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Holography Unveiled: A New Approach to Understanding Dark Energy in LRS Bianchi Type-I Cosmologies

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Abstract: The unexplained nature of dark energy continues to present a challenge to our fundamental understanding of the expansion of the cosmos. A fresh perspective is presented in this work through the lens of holography in the setting of Locally Rotationally Symmetric (LRS) Bianchi Type-I cosmologies. The purpose of this study is to unravel the riddles that surround it. Drawing on the holographic principle, which states that the information content of an area of space can be encoded on its boundary, we suggest a novel framework to investigate the nature of dark energy within these particular cosmological models. This framework is based on the holographic principle. We are able to uncover fascinating linkages between the geometric characteristics of the universe and the fundamental dynamics of dark energy through the utilization of holography. The implications of holographic principles on the evolution of LRS Bianchi Type-I cosmologies are investigated by means of rigorous mathematical analysis and computational simulations. This allows us to shed light on the complicated interplay that exists between geometry and energy content. Based on our findings, it appears that holography presents a potentially fruitful approach to understanding the mysterious nature of dark energy within the context of LRS Bianchi Type-I cosmologies. Further, we highlight the possible consequences of this method for enhancing our knowledge of the ultimate fate of the universe as well as the acceleration of the cosmos as a whole. Not only does this discovery make a contribution to the continuing discussion on dark energy, but it also highlights the significant role that holography plays in forming our understanding of the universe.

Keywords - Dark energy, Holography, LRS Bianchi Type cosmologies, Cosmological paradigm

I. INTRODUCTION

The expansion of the universe is occurring at a rate that has never been seen before, and one of the most perplexing aspects of contemporary cosmology is the unexplained component known as dark energy. Within the framework of Locally Rotationally Symmetric (LRS) Bianchi Type-I cosmologies, this work presents a novel perspective by employing holography within the context of ongoing efforts to comprehend the origins and properties of this type of cosmology. Holography, which is predicated on the concept that the information content of a spatial region can be inscribed on its boundary, offers an exciting lens through which to investigate the intricate relationship that exists between geometry and the dynamics of dark energy. The purpose of this effort is to increase our understanding of the fundamental mechanisms that guide the evolution of the universe by providing light on the nature of dark energy in specific cosmological scenarios. This will be accomplished by performing an investigation into the implications of holographic principles. The Locally Rotationally Symmetric (LRS) Bianchi type-I cosmological model loaded up with anisotropic liquid was examined by Adhav et al. (2013). This model was introduced with regards to general hypothesis of relativity.

Mete et al.(2018) investigated the interaction between cold dark matter (CDM) and holographic dark energy (DE) in a Bianchi-type system that is locally rotationally symmetric (LRS). Utilizing scalar development proportionate to the shear scalar, directly factor deceleration boundary, and energy thickness of adjusted holographic Ricci dull energy, Rao et al. (2018) had the option to decide the answer for the model that we had used. Inside the setting of the $f(G)$ hypothesis of gravity, Shaif et al. (2020) directed research on Locally Rotationally Symmetric (LRS) Bianchi type-I displays that included holographic dim energy.

An examination concerning the (LRS) Bianchi-type-I cosmological model with holographic dim energy was done by Pradhan et al. (2021). Through the use of the summed up cross breed extension regulation (HEL), they had the option to obtain the exact answers for the field conditions that related to them. With regards to the Brans-Dicke hypothesis of gravity, Santhi et al. (2022) led an examination concerning the spatially homogenous and anisotropic space-seasons of the Bianchi type-II, VIII, and IX assortments. This examination was done inside the structure of thick holographic dull energy. With regards to the self-creation hypothesis, Santhi et al. (2022) looked into the LRS Bianchi type-I space-time within the Barrow holographic dark energy continuation. Inside the structure of Bianchi type-II cosmology, Sen and Agrawal (2022) explore the change $R, f(t)$by utilizing the $f(R,T)$model. In order to successfully obtain the answer, they made use of the power law relationship that exists between the typical scale factor (R) and the average Hubble parameter H. A communicating dull energy (DE) model was examined by Rathore and Singh (2023) with regards to a locally rotationally symmetric (LRS) Bianchi type I cosmological model. This model incorporated a scalar field that was as an outstanding potential.

The LRS Bianchi type-I cosmological model was researched by Patil et al. (2023) inside the setting of the $f(R,T)$gravity structure. In this specific situation, R addresses the Ricci scalar, and T addresses the pressure energy force tensor. The review was led within the sight of a space wall.

II. FUNDAMENTAL FIELD EQUATIONS AND THE LRS BIANCHI TYPE-I UNIVERSE EQUATIONS

As part of this cosmological model, we take into consideration the LRS Bianchi type I metric, which is expressed as

$$ds^2 = -dt^2 + {A_1}^2 dx^2 + {A_2}^2 (dy^2 + dz^2) \quad (1)$$

which means that the metric coefficients "$A_1$and A_2" are simply functions of the variable t.

