Hypersphere World-Universe Model

Cosmological Time

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Abstract

The main objective of this paper is to discuss the most important notions for any Cosmological model – Space, Time and Gravitation. According to Hypersphere World-Universe Model (WUM), the World is a 3D Hypersphere of the 4D Nucleus of the World, which is a 4D ball expanding in the fourth spatial dimension. All points of the Hypersphere are equivalent; there are no preferred centers or boundaries of the World. The World is **Finite** and has a **Spatial Measure** – Radius of the curvature in the fourth spatial dimension R. All spatial parameters of the World can be measured relatively to R. Any cosmological model of the **Infinite** Universe has no Spatial Measure.

WUM introduces a Cosmological Time that is principally different from a Solar Time which is defined by the parameters of the Solar System: the **Rotation** of the Earth around its own axis (day) and the Sun (year). Cosmological Time is defined by an **Impedance** of the Medium of the World that equals to the Hubble's parameter. Cosmological Time τ is a **Timing Measure** of the World that defines the Age of the World. All timing parameters of the World can be measured relatively to τ. WUM concludes that any theory of evolution of the Universe should be consistent with the Cosmological Time.

WUM states a Supremacy of Matter: Time, Space and Gravitation have no separate existence from Matter. They are closely connected with the Impedance, Gravitomagnetic parameter, and Energy density of the Medium of the World respectively. Gravitation, Space and Time are all emergent phenomena. In this regard, it is worth recalling Albert Einstein quote: "*When forced to summarize the theory of relativity in one sentence: time and space and gravitation have no separate existence from matter*".

Keywords

"Hypersphere World-Universe Model"; "Spatial Measure"; "Timing Measure"; "Cosmological Time"; "Solar Time"; "Medium of the World"; "Macroobjects"; "Supremacy of Matter"; "The World"; "Gravitomagnetic parameter"; "Impedance"; "Energy Density"; "Gravitational Constant"; "Hubble's Parameter"; "Temperature of Microwave Background Radiation"; "Inter-Connectivity of Primary Cosmological Parameters"; "Variable Speed of Time": "Emergent Phenomena".

1. Introduction

E. Conover outlined the following situation with the measurements of an expansion rate of the universe in "*Debate over the universe's expansion rate may unravel physics. Is it a crisis?*" [1]:

- *Scientists with the Planck experiment have estimated that the universe is expanding at a rate of 67.4 km/s Mpc with an experimental error of 0.5 km/s Mpc;*
- *But supernova measurements have settled on a larger expansion rate of 74.0 km/s Mpc, with an error of 1.4 km/s Mpc. That leaves an inexplicable gap between the two estimates.*

L. Verde, T. Treu, and A. G. Riess gave a brief summary of the "*Workshop at Kavli Institute for Theoretical Physics, July 2019*" [2]. It is not yet clear whether the discrepancy in the observations is due to systematics, or indeed constitutes a major problem for the Standard Cosmology.

In our view, the situation with conflicting measurements of expansion rate of the universe is only a crisis for the "Big Bang" Cosmology when based on Solar Time along with constant Primary Cosmological Parameters (PCPs). This major problem for the "Big Bang" Cosmology can be explained by WUM based on Cosmological Time along with time-varying PCPs (see Section 2.3).

Many results obtained in WUM are quoted in the current work without a full justification; an interested reader is encouraged to view the referenced papers in such cases [3]-[21].

2. The World

2.1. Beginning, Expansion, Creation of Matter, Content

Before the Beginning of the World there was nothing but an Eternal Universe. About 14.22 billion years ago the World was started by a fluctuation in the Eternal Universe, and the Nucleus of the World, which is a 4D ball, was born. An extrapolated Nucleus radius at the Beginning was equal to the basic unit of size a [3], [4], [14]. The 3D World is a Hypersphere that is the surface of a 4-ball Nucleus. All points of the Hypersphere are equivalent; there are no preferred centers or boundaries of the World [17], [18], [19], [21].

The 4-ball is expanding in the Eternal Universe, and its surface, the Hypersphere, is likewise expanding. The radius of the Nucleus R is increasing with speed c (gravitodynamic constant [18]) for the Cosmological time τ from the Beginning and equals to $R = c\tau$. The expansion of the Hypersphere World can be understood through the analogy with an expanding 3D balloon: imagine an ant residing on a seemingly two-dimensional surface of a balloon. As the balloon is blown up, its radius increases, and its surface grows. The distance between any two points on the surface increases. The ant sees her world expand but does not observe a preferred center [17].

