# Time as an Imaginary Space: A New Framework for a Predetermined Universe


Sardar Dilbag Singh Khalsa[1,2*]

[1*]Quantum Matters Laboratory, School of Basic Science, Indian Institute of Technology, Jatni, Bhubaneswar, 752050, Odissa, India.
[2]School of Basic Science, Indian Institute of Technology, Kamand, Mandi, 175075, Himachal Pradesh, India.

Corresponding author(s). E-mail(s): s21ph09010@iitbbs.ac.in;



**Abstract**

Interpreting spacetime as a 4-dimensional manifold, an entity that locally resembles $\mathbb{R}^4$ but may possess global geometric or topological characteristics, leads to asymmetry when time is treated differently from space. We propose a manifold having three spatial dimensions $\mathbb{R}^3$ and time as three spacelike imaginary construct where every spatial dimension associated as $\boldsymbol{t = i\tau}$ with $\boldsymbol{\tau} \in \mathbb{R}$ treated as an imaginary space $\boldsymbol{\iota}\mathbb{R}$. It preserves the Minkowski interval $\boldsymbol{\Delta s^2}$ without explicit time requirement for lorentz boost along $\boldsymbol{x}$. Conventionally, time is treated as an entity passing from one time $\boldsymbol{t_1}$ to $\boldsymbol{t_2}$, and all the objects observed at a single instance are called $\boldsymbol{t_{now}}$. Contrary to this, objects that are in two distinct times called $\boldsymbol{t^1_{now}}$ and $\boldsymbol{t^2_{now}}$ can exist simultaneously! We can explain this perspective of reality by viewing time as an imaginary space within the 6-dimensional Space-Imaginary Space manifold. We will raise the conjecture that the 6-dimensional volume ( for simplicity, we take it for the cubic object) $\boldsymbol{V} = [(\text{length})\,(\text{breadth})\,(\text{height})\,(\boldsymbol{i\,c_x})\boldsymbol{\Delta T_x}\,\,(\boldsymbol{i\,c_y})\boldsymbol{\Delta T_y}\,\,(\boldsymbol{i\,c_z})\boldsymbol{\Delta T_z}]$ of the object is independent of the observer in a frame. Where $\boldsymbol{\Delta T_x}$, $\boldsymbol{\Delta T_y}$ and $\boldsymbol{\Delta T_z}$ are the time intervals along the length, breadth and height, respectively. We also postulate that the now-frame of time isn't a single specific time but an interval $\boldsymbol{\iota\delta}$