Using Einstein's field equation in conjunction with the cosmic constant in general relativity's framework

$$R_{ij} - \frac{1}{2} g_{ij} R + \Lambda_{g_{ij}} = -\left(T_{ij} + \bar{T}_{ij}\right) \quad (2)$$

These notations carry the significance that is typical of them. In order to assemble the new HDE for actual interpretation and the energy momentum tensor for matter, the following formula can be used:

$$T_{ij} = \rho_m u_i u_j \quad (3)$$

$$\bar{T}_{ij} = (\rho_d + p_d) u_i u_j + g_{ij} p_d \quad (4)$$

The matter energy density and the new HDE density are denoted by the symbols ρ_m and ρ_d, respectively, while the HDE pressure is denoted by the symbol p_d. The field equations, which are given by equation (2), in conjunction with the energy momentum tensors that were defined earlier for the LRSBT-I metric composed of three independent equations are as follows:

$$2\frac{\ddot{A_2}}{A_2} + \frac{\dot{A_2}^2}{{A_2}^2} = -\rho_d + \Lambda \quad (5)$$

$$\frac{\ddot{A_1}}{A_1} + \frac{\ddot{A_2}}{A_2} + \frac{\dot{A_1}}{A_1}\frac{\dot{A_2}}{A_2} = -\rho_d + \Lambda \quad (6)$$

$$2\frac{\dot{A_1}}{A_1}\frac{\dot{A_2}}{A_2} + \frac{\dot{A_2}^2}{{A_2}^2} = \rho_m + \rho_d + \Lambda \quad (7)$$

The HDE density with IR cut-off is defined as:

$$\rho_d = 3M_p^2 (aH^2 + lb) \quad (8)$$

Given that a and b are dimensionless parameters, it is imperative that they adhere to the constraints imposed by the existing observational framework, which is characterized by $M_p^2 = 8\pi G = 1$. The legislation governing the conservation of energy is established as

$$T^{ij}_{;j} = 0 \tag{9}$$

gives $\rho_m + \dot{\rho}_d + 3H(\rho_{m+}\rho_d + p_d) = 0$ (10)

Separately represented as the energy conservation law formatter and dark energy are the characteristics of the

$$\dot{\rho}_m + 3H\rho_m = 0 \tag{11}$$

$$\dot{\rho}_d + 3H(\rho_d + p_d) = 0 \tag{12}$$

The parameter H, which is given by the equation $H = \frac{\dot{R}(t)}{R(t)}$, is the Hubble parameter. The dot in this equation denotes a time derivative. Due to the fact that the Hubble constant H_0 is the current value, the Hubble parameter changes throughout time rather than traveling across space. A dimensionless scale factor $R(t)$ is used to parametrize the relative growth of the universe from the beginning of time. It is essential to have the Hubble constant, also known as H_0, because it is required in order to calculate the age and size of the universe. From the time of the "Big Bang" up until the present day, the rate at which the universe is expanding is denoted by the letter H.

III. Solution of the Problem

The time variable deceleration parameter that Akarsu and Dereli (2019) brought up for consideration

$$q = -\frac{R\ddot{R}}{\dot{R}^2} = -kt + n - 1 \tag{13}$$

While $k \geq 0$and $n \geq 0$ are constants, the average scale factor is denoted by the letter $R(t)$. By solving equation (13), we obtain

$$R(t) = \left(\frac{kt}{2n-kt}\right)^{\frac{1}{n}} \tag{14}$$

A connection between metric potentials and the link between

$$A_1 = {A_2}^m \tag{15}$$

In which $m$is a positive constant that is responsible for the anisotropic behavior of the space-time, and where m is not equal to 1. There is a relationship between the scale factor $(R)$and the spatial volume $(V)$of the space-time (4).

$$V = R^3 = A_1{A_2}^2 \tag{16}$$

Using equations (14) and (16), we are able to obtain

$$A_1{A_2}^2 = \left(\frac{kt}{2n-kt}\right)^{\frac{3}{n}}$$

$${A_2}^m{A_2}^2 = \left(\frac{kt}{2n-kt}\right)^{\frac{3}{n}}$$

$${A_2}^{m+2} = \left(\frac{kt}{2n-kt}\right)^{\frac{3}{n}}$$

$$A_2 = \left(\frac{kt}{2n-kt}\right)^{\frac{3}{n(m+2)}} \tag{17}$$

$$A_1 = \left(\frac{kt}{2n-kt}\right)^{\frac{3m}{n(m+2)}} \tag{18}$$

The Hubble Parameter can be calculated as follows:

$$H = \frac{1}{3}\left(\frac{\dot{A_1}}{A_1} + 2\frac{\dot{A_2}}{A_2}\right) \tag{19}$$

Where

$$H_1 = \frac{\dot{A_1}}{A_1}, H_2 = \frac{\dot{A_2}}{A_2}$$

$$H_1 = \frac{\dot{A_1}}{A_1} = \frac{\frac{6m\left(\frac{kt}{2n-kt}\right)^{\frac{3m}{n(m+2)}}}{t(m+2)(2n-kt)}}{\left(\frac{kt}{2n-kt}\right)^{\frac{3m}{n(m+2)}}} = \frac{6m}{t(m+2)(2n-kt)}$$

$$H_2 = \frac{\dot{A_2}}{A_2} = \frac{\frac{6\left(\frac{kt}{2n-kt}\right)^{\frac{3}{n(m+2)}}}{t(m+2)(2n-kt)}}{\left(\frac{kt}{2n-kt}\right)^{\frac{3}{n(m+2)}}} = \frac{6}{t(m+2)(2n-kt)}$$

$$H = \frac{1}{3}\left[\frac{6m}{t(m+2)(2n-kt)} + \frac{12}{t(m+2)(2n-kt)}\right] = \frac{2}{(2n-kt)t} \tag{20}$$