According to WUM, the surface of the 4-ball is created in a process **analogous to sublimation**. Continuous creation of matter is the result of this process. Sublimation is a well-known endothermic process that happens when surfaces are intrinsically more energetically favorable than the bulk of a material, and hence there is a driving force for surfaces to be created [9].

As the result of this process, the radius of the Nucleus R is increasing. It allows us to introduce a notion of "Time" and answer an unsolved General Physics question about the "arrow of time" – a

concept positing the "one-way direction" or "asymmetry" of time. In frames of WUM, R and $\tau = \frac{R}{c}$ are continuously increasing in "one-way direction" due to the driving force for surfaces to be created.

Matter arises from the fourth spatial dimension. The Universe is responsible for the creation of Matter. Dark Matter Particles (DMPs) carry new Matter into the World. Luminous Matter is a byproduct of DMPs self-annihilation. Consequently, the matter-antimatter asymmetry problem discussed in literature does not arise (since antimatter does not get created by DMPs self-annihilation). Creation of Matter is a direct consequence of expansion [6], [7], [10].

The World consists of the Medium and Macroobjects (Superclusters, Galaxies, Extrasolar systems, planets, moons, etc.). Total energy density of the World equals to the critical energy density throughout the World's evolution. The energy density of the Medium is $2/3$ of the total energy density and Macroobjects —$1/3$ in all cosmological times [9], [12], [15], [16].

2.2. The Medium of the World

WUM introduces the Medium of the World, which consists of stable elementary particles: protons, electrons, photons, neutrinos, and DMPs. The existence of the Medium is a principal point of WUM. It follows from the observations of Intergalactic Plasma; Cosmic Microwave Background Radiation (MBR); Far-Infrared Background Radiation. Cosmic MBR is part of the Medium; it then follows that the Medium is an absolute frame of reference. Relative to the MBR rest frame, the Milky Way galaxy and the Sun are moving with the speed of 552 and 370 km/s respectively [9].

WUM is based on Maxwell's equations for the Electromagnetism and Gravitoelectromagnetism, which contain [13]:

- a single constant: the electrodynamic and gravitodynamic constant c ;
- two parameters of the Medium: the magnetic constant (or vacuum permeability) μ_0 and the gravitomagnetic parameter μ_g ; impedance of free space $Z_0 = \mu_0 c$ and impedance of the Medium $Z_g = \mu_g c$;
- two measurable characteristics: an energy density and energy flux density.

Following WUM approach, we can find the gravitomagnetic parameter of the Medium $\mu_g = R^{-1}$ and the impedance of the Medium $Z_g = H = \tau^{-1}$, where H is a Hubble's parameter [5].

It follows that measuring the value of Hubble's parameter **anywhere** in the World and taking its inverse value allows us to calculate the absolute Age of the World. The Hubble's parameter is then the most important characteristic of the World, as it defines the Worlds' Age. While in our Model Hubble's parameter H has a clear physical meaning, the gravitational parameter $G = \frac{a^3 c^3}{8\pi h c} H$ is a phenomenological coefficient in Newton's law of universal gravitation (h is Planck constant).

The second important characteristic of the World is the gravitomagnetic parameter μ_g . Taking its inverse value, we can find the absolute radius of the curvature of the World in the fourth spatial dimension. We emphasize that the above two parameters (Z_g and μ_g) are principally different physical characteristics of the Medium that are connected through the gravitodynamic constant c .

It means that "Time" is not a physical dimension and is an absolutely different entity than "Space". Time is a factor of the World.

The third important parameter is an energy density of the Medium ρ_M of the World. Gravitational parameter G can be calculated based on the value of ρ_M [9]:

$$G = \frac{\rho_M}{4\pi} \times P^2$$

where a dimension-transposing parameter P equals to:

$$P = a^3 c^2 / 2hc$$

Then the Newton's law of universal gravitation can be rewritten in the following way:

$$F = G\frac{m \times M}{r^2} = \frac{\rho_M}{4\pi}\frac{\frac{a^3}{2L_{Cm}} \times \frac{a^3}{2L_{CM}}}{r^2}$$

where we introduced the measurable parameter of the Medium ρ_M instead of the phenomenological coefficient G; and gravitomagnetic charges $\frac{a^3}{2L_{Cm}}$ and $\frac{a^3}{2L_{CM}}$ instead of macroobjects masses m and M (L_{Cm} and L_{CM} are Compton length of mass m and M respectively). The gravitomagnetic charges have a dimension of "Area", which is equivalent to "Energy", with the constant that equals to the basic unit of surface energy density $\sigma_0 = \frac{hc}{a^3}$ [3], [9].

