(t) which describes evolution of the cosmological scale.

From the two curves we see that the cosmos must undergo a period in which the cosmos expands with a deceleration and the present period in which the cosmos expands with a acceleration.

Ignoring Ω_vγ0, Ω_m0 → −Ω_m0 and taking a ~ 0, we can reduce (84) to the corresponding formula\[12\].

2. The relation between redshift and optical distance

Considering k = −1, from (40) and (81) we have

\[ \int_a^1 \frac{cdR}{R \dot{a}} = - \int_0^0 \frac{dr}{\sqrt{1 + r^2}}, \]  

\[ H_0 d_L = H_0 R_0 r (1 + z_d) = \frac{2c}{(Ω_m0 - 2Ω_vγ0)^2 - 4Ω_vγ0} \]

\[ \left\{ 2(1 + Ω_0) - (1 + z_d) Ω_m0 - [2(1 + Ω_0) - Ω_m0] \sqrt{1 - (Ω_m0 - 2Ω_vγ0) z_d + Ω_vγ0 z_d^2} \right\}, \]

where z_d = (1/a) - 1 is the redshift caused by R increasing. Provided Ω_m0 → −Ω_m0, (86) is consistent with the corresponding formula\[12\]. Ignoring Ω_vγ0, Ω_m0 → −Ω_m0 we reduce
\[ H_0d_L = \frac{2c}{\Omega m^2} \left\{2 + \Omega m_0 (1 - z_d) - [2 + \Omega m_0] \sqrt{1 - \Omega m_0 z_d} \right\}. \]  

(87a)

Approximating to \( \Omega^1 m_0 \) and \( z_d^2 \), we obtain

\[ H_0d_L = z_d + \frac{1}{2} z^2_d \left(1 + \frac{1}{2} \Omega m_0 \right). \]  

(87b)

Taking \( \Omega_{v0} = 0.001 \), \( \Omega_{m0} = 0.3 \Omega_{v0} + 2\sqrt{\Omega_{v0}} \) and \( H_0^{-1} = 9.7776 \times 10^9 h^{-1} yr^{12} \) and \( h = 0.8 \), we get the \( d_L - z_d \) relation which showed by the curve A in the figure 2; Taking \( \Omega_{v0} = 0.05 \), \( \Omega_{m0} = 2\sqrt{\Omega_{v0}} \) we get the \( d_L - z_d \) relation which showed by the curve B in the figure 2.

From (84), (86), figure 1 and 2 we can choose suitable parameters to get the curves describing true evolution of the cosmos.

V. DARK ENERGY AND VISIBLE ENERGY TRANSFORM EACH OTHER

A. Dark energy and visible energy transform each other

As mentioned above, when temperature \( T_s \sim T_{\text{max}} \) in \( S - space \), \( \langle \omega_s \rangle \rightarrow 0 \) and \( \langle \omega_v \rangle = 0 \), the masses of Higgs bosons tend to zero. Consequently \( \Omega_s, \Phi_s \) and \( \chi_s \) can be enormously produced and easily transform into \( \Omega_v, \Phi_v \) and \( \chi_v \) by the couplings in (13), and there is thermal equilibrium between the \( v - \text{particles} \) (the dark energy in \( S - space \)) and the \( s - \text{particles} \) when \( T_s \sim T_v \sim T_{\text{max}} \).

When the temperature \( T_s \) is low, there is no thermal equilibrium between the \( v - \text{particles} \) and the \( s - \text{particles} \). But the repulsive potential energy between \( v - \text{matter} \) and the \( s - \text{matter} \) can transform into the energy of the dark energy.

The repulsion potential energy is determined by the distributing mode of \( s - \text{matter} \) and \( v - \text{matter} \). In \( V - space \) \( v - \text{particles} \) with their masses can form celestial bodies. There is no interaction except gravity among \( S - SU(5) \) color single states, hence the color single states cannot form any dumpling and must relaxedly distribute in \( V - space \). Consequently, the huge repulsion potential energy between the \( V - \text{celestial} \) bodies and the \( S - SU(5) \) color single states must chiefly transform into the kinetic energy of \( S - SU(5) \) color single states, i.e., the dark energy in \( V - space \). In fact, we can prove in flat space that when space
expands $K$ times, i.e., $R \rightarrow KR$, the repulsive-potential energy density $V_r$ becomes $V_r/K$ and

$$\Delta V_r = (1 - 1/K) V_r. \tag{88}$$

To consider a system in flat space which is composed of a $v$–body with its mass $M$ and a $s$–colour single state with its mass $m$. It is easily to get the rate $\Delta E_m/\Delta E_M$ for static $M$ and $m$ at the initial moment..