We are able to derive the HDE of the model by using equations (8) and (20) as follows:

$$\rho_d = 3\left(aH^2 + b\dot{H}\right)$$

$$\dot{H} = \frac{4(kt-n)}{t^2(2n-kt)^2}$$

$$\rho_d = 3\left[\frac{4a}{t^2(2n-kt)^2} + \frac{4b(kt-n)}{t^2(2n-kt)^2}\right]$$

$$\rho_d = 12\left[\frac{a+bkt-bn}{t^2(2n-kt)^2}\right] = \frac{12(bkt+a-bn)}{t^2(2n-kt)^2} \tag{21}$$

Given that the energy conservation law $\dot{\rho_d} + 3H(1+\omega_d)\rho_d = 0$ is established, the EoS parameter can be obtained as follows:

$$\omega_d = -\frac{\dot{\rho_d}}{3H\rho_d} - 1$$

$$\omega_d = \frac{\frac{12\{3k^2bt^2+(4ak-6kbn)t+4bn^2-4an\}}{t^3(2n-kt)^3}}{3\frac{2}{(2n-kt)t}\cdot\frac{12(bkt+a-bn)}{t^2(2n-kt)^2}} - 1$$

$$\omega_d = \frac{\{3k^2bt^2+(4ak-6kbn)t+4bn^2-4an\}}{6(bkt+a-bn)} - 1 \tag{22}$$

A parameter for the HDE density

$$\Omega_d = \frac{\rho_d}{3H^2} = \frac{\frac{12(bkt+a-bn)}{t^2(2n-kt)^2}}{\frac{12}{t^2(2n-kt)^2}} = bkt + a - bn \tag{23}$$

We are in possession of the equation of state.

$$p_d = \rho_d\omega_d$$

$$p_d = \frac{12(bkt+a-bn)}{t^2(2n-kt)^2}\left[\frac{\{3k^2bt^2+(4ak-6kbn)t+4bn^2-4an\}}{6(bkt+a-bn)} - 1\right] \tag{24}$$

$$2\frac{\ddot{A_2}}{A_2} + \frac{\dot{A_2}^2}{A_2^2} = -\rho_d + \Lambda$$

$$\Lambda = 2\frac{\ddot{A_2}}{A_2} + \frac{\dot{A_2}^2}{A_2^2} + \rho_d$$

$$\frac{\dot{A_2}^2}{A_2^2} = \frac{36}{t^2(m+2)^2(2n-kt)^2}$$

$$\frac{\ddot{A_2}}{A_2} = \frac{\frac{12\{(m+2)kt-(m+2)n+3\}\left(\frac{kt}{2n-kt}\right)^{\frac{3}{n(m+2)}}}{t^2(m+2)^2(2n-kt)^2}}{\left(\frac{kt}{2n-kt}\right)^{\frac{3}{n(m+2)}}} = \frac{12\{(m+2)kt-(m+2)n+3\}}{t^2(m+2)^2(2n-kt)^2}$$

$$\Lambda = 2\frac{\ddot{A_2}}{A_2} + \frac{\dot{A_2}^2}{A_2^2} + \rho_d$$

$$\Lambda = \frac{24\{(m+2)kt-(m+2)n+3\}}{t^2(m+2)^2(2n-kt)^2} + \frac{36}{t^2(m+2)^2(2n-kt)^2} + \frac{12(bkt+a-bn)}{t^2(2n-kt)^2}$$

$$\Lambda = \frac{36+24\{(m+2)kt-(m+2)n+3\}+12(bkt+a-bn)}{t^2(m+2)^2(2n-kt)^2} \tag{25}$$

$$2\frac{\dot{A_1}}{A_1}\frac{\dot{A_2}}{A_2} + \frac{\dot{A_2}^2}{A_2^2} = \rho_m + \rho_d + \Lambda$$

$$\rho_m = 2\frac{\dot{A_1}}{A_1}\frac{\dot{A_2}}{A_2} + \frac{\dot{A_2}^2}{A_2^2} - \rho_d - \Lambda$$

$$\rho_m = \frac{6m}{t(m+2)(2n-kt)}\cdot\frac{6}{t(m+2)(2n-kt)} + \frac{36}{t^2(m+2)^2(2n-kt)^2} - \frac{12(bkt+a-bn)}{t^2(2n-kt)^2} - \frac{36+24\{(m+2)kt-(m+2)n+3\}+12(bkt+a-bn)}{t^2(m+2)^2(2n-kt)^2}$$

