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WHY TIME IS FUTURE ORIENTED

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Abstract

We assume that the universe consists of clusters which in turns have sub-clusters and the sub-clusters have sub-subclusters and so on. Confining to three-dimensional space, it is shown that the universe is expanding if entropy of the universe increases. It is also shown that clocks slow down when time progresses towards future. Our model also justfies the big bang theory.

1 Introduction

Our physical world is the manifestation of space, time and matter. A discipline which relates space, time and matter is the general theory of relativity. Although general relativity is compatible with experimental tests [1, 2], we present here an alternate approach to incorporate matter content in a curvature-free space time.

We find an analogy between bending of light in the gravitational field and a light beam trapped in an optical fiber. An optical fiber is able to trap a light beam in the core by total internal reflection [3]. Consider an optical fiber and put it in a curved way. Let there is a light source at one end and the observer is at the other end. The observer always sees the source directed away from him and thus detects no curvature in the tube. Similar is the case of a light coming from a star passing near the Sun. This produces a slight shift in the apparent position of the star as seen by an observer at the Earth. The observer at the Earth perceives that the star is actually situated at its apparent position and so he connects the apparent position of the star with the Earth according to $l = ct$.

An interesting feature of optical fibre is as follow: Take an extensionless optical fiber. Put it in a volume element in such a way that it passes through all points of the volume element. Send a light signal from one end which will shine all points within the tube. The observer at the other end sees an array of points along the tube. But since the points belong to the volume element, thus the observer sees the whole three dimensional space in his one dimensional tube. In other words the observer can not distinguish between one dimension or any higher dimensions.

We incorporate this idea in an oversimplified statistical model. In this article we emphasize on qualitative analysis, numerical estimates will be discussed elsewhere.

2 Model

We assume that the universe is unique [4], that no part of the universe is disconnected from the other part of the universe. We further assume that the universe consists of super-clusters which in turns contain group of clusters and each cluster then consists of galaxies and so on.

We can represent the universe by a set G^n

$$G^n = \{G_1^{n-1}, G_2^{n-1}, ..., G_{p_n}^{n-1}\},$$

where G_i^{n-1} represents i^{th} super-cluster for instant and p_n is the number of super-cluster in G^n and

$$G_i^{n-1} = \{G_1^{n-2}, G_2^{n-2}, ..., G_{p_{n-1}}^{n-2}\},$$

We can Continue this to sub-atomic level and finally we get

$$G_j^1 = \{G_1^0, G_2^0, ..., G_{p_1}^0\},$$

where G_k^0 corresponds to constituent particle which has no further substructure.

The number of accessible states for this system can be written as [5, 6]

$$W_n = \left(\frac{V}{\Delta V_{n-1}}\right)^{p_n}, \tag{1}$$

where V is the volume of the universe (i.e. G^n) and ΔV_{n-1} is the volume occupied by G_i^{n-1}.

Similarly,

$$W_{n-1} = \left(\frac{\Delta V_{n-1}}{\Delta V_{n-2}}\right)^{p_{n-1}}, \tag{2}$$

where ΔV_{n-2} is the volume occupied by G_j^{n-2}. Putting ΔV_{n-1} from eq.(2) in to eq.(1) and on re-arranging we get

$$W_n W_{n-1}^{p_n/p_{n-1}} = \left(\frac{V}{\Delta V_{n-2}}\right)^{p_n}, \tag{3}$$

Generalizing and after re-arranging it, we finally get

$$\frac{V}{\Delta V_0} = \prod_{i=1}^{n} W_i^{1/p_i}, \tag{4}$$

or

$$\ln\left(\frac{V}{\Delta V_0}\right) = \sum_{i=1}^{n} \frac{s_i}{k_B p_i}, \tag{5}$$

where we have used the relation,

$$s = k_B \ln W, \tag{6}$$

in which s is the entropy and k_B is the Boltzmann's constant, ΔV_0 is the spread or uncertainty in volume of the constituent particle. For the sake of simplicity, we assume that the volume of the universe is spherical, i.e. $V \sim l^3$, and also $\Delta V_0 \sim \Delta l^3$. We get

