INFORMATION, EXPANSIVE NONDECELERATIVE
UNIVERSE AND SUPERSTRING THEORY

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Abstract. Stemming from relationships between a number of informa-
tion describing a system and entropy content of the system it is possible to
determine maximal cosmological time. The contribution manifests a compat-
ibility of the superstring theory and the model of Expansive Nondecelerative
Universe.

Entropy and Information
In spite of several justified objections raised to the second law of thermody-
namics in specific cases [1], its validity for the Universe and the importance of
entropy conception is generally accepted. Along with its probability meaning
expressed by relation [2]

\[ S = -k \ln p = k \ln P \]  

where \( S \) is the entropy, \( k \) is the Boltzmann constant, \( p \) is the probability
of the existence of a microstate, \( P \) is the number of microstates associated
with a macroscopic state, entropy is also a measure of information needed
to describe system properties. In accordance with a common usage, entropy
will be expressed as dimensionless quantity, number of information is given
in bit. Since a number of information transferred \( I \) by binary characters is

\[ I = -\log_2 p \]  

the entropy of a state fully describable by a number of information \( I \) is then

\[ S = I(k \ln 2) \approx 9 \times 10^{-24} I \]  

Thus, a number of information needed to fully describe a system can be
expressed either via its entropy or by a number of bits.

Applying the above ideas to the Universe with a permanent increase of
its entropy content, it is obvious that to describe such a universe, a number
of information must growth as well.
Information, ENU and the Universe Dimensionality

One of the corner-stones of the holographic model of the Universe, elaborated by Bohm [4], declares that every point of the Universe (every elemental particle) is in mutual contact with the other points (particles) and holds the information about the whole Universe. The higher dimensionality of the Universe, the higher number of information is needed to its description. A postulate relating a maximum information $I_{\text{max}}$ and a certain space dimensionality $n$ of the Universe may be generally expressed as

$$\log_2 I_{\text{max}} = 2^{(n-1)} \quad (4)$$

As a starting point (rationalized latter) let us suppose that

$$n = 10 \quad (5)$$

Then it follows from (4) and (5)

$$I_{\text{max}} \approx 10^{154} \quad (6)$$

Corresponding maximum entropy based on (3) and (6) is

$$S_{\text{max}} \approx 10^{131} \quad (7)$$

In the ENU model [5] it holds

$$a = c.t_c = \frac{2G.m_U}{c^2} \approx 1.3 \times 10^{26}\text{m} \quad (8)$$

where $a$ is the gauge factor, $t_c$ is the cosmological time, and $m_U$ is the mass of the Universe. The elementary particles did not exist at the very beginning of the Universe, the gravitational field quanta, however, existed. This is why the entropy of the Universe can be expressed by means of a number of gravitational field quanta at a given cosmological time. If the mean energy of a gravitational field quantum is denoted as $E_g$, then

$$S = \frac{m_U.c^2}{|E_g|} = \frac{t_c.c^5}{2G.|E_g|} \quad (9)$$

As shown in our previous paper [6], it holds in the ENU

$$i.h \frac{d\Psi_g}{dt} = E_g.\Psi_g \quad (10)$$
where $\Psi_g$ is the wave function of the Universe defined as

$$\Psi_g = e^{-i(t_Pc.t_c)^{-1/2}.t} \quad (11)$$

It follows from (10) and (11) that

$$|E_g| = \hbar(t_Pc.t_c)^{-1/2} \quad (12)$$

where $t_Pc$ is the Planck time

$$t_Pc = \left(\frac{G.\hbar}{c^5}\right)^{1/2} = 5.39056 \times 10^{-44}s \quad (13)$$

The entropy content at a time $t$ is then, based on (9), (10), and (11), given by

$$S = \left(\frac{t}{t_Pc}\right)^{3/2} \quad (14)$$

i.e. at the time being

$$S \approx 10^{92} \quad (15)$$

A crucial conclusion stems from (7) and (14). It determines a cosmological time in which the maximum entropy should be reached

$$t_{c(max)} \approx 10^{35} - 10^{36} \text{years} \quad (16)$$

A significance of this result lies in the fact that $t_{c(max)}$ represents the time for which a decay of of baryonic matter is anticipated.

**Concluding Remarks**

Standard cosmological theories deals with the 3-dimensional space. Within the Kaluza-Klein theoretical approaches [7] more-dimensional spaces ($n = 4$ to 6) are elaborated [8]. A classic superstring theory used space with $n = 9$, in the M-theory $n = 10$. There are other conceptions within the superstring theories [9, 10] in which a number of dimensions is even higher.

The ENU model is compatible with superstring theory having $n = 10$. Calculations based on relations present in this work lead to a result showing that if $n < 10$, the maximum cosmological time would be less than the present time.

New results might be obtained when some features of the ENU model (such as the matter creation and gravitational energy localization) are incorporated into superstring theory.
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