$$\rho_m = \frac{36m}{t^2(m+2)^2(2n-kt)^2} + \frac{36}{t^2(m+2)^2(2n-kt)^2} - \frac{12(bkt+a-bn)}{t^2(2n-kt)^2} - \frac{36+24\{(m+2)kt-(m+2)n+3\}+12(bkt+a-bn)}{t^2(m+2)^2(2n-kt)^2}$$

$$\rho_m = \frac{36m}{t^2(m+2)^2(2n-kt)^2} - \frac{12(bkt+a-bn)}{t^2(2n-kt)^2} - \frac{24\{(m+2)kt-(m+2)n+3\}+12(bkt+a-bn)}{t^2(m+2)^2(2n-kt)^2}$$

$$\rho_m = \frac{36m-12(m+2)^2(bkt+a-bn)-24\{(m+2)kt-(m+2)n+3\}+12(bkt+a-bn)}{t^2(m+2)^2(2n-kt)^2}$$

Determining the density of the matter substance

$$\Omega_d = \frac{\rho_m}{3H^2} = \frac{\frac{36m-12(m+2)^2(bkt+a-bn)-24\{(m+2)kt-(m+2)n+3\}+12(bkt+a-bn)}{t^2(m+2)^2(2n-kt)^2}}{\frac{12}{t^2(2n-kt)^2}}$$

$$\Omega_m = \frac{\rho_m}{3H^2} = \frac{3m-(bkt+a-bn)-2\{(m+2)kt-(m+2)n+3\}+(bkt+a-bn)}{(m+2)^2} \quad (26)$$

Our capacity to describe the qualities of dull energy in a way that is free of a specific model is made conceivable by the Statefinder, which is a mathematical symptomatic. Just the scale component of the universe and its worldly subsidiaries are utilized in the development of the Statefinder, which is dimensionless for its development. We have demonstrated that the Statefinder diagnostic is effective at distinguishing between various types of dark energy in the model we have developed. It is additionally conceivable to examine the strength of DE models by using the statefinder indicative pair (r, s), which furnishes us with a comprehension into the dynamical idea of the model. A couple of boundaries known as the statefinder boundaries $(r, s)$are used to examine the elements of the development of the universe. Utilizing the scale factor's higher derivatives allows for this. In actuality, the directions in the (r, s)plane that relate to different cosmological models show subjective way of behaving.

$$r = \frac{\dddot{R}}{RH^3} = \frac{\frac{4\{3k^2t^2-6k(n-1)t+4n^2-6n+2\}\left(\frac{kt}{2n-kt}\right)^{\frac{1}{n}}}{(2n-kt)^3t^3}}{\left(\frac{kt}{2n-kt}\right)^{\frac{1}{n}}\frac{8}{(2n-kt)^3t^3}} = \frac{3k^2t^2-6k(n-1)t+4n^2-6n+2}{2}$$

$$r = \frac{\dddot{R}}{RH^3} = 1 + \frac{3k^2t^2-6k(n-1)t+4n^2-6n}{2} \quad (27)$$

$$s = \frac{r-1}{3\left(-\frac{1}{2}+q\right)} = \frac{\frac{3k^2t^2-6k(n-1)t+4n^2-6n}{2}}{3\left(-\frac{1}{2}+q\right)} = \frac{3k^2t^2-6k(n-1)t+4n^2-6n}{3(2n-2kt-3)}$$

$$s = \frac{r-1}{3\left(-\frac{1}{2}+q\right)} = \frac{3k^2t^2-6k(n-1)t+4n^2-6n}{3(2n-2kt-3)} \quad (28)$$

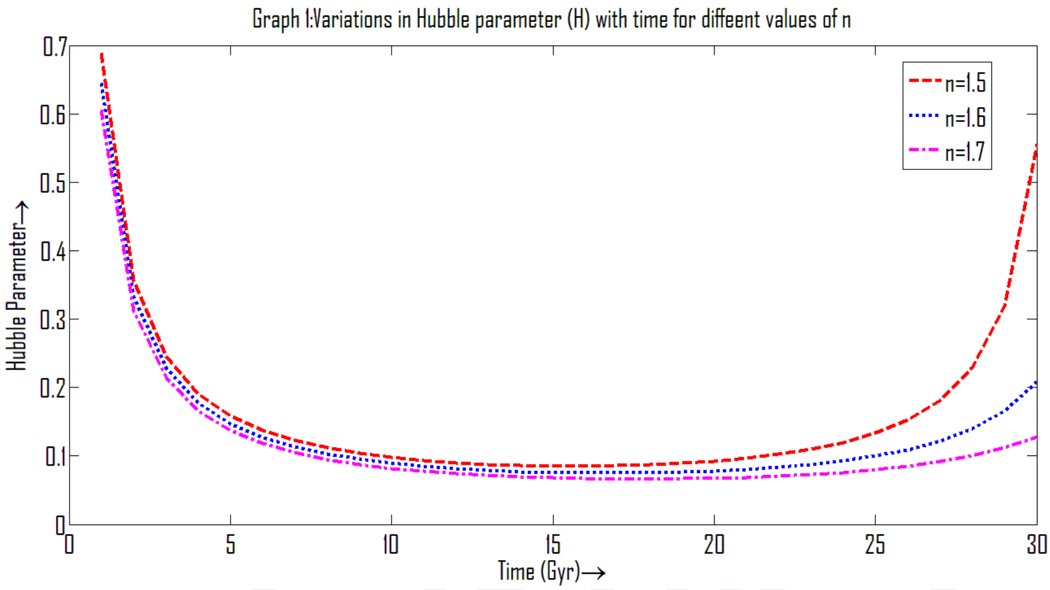
$$r = \frac{\dddot{R}}{RH^3} = \frac{1+3k^2t^2-6knt+5kt+4n^2-5n-n+kt+1}{2}$$