$$\frac{\Delta E_m}{\Delta E_M} = \frac{2M + \Delta V_r}{2m + \Delta V_r} \tag{89}$$

Because $M \gg m$, $\Delta E_m > \Delta E_M$. Thus, although $\rho_v > \rho_s$ after inflating, after $V$–space expands with a deceleration for some time, it is also possible $\rho_v < \rho_s$. This implies that $\rho_v - \rho_s = \rho$ is changeable, can change from $\rho > 0$ to $\rho < 0$ as expanding of $V$–space.

Space expansion is not the necessary condition to transform repulsive potential energy into kinetic energy. Let $\dot{R}_V = 0$ or $< 0$. Because $\rho_v$ is not absolutely even, some $v$–matter can gather to a region and forms a galaxy by its gravity. Thus $s$–matter which is initially in the region must be repelled away the region and increases its kinetic energy, and the repulsive potential energy chiefly transforms into the kinetic energy of the $s$–matter in the case as well. Thus, although $\rho_v \gtrsim \rho_s$ when $\dot{R}_V = 0$ or $< 0$, it is also possible that $\rho_v \gtrsim \rho_s$ evolves to $\rho_v < \rho_s$ since $v$–matter gathers and forms galaxies. Because there is no interaction except the repulsion, a $v$–observer will regard that energy seems to come into being or annihilate at the highest temperature $T_{\text{max}}$.

B. Steadiness of galaxies

According to the conventional theory, when space expands with an acceleration, a galaxy will suffer a force $F$ which causes the volume of the galaxy to increase, and if the acceleration is big enough, the galaxy will break apart. But according to the present theory, this cannot occur. As mentioned above, expanding of $V$–space is because there is $s$–matter, more precisely, is because $\rho_v - \rho_s = \rho < 0$, and expanding acceleration is $\ddot{R} = \eta \rho R_0^3/2R^2$. The force $F$ caused by accelerative expanding is directly proportional to $\ddot{R}$. On the other hand, because there is repulsion between $s$–matter and $v$–matter, the $v$–galaxy also suffers the pressure $P$ coming from $s$–matter surrounding it. If we regard $s$–matter and $v$–matter as relatively static, i.e., they move only with expanding of $V$–space, the pressure $P$ suffered
by the $v$–galaxy will directly proportional to $\eta \rho R_0^3/2R^2$ as well. Thus $P/F$ is irrelative to $R$. Because the directions of the two forces $P$ and $F$ are opposite, the resultant of $P$ and $F$ on the $v$–galaxy is direct proportion to $\eta \rho R_0^3/2R^2$, and can be lesser or approach to zero as $R$ increases. Thus, although $V$–space expands with an acceleration, $v$–galaxies can still be steady.

The pressure $P$ on a visible $v$–galaxy coming from $s$–matter is similar to the gravity of $v$–dark matter inside the visible $v$–galaxy.

VI. REPULSIVE REDSHIFT

As mentioned above, in $V$–space $v$–matter can form galaxies, $s$–matter cannot form dumplings and can only relaxedly distribute in $V$–space. A $v$–particle static relatively to $s$–matter suffers the resultant of repulsive forces coming from $s$–matter to be zero. But when a $v$–particle, e.g. a $v$–photon, moves relatively to $s$–matter, it suffers the resultant of repulsive forces coming from $s$–matter not to be zero. This is because the density of $s$–energy in the front of the $v$–photon seems higher than that in the rear of the $v$–photon. Thus the $v$–photon will suffer a repulsive force in the direction opposing to its velocity. Analogously to gravitational shift, the $v$–photon will have a repulsive redshift in $V$–space. The repulsive redshift of the photon should be directly proportional to the density $\rho_s$, the energy of the photon and the moving distance $l = ct = t$ of the photon (where $c = 1$). Thus we have

$$d\nu = -f (\rho_s - \rho_v) \nu dl = -f (\rho_s(t) - \rho_s(t)) \nu(t) dt = -f \rho(t) \nu(t) dt,$$

where $f \sim \eta$ is a constant.