$$l = \Delta l \exp\left(S/3k_B\right). \tag{7}$$

where

$$S = \sum_{i=1}^{n} s_i/p_i, \tag{8}$$

According to the second law of thermodynamics, S has to increase so as l. This means that the universe is expanding. Now according to our assumption of hypothetical optical fiber any observer will perceive that for light ray $l = ct$, so eq.(7) becomes

$$t = \Delta t \exp\left(S/3k_B\right) \tag{9}$$

Writing for S we have

$$S = 3k_B \ln \frac{t}{\Delta t}$$

This determines entropy-time arrow. As from the law of increase of entropy, entropy always increases and also time is future oriented. So we can not draw a conclusion to say which quantity is the true independent variable, time or entropy. In order to solve this problem we proceed as follow.

Entropy of a cluster and successive sub-cluster is related through relation

$$s_j = p_j s_{j-1} \tag{10}$$

where s_j is the entropy and p_j is the number of clusters corresponding to an element G^j. This is the difference equation which holds provided that all elements G^{j-1} of G^j have equal entropy and otherwise s_j represents average entropy of G^j. Using eq.(10) in to eq.(8) and after iteration we finally get,

$$S = N(p)s_0 \tag{11}$$

where

$$N(p) = 1 + p_1 + p_1 p_2 + ... + \prod_{i=1}^{n-1} p_i \tag{12}$$

Therefore eq.(9) becomes

$$t = \Delta t \exp\left(N(p) s_0 / 3k_B \right), \tag{13}$$

in which s_0 is entropy of the constituent particle. The last equation faces a serious problem. In order that t kept on increasing then either s_0 should increase or $N(p)$. But since s_0 is the entropy of constituent particle, it can not alter t significantly. Therefore $N(p)$ should increase monotonically. This means that something is continuously leaking from each element G^{i-1} of G^i in to G^i of G^{i+1}. This may correspond to some interaction which bounds the whole universe. It also confirms that the universe is unique. Since $N(p)$ is some number which is difficult to estimate, we can write it in terms of mass.

Like eq.(10), we have a similar equation for mass,

$$m_j = p_j m_{j-1} \tag{14}$$

where m_j is the total mass of G^j. Eq.(14) holds under the similar argument as eq.(10). Now using eq.(14) in to eq.(12) and after iteration we finally get,

$$t = \Delta t \exp\left(\lambda \mathcal{M} \right) \tag{15}$$

where

$$\mathcal{M} = \sum_{i=0}^{n-1} m_i, \tag{16}$$

and

$$\lambda = \frac{s_0}{3 m_0 k_B} \tag{17}$$

$\mathcal{M}$ can be assumed as Lyapunov variable, a variable that never decreases [7]. It is worth noting that spontaneous creation of matter is discussed in literature [8, 9] and also abandoned because of the violation of energy-momentum conservation. It will become clear that our case is different and quite natural.

3 Discussion

Using the initial condition i.e. $\mathcal{M} = 0$ in eq.(15) we get

$$t_0 = \Delta t, \tag{18}$$

where t_0 is the initial time at $\mathcal{M} = 0$. Now putting t_0 for Δt in eq.(15) we obtain

$$t = t_0 \exp(\lambda \mathcal{M}) \tag{19}$$

This equation is interesting in the sense that zero initial time is not allowed by the universal time scales and otherwise if we set $t_0 = 0$, then time can never begin. Using eq.(19) we can define time-interval,

$$\Delta t = \lambda t \Delta m \tag{20}$$

Clearly the time interval depends on the initial time. Let us define two intervals of time one at time t_i and the other at time $t_j > t_i$, given by

$$\Delta t_i = \lambda t_i \Delta m_i \tag{21}$$

and

$$\Delta t_j = \lambda t_j \Delta m_j \tag{22}$$

There are two alternatives:

i)

$$\begin{aligned} \Delta m_i &\neq \Delta m_j \\ \Delta t_i &= \Delta t_j \end{aligned}$$

ii)

$$\begin{aligned} \Delta t_i &\neq \Delta t_j \\ \Delta m_i &= \Delta m_j \end{aligned}$$

Let us investigate alternative (i) first. We see that $\Delta m_j < \Delta m_i$. Therefore $\mathcal{M}$ will tend to a limit and so t will become constant after that Δt will become zero. This corresponds to close universe. On the other hand alternative (ii) corresponds to open universe. It is clear from the second alternative that $\Delta t_j > \Delta t_i$. It means that clocks slow down when time advances from present to future.