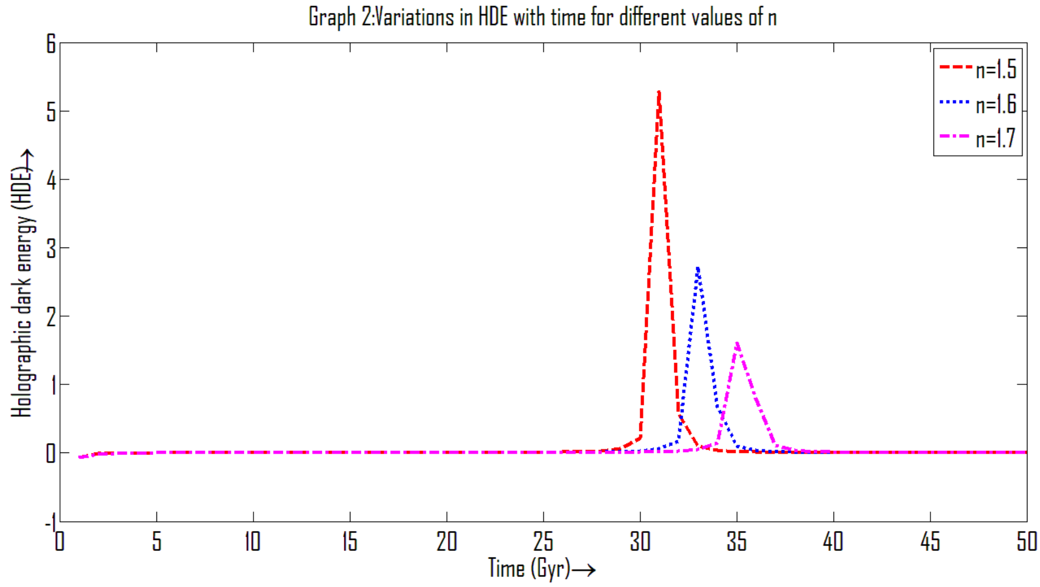
$$r = \frac{\dddot{R}}{RH^3} = \frac{1+3k^2t^2-6knt+5kt+4n^2-5n-(-kt+n-1)}{2}$$

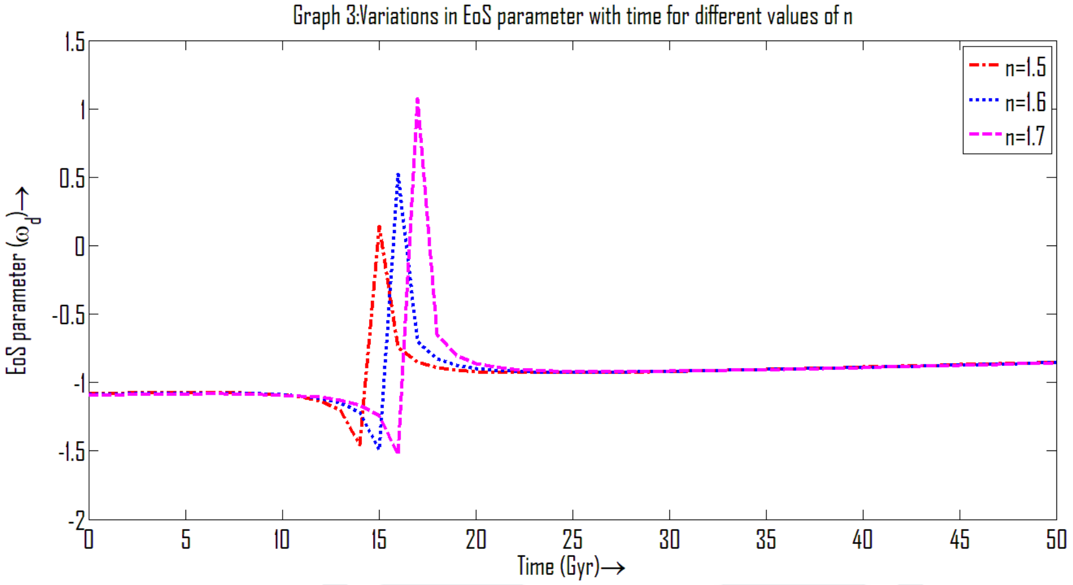
$$r = \frac{\dddot{R}}{RH^3} = \frac{1+3k^2t^2-6knt+5kt+4n^2-5n-q}{2} \quad (29)$$