A. The case $k_V = -1$ and $\rho \equiv \rho_{vm} - \rho_{sm} < 0$

Considering $\rho_{sm}(t) = \rho_{sm0}/a^3(t)$, $\rho_{vm}(t) = \rho_{vm0}/a^3(t)$ so that $\rho(t) = \rho_{m0}/a^3(t)$, ignoring $\rho_{v\gamma}$ and taking $c = 1$, from (81) and (90), we have

$$\int_{\nu_0}^{\nu} \frac{d\nu}{\nu} = -f \rho_0 \int_0^1 \frac{1}{a^3} \frac{da}{a^2 \sqrt{a^2 - Q_0 \dot{a}}},$$

(91)
\[
\nu = \exp \frac{2}{3} \frac{A}{Q_0} \left\{ \left( 1 + \frac{2}{Q_0} \right) \sqrt{1 - Q_0} - \left( 1 + \frac{2}{Q_0} + z_d \right) \sqrt{1 - (1 + z_d) Q_0} \right\}, \quad (92)
\]
\[
A \equiv \frac{f Q_0}{\eta R_0} = \frac{f}{\eta} H_0^2 R_0 \Omega_{s0} = f (\rho_{s0} - \rho_{c0}) R_0, \quad Q_0 < 1. \quad (93)
\]

Thus the red shift caused by repulsion is

\[
z_r = \frac{\nu}{\nu_0} - 1. \quad (94)
\]

A is very small, e.g., for \( Q_0 = 1/2 \), \( A = f/2\eta R_0 \). Approximately to \( A \), we have

\[
z_r \simeq A \left( z_d + \frac{1}{2} z_d^2 \right), \quad (95)
\]

A red shift \( z \) observed by us satisfies[12],

\[
(1 + z) = (1 + z_r) (1 + z_d). \quad (96)
\]

We should represent the relation between a redshift and distance by total red-shift. From (94) – (96) we have

\[
z_d = z \frac{z_d}{z} \equiv z q^{-1}, \quad q = 1 + z_r/z_d + z_r. \quad (97)
\]

Approximately to \( A \) we have

\[
q \simeq 1 + A \left( 1 + \frac{3}{2} z + \frac{1}{2} z^2 \right). \quad (98)
\]

Considering \( z_d = z q^{-1} \), approximately to \( A \) and \( z^2 \) when \( z < 1 \), from (87b) we have

\[
(1 + A) H_0 d_L \equiv H_{0eff} d_L \simeq z + \frac{1}{2} z^2 \left\{ \left( 1 + \frac{1}{2} \Omega_{mo} \right) - A \left( \frac{5}{2} + \frac{1}{2} \Omega_{mo} \right) \right\}. \quad (99)
\]

where \( H_{0eff} = (1 + A) H_0 \) is the effective Hubble constant.

From \((1 + z_d)^{-1} = a(t)\) and (95) – (96) we obtain

\[
\ddot{a}(t) = \frac{\ddot{R}(t)}{R_0} \equiv (1 + z)^{-1} = (1 + z_d)^{-1} (1 + z_r)^{-1}
\]

\[
\simeq (1 + z_d)^{-1} \left[ 1 + A \left( z_d + \frac{1}{2} z_d^2 \right) \right]^{-1} = a(t) \left[ 1 - \frac{1}{2} A \left( \frac{1}{a^2} - 1 \right) \right]. \quad (100)
\]

where \( \ddot{R}(t) \) is not the true scalar curvature, but is an apparent scalar curvature determined by the total red shift \( z \). From (100) we can determine \( \ddot{a}(t) \) after \( a(t) \) is determined. Because \( A \) is very small, the correction coming from \( z_r \) is very small.
VII. STRUCTURE OF THE UNIVERSE

A. The universe is composed of infinite cosmic islands

If the whole universe is the $s-world$ or the $v-world$, the analysis above is correct. But according to the present model, there possibly is new structure of the universe.

As mentioned above, $v\text{-}matter$ and $s\text{-}matter$ are symmetric and mutually repulsive, $v\text{-}matter$ in $v\text{-}space$ can form a $v\text{-}world$ and $s\text{-}matter$ in $s\text{-}space$ can form a $s\text{-}world$. From this we present a new cosmic model to be that the universe is composed of infinite cosmic islands and every cosmos island is just a $s\text{-}world$ in $s\text{-}space$ or a $v\text{-}world$ in $v\text{-}space$. Here both $v\text{-}space$ and $s\text{-}space$ are finite.