In WUM, Time, Space and Gravitation are closely connected with the Mediums' parameters. It follows that neither Time, Space nor Gravitation could be discussed in absence of the Medium. Gravitation, Space and Time are all emergent phenomena [8].

2.3. Inter-Connectivity of Primary Cosmological Parameters

The constancy of the universe fundamental constants, including Newtonian constant of gravitation, is now commonly accepted, although has never been firmly established as a fact. All conclusions on the (almost) constancy of G are model-dependent. A commonly held opinion states that gravitation has no established relation to other fundamental forces, so it does not appear possible to calculate it from other constants that can be measured more accurately, as is done in some other areas of physics. WUM holds that there indeed exist relations between all PCPs, which depend on dimensionless time-varying quantity $Q = \frac{R}{a} = \frac{\tau}{t_0}$ ($t_0 = \frac{a}{c}$ is a basic unit of time [3]) that increases with cosmological time τ, and is, in fact, a measure of the Size and the Age of the World.

The Model develops a mathematical framework that allows for direct calculation of the following PCPs through Q [3], [11]:

- Age of the World: $A_\tau = \tau \sim Q$;
- The Worlds' radius of curvature in the fourth spatial dimension: $R = c\tau \sim Q$;
- Newtonian parameter of gravitation: $G \sim Q^{-1} \sim \tau^{-1}$;
- Hubble's parameter: $H = \tau^{-1} \sim Q^{-1}$;
- Critical energy density: $\rho_{cr} = 3\rho_{cr0} \times Q^{-1} \sim \tau^{-1}$ ($\rho_{cr0} = \frac{hc}{a^4}$):
- Concentration of Intergalactic Plasma: $n_{IGP} \sim Q^{-1} \sim \tau^{-1}$;
- Minimum Energy of Photons: $E_{ph} \sim Q^{-1/2} \sim \tau^{-1/2}$;

- Temperature of the Far-Infrared Background Radiation peak: $T_{FIRB} \sim Q^{-1/4} \sim \tau^{-1/4}$;
- Temperature of the Microwave Background Radiation: $T_{MBR} = T_{MBR0} \times Q^{-1/4} \sim \tau^{-1/4}$.

In frames of WUM, we calculate the values of these PCPs, which are in good agreement with the latest results of their measurements [9], [17], [20].

At the Beginning of the World ($Q=1$), the extrapolated values of ρ_{cr0} and T_{MBR0} were:

$$\rho_{cr0} \cong 6.064 \times 10^{30} J\, m^{-3}$$

that is four orders of magnitude smaller than the nuclear density, and

$$T_{MBR0} \cong 2.5446 \times 10^{10}\ \mathrm{K}$$

which is considerably smaller than values commonly discussed in literature [3]. Let's proceed to calculate the value of T_{MBR} and H at different Cosmological times of the World.

Table 1. Values of Temperature of Microwave Background Radiation and Hubble's parameter at different Cosmological times of the World.

Cosmological Time, τ	T_{MBR} , K	H, $km/s\,Mpc$
1 s	7.0538×10^4	
0.45 Byr (Luminous Epoch)	6.4775	2172
9.65 Byr (Birth of the Solar system)	3.0141	101.3
14.22 Byr (Present)	2.72518	68.7457

The calculated value of T_{MBR} in present epoch is in excellent agreement with experimentally measured value of $2.72548 \pm 0.00057\ K$ [22].

Calculating the value of Hubble's parameter in the present epoch H_0 based on the average value of the gravitational parameter G we find $H_0 = 68.7457\ km/s\ Mpc$, which is in good agreement with $H_0 = 69.32 \pm 0.8\ km/s\ Mpc$ obtained using WMAP data [23] and with the newest value of

$$H_0 = 69.6 \pm 0.8\ (\pm 1.1\%\ stat) \pm 1.7\ (\pm 2.4\%\ sys)\ km/s\ Mpc$$

found by W. L. Freedman, *et al.* using *the revised (and direct) measurement of the LMC (Large Magellanic Cloud) TRGB (Tip of the Red Giant Branch) extinction* [24].