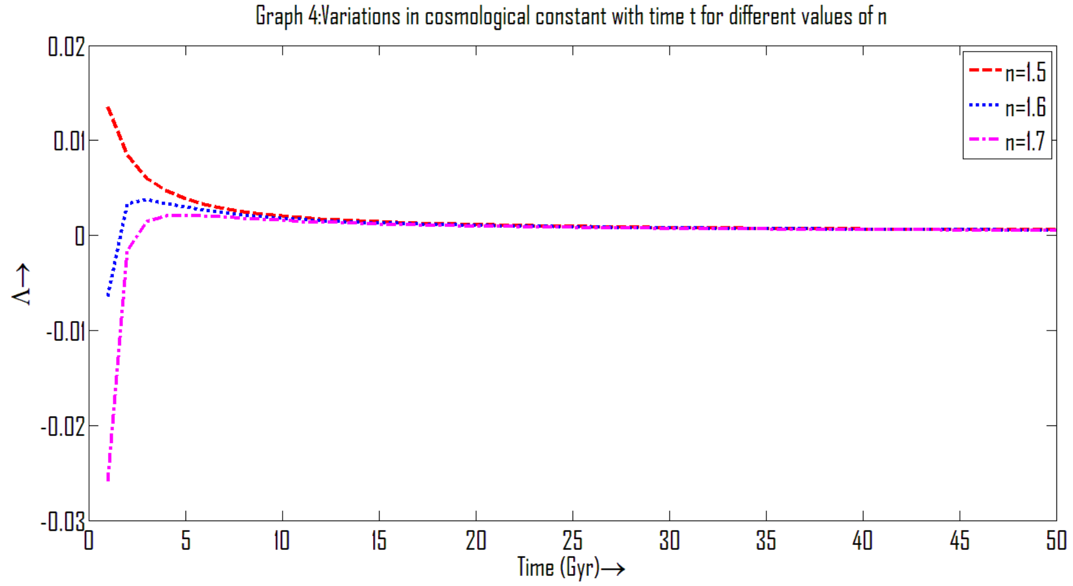
$$r = \frac{\dddot{R}}{RH^3} = 1 + \frac{3(2n-2kt-3)s}{2} \quad (30)$$