According to the model we easily see that there must be only $v\text{-}cosmic$ islands neighboring a $s\text{-}cosmic$ island. This is because if two $s\text{-}cosmic$ islands are neighboring, they will combine to form one new larger $s\text{-}cosmic$ island by their gravitation. It is necessary that the distance between two $v\text{-}cosmic$ islands must be very huge. Because of the same reason there are only $s\text{-}cosmic$ islands around a $v\text{-}cosmic$ island. Because there is no interaction except the repulsion between $v\text{-}matter$ and $s\text{-}matter$, there is no interaction except the repulsion between a $s\text{-}cosmic$ island and a $v\text{-}cosmic$ islands as well. Because of the following reasons, we in a $v\text{-}cosmic$ island cannot observe anything of the $s\text{-}cosmic$ islands around us.

All Higgs particles whose masses are not zero will fast decay into fermions and gauge bosons. The masses of $V\text{-}fermions$ and $v\text{-}gauge$ bosons in a $s\text{-}cosmic$ island are all zero and must form $v\text{-}SU(5)$ colour single states. The masses of $V\text{-}fermions$ and $v\text{-}gauge$ bosons in a $v\text{-}cosmic$ island are not zero (the masses of $v\text{-}photons$ and $v\text{-}glutons$ in $v\text{-}cosmic$ island are zero). Hence a $v\text{-}SU(5)$ colour single states in a $s\text{-}cosmic$ island cannot come into the $v\text{-}cosmic$ island in which $v\text{-}SU(5)$ has broken to $v\text{-}SU(3)\times U(1)$.

A $s\text{-}particle$ in a $s\text{-}cosmic$ island must be $s\text{-}SU(5)$ non-colour single state. If a $s\text{-}particle$ came into the $v\text{-}cosmic$ island, it would still be non-colour single state and would have very big mass. Hence a $s\text{-}particle$ in a $s\text{-}cosmic$ island cannot come into the $v\text{-}cosmic$ island. Because of the same reason, no particle can fly away the $v\text{-}cosmic$ island.

As a consequence a $v\text{-}observer$ in the $v\text{-}cosmic$ island can regard the $v\text{-}cosmic$ island
as the whole world.

A $v$ – *cosmic* islands and a $s$ – *cosmic* island can influence each other by the Higgs potential in their boundary. For example, $\rho_s \sim 0$ and $\rho_v \sim 0$ in a $v$ – *cosmic* island, the expectation values of the $v$ – *Higgs* field in the island will be assimilated by the $s$ – *cosmic* islands neighboring to it. Hence the $v$ – *cosmic* island will disappear.

Thus we can approximately regard a cosmic island as the whole cosmos. It is possible that some cosmic islands are forming or expanding, and the other cosmic islands are contracting or disappear. It is also possible that some cosmic islands anew combine to form a new larger cosmic island due to their motion or expansion. The cosmic island in which we exist is expanding.

Thus, according to the present model the cosmos as a whole is infinite and its properties are always unchanging, and there is no starting point or end of time.

B. Redshifts and characters of quasars

Hydrogen spectrum is

$$\omega_{nk} = (E_n - E_k)/h = -\frac{\mu e^4}{2h^3} \left( \frac{1}{n^2} - \frac{1}{k^2} \right), \quad \mu = \frac{mM}{m + M}, \tag{101}$$

where $m$ is the mass of an electron, and $M$ is the mass of a proton. According the unified model, $m \propto v_e$, the mass of a quark $m_q \propto v_q$, where $v_e$ and $v_q$ are the expectation values of the Higgs fields coupling with the electron and the quark, respectively. Consequently the mass of a proton is approximately $M \propto v_q$.

Because the cosmic islands neighboring with a $s$ – *cosmic* island in which $\omega_v = 0$ and $\omega_s = \omega_{s0}$ must be $v$ – *cosmic* islands in which $\omega_v = \omega_{v0}$ and $\omega_s = 0$, it is necessary there is the transitional region in which $\omega_v = 0 \rightarrow \omega_{v0}$ and $\omega_s = \omega_{s0} \rightarrow 0$ in the boundary of the $s$ – *cosmic* island, i.e., $0 \leq |\omega_s| \leq |\omega_{s0}|$ and $0 \leq |\omega_v| \leq |\omega_{v0}|$ in the transitional region. Consequently the masses $m'$, $M'$ and $\mu'$ in the transitional regions must be less than the conventional masses. From (129) we see the characteristic frequency $\omega'_{nk}$ must be less than $\omega_{nk}$:

$$\Delta \omega_{nk} = \omega_{nk} - \omega'_{nk} = -\frac{(\mu - \mu')e^4}{2h^3} \left( \frac{1}{n^2} - \frac{1}{k^2} \right). \tag{102}$$