Note that the precision of H_0 value has increased by three orders of magnitude. Similar precision enhancement holds for other PCPs' values as well.

E. Siegel in the paper "*Surprise! The Hubble Constant Changes Over Time*" [25] said that

The expansion rate, and therefore the value of the Hubble constant, changes with time. The Hubble constant was higher in the distant past, when much of the light was emitted, but it's taken billions of years for that light to arrive at our eyes. If we went back to a time when the Universe was half its present age, the expansion rate was 80% greater than it is today. When the Universe was just 10% of its current age, the expansion rate was 17 times greater than its present value.

These values of the Hubble's parameter are in good agreement with the calculated values in frames of WUM (see **Table 1**).

3. Cosmological Time and Solar Time

The time we use in everyday life is defined by parameters of the Solar System: the rotation of the Earth around its own axis (day) and the Sun (year). Let's name this scale "Solar Time". The World exists for much longer time than our Solar system: 14.22 Billion years vs. 4.57. Are we justified in using Solar Time to describe events throughout the history of the World?

In WUM, we introduced a Cosmological Time and defined the Age of the World A_τ that equals to $A_\tau = \tau$ and the Worlds' radius of the curvature in the fourth spatial dimension $R = c\tau$. Cosmological Time marches on at constant pace since the Beginning of the World until the present Epoch and is, in fact, a Timing Measure.

WUM revealed the Inter-Connectivity of PCPs and found them to be inversely proportional to different exponents of τ (see Section 2.3.). It means that at cosmological times close to the Beginning of the World, PCPs changed considerably faster than in the present Epoch. For example, the temperature of Microwave Background Radiation dropped down from the extrapolated value of 2.5446×10^{10} K to the value of 6.4775 K during Dark Epoch (0.45 Byr) and to the value of 2.72518 K during Luminous Epoch (13.77 Byr).

R. M. L. Baker Jr. in the paper "*A Theory of Our Universe*" proposed a revolutionary "*idea of a variable speed of time that has never before been put into the context of cosmology and a theory of our Universe*". According to Baker, "*the speed of time variation is much faster in the past than at the more recent time*" [26]. It is interesting that "*Notional graph of the change-of-speed-of-time variation with today's time dimension*" in [26] looks like a graph of a function $y = \frac{1}{x}$ (compare with the dependence of PCPs values $\sim \frac{1}{\tau}$ in WUM).

4. Conclusions

In our view, the situation with conflicting measurements of expansion rate of the universe (outlined in the Introduction) is only a crisis for the "Big Bang" Cosmology when based on Solar Time along with constant PCPs. This major problem for the "Big Bang" Cosmology can be explained by

- "Big Rollout" Cosmology proposed by R. M. L. Baker Jr. that is based on a variable speed of the Solar Time [26];
- WUM that is based on Cosmological Time that marches on at the constant pace along with time-varying PCPs.

In our opinion, WUM gives the most probable way to solve the crisis with the measurements of the expansion rate of the World.

WUM does not attempt to explain all available cosmological data, as that is an impossible feat for any one manuscript. Nor does WUM pretend to have built an all-encompassing theory that can be accepted as is. The Model needs significant further elaboration, but in its present shape, it can already serve as a basis for a new Physics proposed by Paul Dirac in 1937. The Model should be developed into a well-elaborated theory by the entire physical community.

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I am a Doctor of Sciences in Physics. I belong to the school of physicists established by Alexander Prokhorov–Nobel Prize Laureate in Physics. I am a Laser Physicist by education, having published over 150 papers in the field of "Interaction of Laser Radiation with Matter". I'm eternally grateful to Prof. A. M. Prokhorov and Prof. A. A. Manenkov, whose influence on my scientific life has been decisive.

18 years ago, I developed an interest in Cosmology. I have been elaborating a model I dubbed the World-Universe Model, and published a series of papers in the Journal of High Energy Physics, Gravitation and Cosmology (JHEPGC). I am much obliged to Prof. C. Corda for publishing my manuscripts in JHEPGC.

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