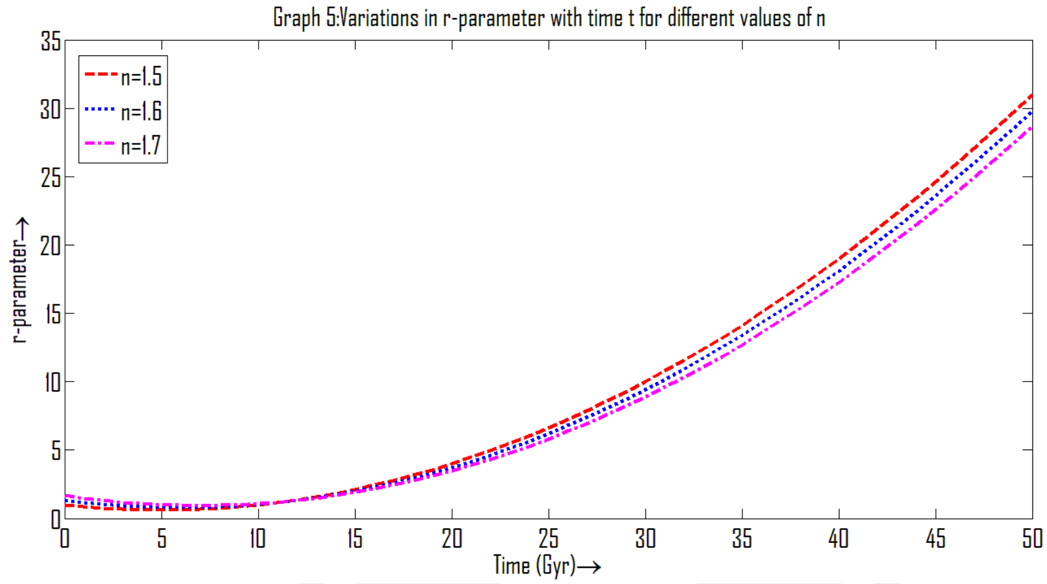
IV. Results and Discussion

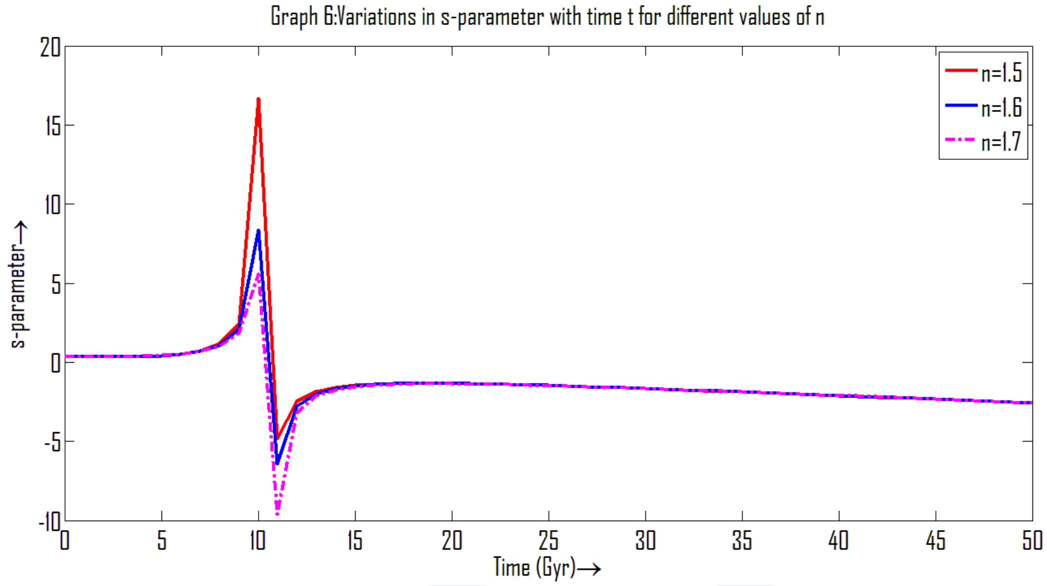


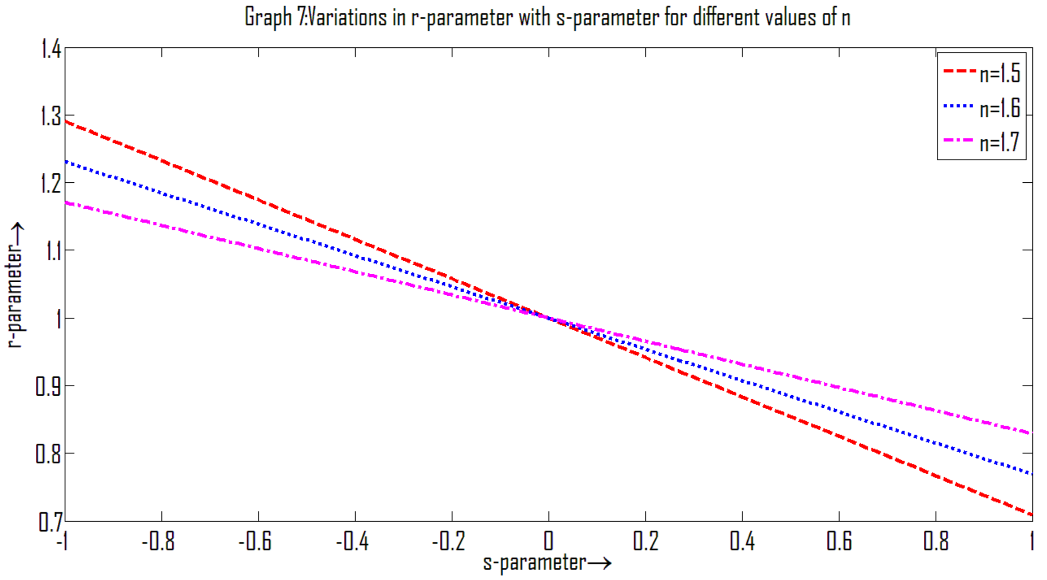



Graph 3:Variations in EoS parameter with time for different values of n
EoS parameter (ω_d)→
Time (Gyr)→
n=1.5
n=1.6
n=1.7
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
5
10
15
20
25
30
35
40
45
50


Graph 4:Variations in cosmological constant with time t for different values of n
Λ→
Time (Gyr)→
n=1.5
n=1.6
n=1.7
0.02
0.01
0
-0.01
-0.02
-0.03
0
5
10
15
20
25
30
35
40
45
50


Graph 5:Variations in r-parameter with time t for different values of n
n=1.5
n=1.6
n=1.7
r-parameter→
Time (Gyr)→


Graph 6:Variations in s-parameter with time t for different values of n
n=1.5
n=1.6
n=1.7
s-parameter→
Time (Gyr)→


Graph 7:Variations in r-parameter with s-parameter for different values of n
n=1.5
n=1.6
n=1.7
r-parameter→
s-parameter→