The sort of red-shifts is called mass redshift. The mass redshift is essentially different from the red-shift mentioned above. Thus, the photons originating from the star in the
transitional region must have larger red-shift than that determined by the Hubble formula at the same distance. Thereby we guess that some quasars are just the galaxies in the transitional region of our cosmos island.

An ordinary $s$-galaxy and an $s$-quasar can be neighboring, because a transitional region in which $|\varpi_s| \leq |\varpi_{s0}|$ and $|\varpi_v| \leq |\varpi_{v0}|$ must be neighboring to an ordinary region in which $\varpi_s = \varpi_{s0}$ and $\varpi_v = 0$. The difference of the redshifts of the neighboring ordinary $s$-galaxy and the $s$-quasar is very large.

If an atom or a star run from the ordinary region to the transitional region with a high velocity, what will occur? the atom or the star will explode because of mass change of the particles composing the atom or the star. We will discuss the problem in other paper.

**VIII. NEW PREDICTIONS**

1. **It is possible that some huge cavity is equivalent to a huge concave lens.**

   According the present model, it is possible that some huge cavities in $V$-space are not empty, but there are $\rho'_s > \rho_s$ and $\rho'_v \ll \rho_v$ in it so that $\rho' \equiv \rho'_s - \rho'_v > \rho = \rho_s - \rho_v$, here $\rho'_s$ and $\rho'_v$ denote the densities in the cavity, and $\rho_s$ and $\rho_v$ denote the average densities. Because there are the repulsion between $s$-matter and $v$-matter and the gravity among $s$-matter, a huge cavity can form. The characters of such a huge cavity are as follows.

   **A.** Because there is no interaction similar to the electromagnetic interaction, except the gravity, among the $s$-$SU(5)$ colour single states and the masses of the $s$-$SU(5)$ colour single states are very small, a cavity in $V$-space must be very large.

   **B.** Because $s$-matter and $v$-matter are mutually repulsive, when $v$-photons pass through such a huge cavity, the $v$-photons must suffer repulsion and consequently are scattered as they pass through a huge concave lens, the galaxies behind the huge cavity seem to be darker and more remote, and $v$-photons pass through such a huge cavity will have larger redshift.

   **C.** Because there is the repulsion from $s$-matter to the background radiation, the density of the background radiation inside the huge cavity must very little. Hence the temperature of the huge cavity must very low. It is seen that the present model can well explain the characters of some huge cavities.

   This is a decisive prediction which distinguishes the present model from other models.
2. The universal total energy observed by us seems not to be conservational.

The universal total energy, of course, is conservational in fact. Because the energies $s$–matter and $v$–matter can transform from one into another at the highest temperature and a $v$–observer in $V$–space cannot detect $s$–matter except by gravity, the universal total energy observed by the $v$–observer seems not to be conservational. As a consequence, the cause of space expanding with an acceleration seems to be because of mass loses or the gravitation decreases.

3. The gravitation between two galaxies distant enough will lesser than that predicted by the conventional theory.

There must be $s$–matter relaxedly distributing between two $v$–galaxies distant enough, hence the gravitation between them must lesser than that predicted by the conventional theory. But when the distance between the two $v$–galaxies is small, the gravitation between them is not influenced by $s$–matter because when $\rho_v$ is big, $\rho_s$ must be small.

4. Transformation of a black hole with its mass big enough

Let there is a $v$–brack hole with its mass big enough in $V$–space. If its mass is so big that its temperature to be $\sim T_{\text{max}}$, the expectation values of the Higgs fields inside the $v$–brack hole will change, $\varpi_v = \varpi_{v0} \to 0$ and $\varpi_s = 0$, so that the space will expand and finally $\varpi_{v0} = 0$ and $\varpi_s = 0 \to \varpi_{s0}$. Consequently, the $v$–brack hole transforms into a $s$–cosmic island which is different from $v$–huge cavities in $V$–space. A $v$–observer can observe it by its repulsive effects, but cannot get other messages.