Now use

$$\Delta E = \Delta mc^2, \tag{23}$$

in eq.(21) we get

$$\Delta E = \frac{c^2 \Delta t_i}{\lambda t_i}, \tag{24}$$

which means that time advances towards future on the expense of energy.

Like time interval a similar expression can be obtained for length interval,

$$\Delta l_i = \frac{\lambda \Delta E l_i}{c^2}, \tag{25}$$

where

$$l_i = l_0 \exp(\lambda \mathcal{M}_i) \tag{26}$$

Eq.(25) is also true for close universe but then the length interval becomes zero for $l \geq l_{\max}$.

Since in our case the time interval, we call it cosmological second, is different at different time. One is required to do care while adding cosmological seconds from the big bang till now. The total time elapsed is,

$$T = \sum_{k=1}^{n} \Delta t_k \tag{27}$$

where Δt_k is a cosmological second at time t_k. The second alternative enables us to discretize time,

$$t_j = t_{j-1} e^{\eta} \tag{28}$$

where the dimensionless increment $\eta = \lambda \Delta E / c^2$. Therefore the total time elapse is,

$$T = \eta t_0 \sum_{k=1}^{n} e^{k\eta}. \tag{29}$$

where n represents the number of cosmological seconds. If we set $n = 1$, we get first cosmological second. For $n = 2$, we get first two cosmological seconds and so on. It is important to find the difference between two consecutive cosmological seconds,

$$\Delta \tau = \Delta t_{n+1} - \Delta t_n = \eta t_0 e^{n\eta}(e^{\eta} - 1), \tag{30}$$

which shows that the difference between two consecutive cosmological seconds during the early stage was small. During each cosmological second an amount Δm was created from energy in to mass due to vacuum fluctuation and so an enormous amount of matter was created very rapidly at the big bang. The creation process slowed down thereafter and it is further slowing down.

4 Conclusion

We have enveloped both classical and quantum regimes and treated them more or less classically. It is a good approximation which is evident from the expression (16). In which the lower values of index i refer to quantum regime which contributes negligibly small as compared to the leading terms in the expression. We have left various parameters like η and t_0 undetermined. In future studies we wish to determine them.

5 Acknowledgment

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From Editors

Our Referee, who preferred to stay anonymous, wrote:

"The authors suggest a description of the Universe where all forms of the matter are contained in clusters. It is assumed that each cluster contains smaller clusters, these clusters are divided into even smaller ones and so on. One can call this idea the universal self-similarity because: 1) it is applied from cosmic to microscopic scales; 2) the number of ways to form a cluster from sub-clusters is determined only by the relation between their volumes (no matter at which scale the given picture is considered).

I do not discuss the conclusions of this hypothesis (some of them like justification of the big bang bring nothing new) because the idea of the universal self-similarity contradicts facts we are aware of.

Indeed, we know, for example, that at large scales (hundreds of parsecs) the Universe is homogenous and isotropic while at lower scales the distribution of matter is highly inhomogenous. At the intermediate scales the structure may depend on the state of the system. For instance, the structures of ice and liquid water are completely different. Finally, at microscopical scales the structure cannot be arbitrary and it depends on the interactions. Take, for instance, the structures of molecules, atoms and nuclei which certainly violate the second assumption.

Therefore, I believe the paper is based on false assumptions and do not recommend its publication".

In spite of this opinion we decided to publish the paper for at least three reasons:

1) We consider the topic of the paper as very interesting and of primary meaning to physics. If, according to General Relativity, the spacetime is created by matter and matter is governed by the Laws of Thermodynamics then there should be some connection between the spacetime notions and the thermodynamical ones. The paper just presents one among the possible attempts to find the relation between future orientation of time and the growth of entropy.

2) The Referee does not criticize the paper but the principle on which the paper is based. Since this principle is widely used his objections cannot be treated as concerned with this particular paper.

3) The Referee's remark that the principle is not universal is very important by itself. It indicates the need to refine this principle and this is another interesting problem to the solution of which we would like to invite the Readers.