We are able to see from graph (1) that the Hubble parameter H diverges at both the beginning of the universe and at the end of the creation of the universe. The graph (2) illustrates how the behavior of holographic dark energy changes over the course of time. The graph would shed light on the behavior of holographic dark energy within the framework of LRS Bianchi Type-I cosmologies, as well as how it affects the dynamics of the evolution of the universe over the course of time. It is possible that it began at some initial epoch that corresponds to the early existence of the universe, when the density of dark energy was extremely low in comparison to the density of other components such as matter and radiation. It is possible that there may be a transitional era in which the impacts of dark energy will become increasingly prominent as the universe continues to expand and grow. The slope or curvature of the graph might shift as a result of this transition, which would be very noticeable. The graph (3) illustrates the progression of the EoS parameter $\omega_d$as a function of time for a variety of different values of n. In addition to being present in both the quintessence and phantom areas, the EoS parameter also penetrates the phantom divided line (PDL) with a value of $\omega_d = -1$. Graph (4) illustrates the relationship between the cosmological constant Λ and time (t), demonstrating the expansion of the universe. During the initial stages of the cosmos, near the Big Bang, the cosmological constant would have had little impact on the dynamics of the universe. Under this regime, the cosmos would be primarily governed by intense energetic phenomena like inflation or radiation, with the cosmological constant potentially having a minimal impact. The graph would exhibit a gradual and fluctuating pattern during this period. As the cosmos undergoes expansion and development, the impact of the cosmological constant may grow in importance. The dominance of the cosmological constant in the cosmic dynamics may occur during a transition phase, depending on the energy density of other components such as matter and radiation. This shift is evident as either a sudden surge or a steadier ascent in the graph. In the later stages of the cosmos, the graph would probably show a period of rapid expansion, mostly caused by the cosmological constant. The acceleration phase mentioned here refers to the observed increase in cosmic acceleration. It is a crucial characteristic of the ΛCDM (Lambda Cold Dark Matter) model, which includes a cosmological constant as its dark energy component. In this stage, the graph would exhibit a rapid rise, signifying the prevailing influence of the cosmological constant in propelling the expansion. The graph (5) illustrates the temporal variation of the r-parameter as the universe undergoes expansion and evolution. Based on the particular characteristics of the model, the value of r gradually increases over time, indicating variations in the level of anisotropy. The graph commences at an initial time that corresponds to the early universe, representing the parameter's state immediately after the Big Bang. As the universe progresses, the graph depicts the temporal variations of the s-parameter. In addition, the stability of DE models may be investigated by means of the statefinder diagnostic pair (r, s), which provides us with an opportunity to get insight into the dynamical characteristics of the model. A pair of parameters known as the statefinder parameters (r, s) are utilized in order to investigate the dynamics of the expansion of the cosmos. This is accomplished by utilizing the higher derivatives of the scale factor. As a matter of fact, the trajectories in the (r, s) plane that correspond to various cosmological theories exhibit qualitative behavior. The (r,s) trajectories in the generated model divide the region into two halves for the various values of n, as shown in graph (7). This is the case for all of the different options. For the region $r < 1, s > 0$, the quintessence era is represented, while the Chaplygin Gas (CG) region is represented by the region $r > 1, s < 0$.

V. Concluding Remarks

To summarize, the investigation of holography within the context of Locally Rotationally Symmetric (LRS) Bianchi Type-I cosmologies has presented a potentially fruitful path towards enhancing our comprehension of dark energy and the acceleration of the evolution of the universe. We were able to throw light on hitherto undiscovered aspects of the evolution of the cosmos by exploiting this novel technique, which allowed us to uncover intriguing linkages between the geometric characteristics of the universe and the dynamics of dark energy. For the purpose of clarifying the mysterious nature of dark energy within particular cosmological frameworks, we have made a huge step forward by adopting holography. Continuing research in this area has the potential to further unveil the mysteries of the cosmos and expand our understanding of fundamental cosmological processes. This opens up a lot of possibilities for the future.

REFERENCE:

1. Adhav K.S., Wankhade R.P., Bansod A.S. (2013): "LRS Bianchi Type-I cosmological model with anisotropic dark energy and special form of deceleration parameter", Journal of Modern Physics, 4(8):137-140.
2. Mete V.G. , Murade P.B. , Bansod A.S., Ingle V.M. (2018): "Interacting dark fluids in LRS Bianchi type-V universe", *Review of Research*, 7(12):1-10.
3. Patil V.R., Bolke P.A., Waghmare S.K., Pawde J.L. (2023): "Energy conditions and statefinder diagnostic of cosmological model with special law of Hubble parameter in $f(R,T)$ gravity", *East European Journal of Physics*, 3:53-61.
4. Pradhan A., Bhardwaj V.K., Dixit A., Krishnannair S. (2021): "A new class of holographic dark energy models in LRS Bianchi Type-I", *International Journal of Modern Physics A*, 36(36):2150256.
5. Rakesh R., Shukla A. Chaubey R., Singh T. (2019): "Locally rotationally symmetric Bianchi type-I cosmological model with dynamical Λ and Gin $f(R)$ gravity, Pramana-Journal of Physics, 92(79):1-9.
6. Rao V.U.M., Prasanthi U.Y.D., Aditya Y.(2018): "Plane symmetric modified holographic Ricci dark energy model in Saez- Ballester theory of gravitation", *Results in Physics*,10:469-475.
7. Rathore S., Singh S. (2023): "Dynamical system analysis of interacting dark energy in LRS Bianchi type I cosmology", Scientific Reports, 13980.
8. Santhi M.V., Chinnappalanaidu T., Madhu S.S., Gusu D.M. (2022): "Some Bianchi type viscous holographic dark energy cosmological models in the Brans–Dicke theory", *Advances in Astronomy*, Article ID 5364541, 29 pages.
9. Santhi M.V., Paparao D.CH.,Chinnappalanaidu T., Madhu S.S. (2022): "LRS Bianchi type-i cosmological model in self creation theory of gravitation", Mathematical Statistician and Engineering Applications, 71(32):1073-1090.
10. Sen G., Agrawal S. (2022): "LRS Bianchi type-II dark energy model in $f(R,T)$ theory of gravity", *Journal of Pharmaceutical Negative Results*, 13(7):7906-7911.
11. Shaikh A.Y., Gore S.V., Katore S.D. (2020): "Holographic dark energy cosmological models in $f(G)$ theory", *New Astronomy*, 80:101420.