5. A sort of huge white holes

Let there be a $s$–cosmic island neighboring on a $v$–cosmic island. It is possible that the $s$–cosmic island transforms into a $v$–cosmic island after it contraction. In this case, a $v$–observer in the $v$–cosmic island must observe a very huge white huge.

There are other predictions. We will discuss them in following paper.

IX. CONCLUSIONS

The new hypotheses are proposed that there are $s$–matter and $v$–matter which are symmetric and mutually repulsive, there are $S$–space and $V$–space whose essential difference is that their expectation values of the Higgs fields are different. In $S$–space the $S$–$SU(5)$ symmetry is broken into $S$–$SU(3) \times U(1)$ for $s$–particles and $V$–$SU(5)$
symmetry still strictly holds for $v$–particles. As a consequence $s$–particles get their masses determined by the $SU(5)$ GUT and form the $s$–world, and $v$–particles without mass form $V–SU(5)$ color-single states which are identified with dark energy in $S$–space. Evolving process of the universe is as follows. Firstly $S$–space contracts due to $\rho_s – \rho_v$ large enough and causes the temperature $T_s$ to rise. When $T_s \rightarrow T_{\text{max}}$, both $V–SU(5)$ and $S–SU(5)$ symmetries strictly hold and therefore the masses of all particles are zero. Secondly inflation of $V$–space occurs. After the inflation the phase transiting of the vacuum occurs. As a consequence $S$–space transforms into $V$–space and the $s$–world transforms into the $v$–world. The results above still hold water when $V \rightleftharpoons S$ and $v \rightleftharpoons s$. The following results are obtained. There is no spacetime singularity. There is the highest temperature and the highest energy density in the universe. The results of the Guth’s inflationary scenario are obtained. $Space$ seems to expand with a deceleration in early period and with an acceleration in later period. A formula which well describes the luminous distance and redshift is obtained. The universe is composed of infinite cosmic islands which are $s$–worlds or $v$–worlds. The new predictions of the present model are as follows. Some huge cavity is not empty and is equivalent to a huge concave lens. The present model can well explains the given characters of some huge cavities. The universal total energy is conservational, but the total energy observed by us seems not to be conservational. The gravitation between two galaxies distant enough will lesser than that predicted by the conventional theory. A possible explanation for the big redshifts of quasi-stellar objects is presented. The huge redshifts of quasars are the mass redshifts. It is possible that a $v$–brack hole with its mass big enough can transform into $s$–huge white hole which cannot be observed by a $v$–observer except by its repulsion effects, and the $s$–cosmic island neighboring on a $v$–cosmic island transforms into a $v$–cosmic island after it contraction. In this case, a $v$–observer in the $v$–cosmic island must observe a very huge $v$–huge white holes which are different from that predicted by conventional theory.

Before inflating occurs, the $s$–world is in thermal equilibrating state. If there is no $v$–matter, because of contraction by gravitation, the $s$–world would become a thermal equilibrating singular point, i.e., the $s$–world would be in the hot death state. As seen, it is necessary that there are both $s$–matter and $v$–matter and both $S$–space and $V$–space.
X. DISCUSSION

A. $k$ in the Robertson-Walker metric is regarded as a function of density $\rho$

For spatially homogeneous and isotropic 3-dimensional space, the Riemann curvature tensor describing the 3-dimensional geometry at any moment satisfies

$$^{(3)}R_{mnsk} = K(t)(\delta^s_m \delta^k_n - \delta^k_m \delta^s_n),$$  \hfill (D1)

The Robertson-Walker metric (40) satisfies (D1) and can equivalently be rewritten as

$$ds^2 = dt^2 - \left[\frac{dr^2}{1 \pm r^2/a(t)^2} + r^2(d\theta^2 + \sin^2 \theta d\varphi^2)\right].$$  \hfill (D2)

We consider it is possible that $k$ can change from $\sim 1$ to 0 and further to $\sim -1$ which cannot attribute to change of $R(t)$. In the conventional theory, because there is one sort of matter so that it is necessary $\rho > 0$, it is unnecessary to consider $k$ to be changeable. But according to the present model, $\rho > 0$, $\rho = 0$ and $\rho < 0$ are all possible, here $\rho = \rho_v - \rho_s$, hence it is necessary to consider $k$ to be changeable. Thus we rewrite (40) as

$$ds^2 = dt^2 - R^2(t)\left[\frac{dr^2}{1 - r^2/A(\rho)} + r^2(d\theta^2 + \sin^2 \theta d\varphi^2)\right]$$  \hfill (D2)

(D2) is invariant under transformation of $A(\rho) \rightarrow A(\rho)/|A(\rho)|$, $r \rightarrow r/\sqrt{|A(\rho)|}$ and $R \rightarrow \sqrt{|A(\rho)|}R$. If $A(\rho)$ is only a positive or negative real function or infinite, (D2) is equivalent to (40). But we suppose $A(\rho)$ is a real function of the density in comoving coordinate system and can change from $A(\rho) > 0$ to $\infty$ and further to $A(\rho) < 0$. Thus (D2) is no longer equivalent to (40).

From (51) or (53) we see when $k = 1$, $\rho > 0$ is necessary, because there is no real solution in this case corresponding to $\rho \leq 0$. When $k = 0$, $\rho \geq 0$ is necessary, because there is no real solution corresponding to $\rho < 0$ in this case. When $k = -1$, there are real solutions for $\rho \geq 0$ or $\rho < 0$. Thus, we suppose, e.g. in $V - space$, that $k$ alters as the density in comoving coordinate system

$$k(\rho) \equiv A^{-1}(\rho) \equiv \frac{V + (\rho_m + \rho_g)}{V_1 + (\rho_{m1} + \rho_{g1})} \frac{R^3}{R_1^3},$$  \hfill (D3a)

for $V_1 + (\rho_{m1} + \rho_{g1}) > 0$, $\rho$ is positive,

$$k(\rho) \equiv A^{-1}(\rho) \equiv -\frac{V + (\rho_m + \rho_g)}{V_1 + (\rho_{m1} + \rho_{g1})} \frac{R^3}{R_1^3},$$  \hfill (D3b)

for $V_1 + (\rho_{m1} + \rho_{g1}) < 0$, $\rho$ is negative.
where \( \rho_m \equiv \rho_{\text{em}} - \rho_{\text{sm}} \), \( \rho_\gamma \equiv \rho_{e\gamma} - \rho_{\text{in}}, \rho(t) = \rho_m(t) + \rho_\gamma(t) = \rho(t, R), \rho_1 \equiv \rho(t_1) \), \( V \) is the Higgs potential energy density, and \( \gamma \) denotes all massless particles. In general, although \( R \) does not change, \( \rho_{\text{em}} - \rho_{\text{sm}} \) can also alter since the repulsive potential energy chiefly transforms kinetic energy of \( s \)-colour single states when \( v \)-celestial bodies form. On the other hand, change of \( R \) must cause \( \rho \) to change. Hence \( \rho = \rho(t, R(t)) \). When \( T = T_{\text{max}}, V = V_0, \rho \sim 0 \) and

\[
k(\rho) = \frac{V_0}{(V_1 + \rho_{m1} + \rho_{\gamma1})}.
\]

After reheating, when temperature is low so that \( V \sim V_1 \sim 0 \), we have

\[
k(\rho) = \frac{(\rho_m + \rho_\gamma) R^3/R_1^3}{(\rho_{m1} + \rho_{\gamma1})} \quad \text{for } \rho_1 > 0, \quad k(\rho) = -\frac{(\rho_m + \rho_\gamma) R^3/R_1^3}{(\rho_{m1} + \rho_{\gamma1})} \quad \text{for } \rho_1 < 0.
\]

When \( \rho(t, R) = \rho(R) \), \( \rho_m R^3 = \rho_{m1} R_1^3 \) and \( \rho_\gamma R^4 = \rho_{\gamma1} R_1^4 \), we have \( k(\rho(t, R)) = k(\rho(R)) \),

\[
k(\rho) = \frac{\rho_{m1} + \rho_{\gamma1} (R_1/R)}{\rho_{m1} + \rho_{\gamma1}}, \quad \text{for } \rho_1 > 0; \quad k(\rho) = -\frac{\rho_{m1} + \rho_{\gamma1} (R_1/R)}{\rho_{m1} + \rho_{\gamma1}} \quad \text{for } \rho_1 < 0
\]

Let \( k(\rho(R')) = 0 \) for \( \rho_1 > 0 \), we have \( k(\rho(R > R')) < 0 \) and \( k(\rho(R < R')) > 0 \); and for \( \rho_1 < 0 \), we have \( k(\rho(R > R')) < 0 \) and \( k(\rho(R < R')) > 0 \); When \( \rho_\gamma \) can be ignored,

\[
k(\rho) = 1, \quad \text{for } \rho_{m1} > 0; \quad k(\rho) = -1, \quad \text{for } \rho_{m1} < 0.
\]

Because \( k(\rho) = k(\rho(t, R(t))) \), the corresponding equations should be deduced from \((D2)\).

As a rough approximation, we have in the international unit

\[
\dot{R}^2 = -k(\rho) c^2 + \eta (\rho_m + \rho_\gamma) R^2,
\]

\[
\ddot{R} = -\frac{c^2 dk}{2 R dt} - \frac{1}{2} \eta (\rho_m + 2 \rho_\gamma) R = -\frac{c^2}{2} \left( \frac{\partial k}{R \partial t} + \frac{\partial k}{\partial R} \right) - \frac{1}{2} \eta (\rho_m + 2 \rho_\gamma) R,
\]

where \( \rho_\gamma = \rho_{\gamma}/3 \) is considered. When \( V = \partial \rho_m/\partial t = \partial \rho_\gamma/\partial t = 0 \), from \((D5)\) we can still obtained \( \rho_m R^3 = \rho_{m1} R_1^3 \) and \( \rho_\gamma R^4 = \rho_{\gamma1} R_1^4 \). In the case, let \( H_1^2 = \left( \frac{\dot{R}_1}{R_1} \right)^2 = \eta \rho_{c1}, \Omega_1 = \rho_1/\rho_{c1} \) for \( \rho_1 > 0 \) and \( \Omega_1 = -\rho_1/\rho_{c1} \) for \( \rho_1 < 0 \), \( \Omega_{m1} = \rho_{m1}/\rho_{c1} \) for \( \rho_{m1} > 0 \) and \( \Omega_{m1} = -\rho_{m1}/\rho_{c1} \) for \( \rho_{m1} < 0 \), and \( a = R/R_1 \), we can simplify \((D5)\) to

\[
a^2 = \frac{\Omega_{m1} - \Omega_{\gamma1}/a}{R_1^2 \Omega_1} c^2 - H_1^2 \left( \frac{\Omega_{m1}}{a} - \frac{\Omega_{\gamma1}}{a^2} \right) = \frac{c^2}{R_1^2} k - H_1^2 \left( \frac{\Omega_{m1}}{a} - \frac{\Omega_{\gamma1}}{a^2} \right)
\]

\[
= \frac{\Omega_{m1} c^2}{R_1^2 \Omega_1} \left( 1 - \frac{P_1}{a} \right) \left( 1 - \frac{Q_1}{a} \right),
\]

\[
(D6a)
\]
\[ \ddot{a} = \frac{H_i^2}{2} \left[ \frac{\Omega_m}{a^2} - 2 \frac{\Omega_\gamma}{a^3} \right] \]

\[ = \frac{H_i^2 \Omega_m}{2Q_1 a^2} \left[ P_1 \left( 1 - \frac{Q_1}{a} \right) + Q_1 \left( 1 - \frac{P_1}{a} \right) \right] \]

\[ , \quad (D6b) \]

where

\[ P_1 = \Omega_\gamma / \Omega_m, \quad \tilde{k} = \Omega_m / \Omega_1, \quad \tilde{\Omega}_m \equiv \Omega_m \left( 1 + \frac{P_1}{Q_1} \right) . \]

\[ (D7a) \]

\[ Q_1 = H_i^2 R_i^2 \Omega_1 / c^2 = \Omega_1 / \left( (1 + \Omega_1) \right), \quad \text{for} \quad \rho_1 < 0, \]

\[ = \Omega_1 / \left( (\Omega_1 - 1) \right), \quad \text{for} \quad \rho_1 > 1. \]

\[ (D7b) \]

\[ (D7c) \]

We can arbitrarily choose \( t_1 \) provided \( \rho (t_1) = \rho_e (t_1) - \rho_s (t_1) = \rho_1 \neq 0. \)

In order for convenience, we may take

\[ k = 1 \quad \text{for} \quad \rho > 0, \]

\[ k = 0 \quad \text{for} \quad \rho = 0, \]

\[ k = -1 \quad \text{for} \quad \rho < 0. \]

\[ (D8a) \]

\[ (D8b) \]

\[ (D8c) \]

From (\( D5 \)) we can obtain the results similar to (84), (86) and figures 1 and 2.

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