**Keywords:** Spacetime, Imaginary Space, Block Universe Theory, Minkowski Interval, Loop Quantum Gravity

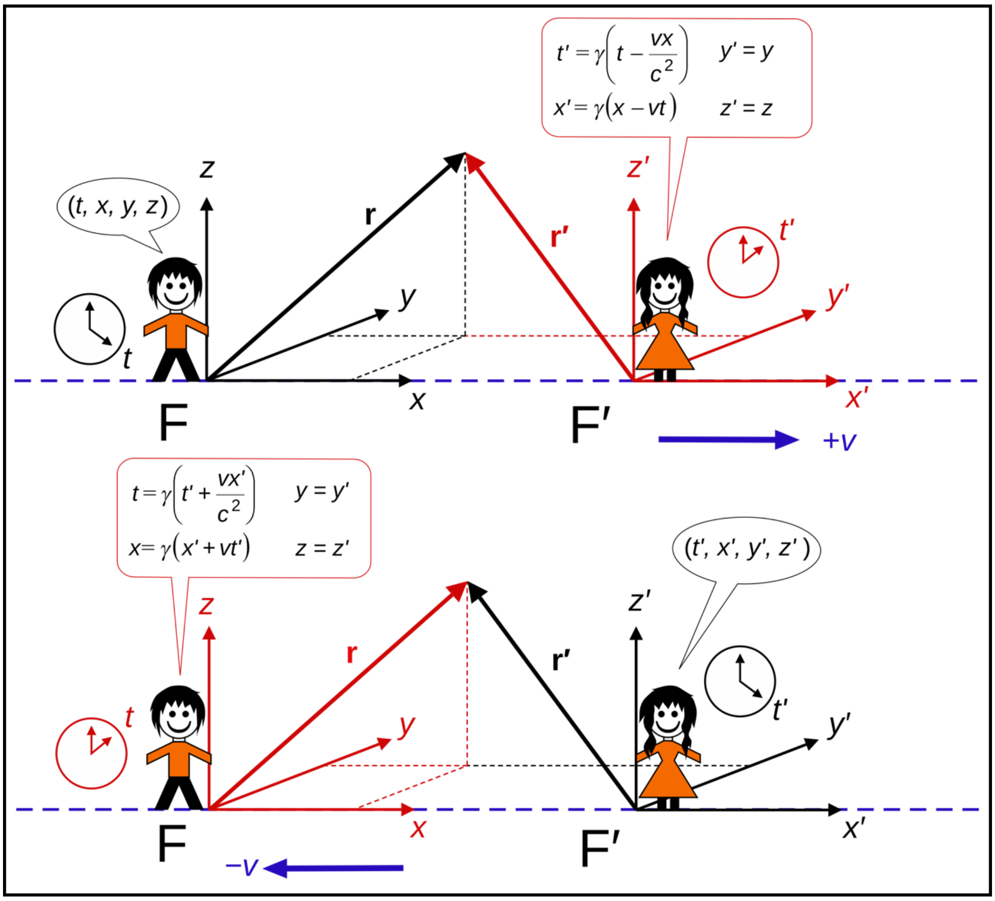


**Fig. 1** Illustration of Lorentz Transformations and Inverse Lorentz Transformation: Demonstrating the relationship between the spacetime coordinates recorded by observer boy $(t, x, y, z)$ in the stationary frame $F$ and spacetime coordinate recorded by girl $(t', x', y', z')$ in the moving frame $F'$, highlighting time dilation and length contraction in special relativity for observers in relative motion at velocity $v$.



## 1 Introduction

The perception of time, a fundamental aspect of reality, is often likened to a flowing river, with each point in this river representing the now-time. This river, however, is not a simple linear progression. It has three dimensions: a three-dimensional space framework and the 4th dimension, time as a frame, existing as past, present, and future. The advent of Einstein's special and general relativity marked a significant shift in our understanding of time. It reinterpreted time's characteristics and described

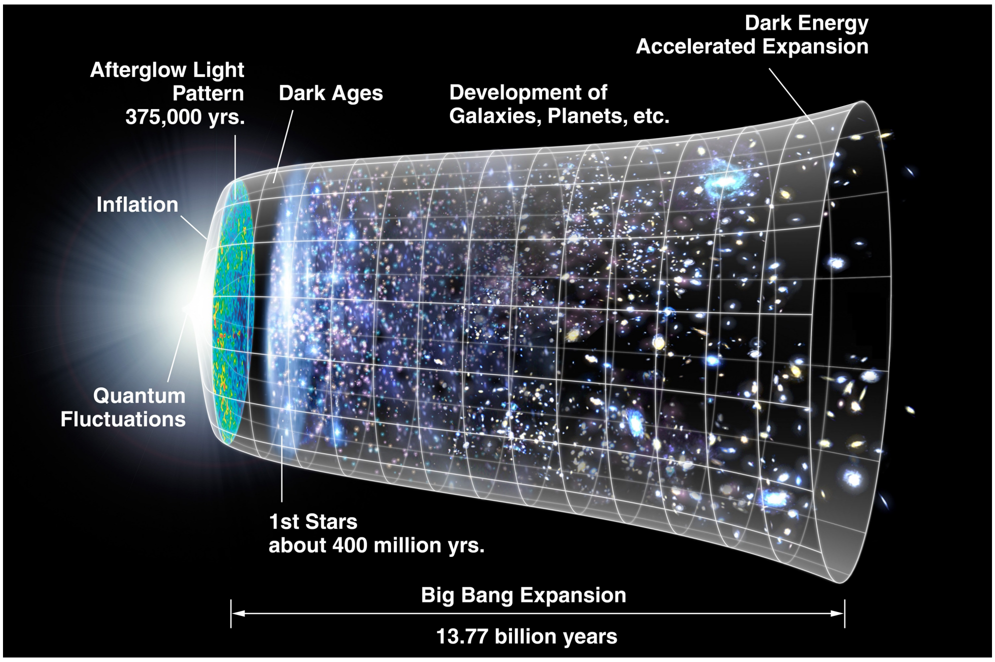


**Fig. 2** A visual timeline of the universe expanding from the Big Bang, where each circular "slice" represents a single instant in cosmic history.

Image by [NASA, Modified by Cherkash :] / Wikimedia Commons, used under [CC License Name] ([NASA/WMAP Science Team]).

a mathematical framework where the river can have different speeds at points, discarding Newton's absolute time and space[1]. The element of reality is now designed in a framework described by the relativity principles, where the objective reality of time is frame-dependent. This shift in perspective, expressed through Lorentz's transformation, which Einstein adopted to formulate relativity principles, underscores the evolution of our scientific understanding. By proposition of special relativity, let two observers, a boy in a frame of reference $F$ and a girl in a frame of reference $F'$ (An aeroplane). $F'$ is moving with the constant velocity v concerning frame $F$ along the x direction. Initially, the system is in standard configuration or synchronized. The spacetime coordinates measured by the boy in the F frame is $(t, x, y, z) = (0, 0, 0, 0)$, and the spacetime coordinate measured by the girl in the F' frame is $(t', x', y', z') = (0, 0, 0, 0)$. When spacetime coordinates are measured after some duration of time(this duration will not be the same for both due to time dilation discussed later in section 2), both boys and girls measure different coordinates. As shown in Figure 1, boy measures the coordinate $(t, x, y, z)$. The spacetime coordinates measured by the girl can be expressed mathematically as,

$$t' = \gamma \left( t - \frac{vx}{c^2} \right), x' = \gamma( x - vt ), y' = y, z' = z. \quad (1)$$

Where

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{2}$$

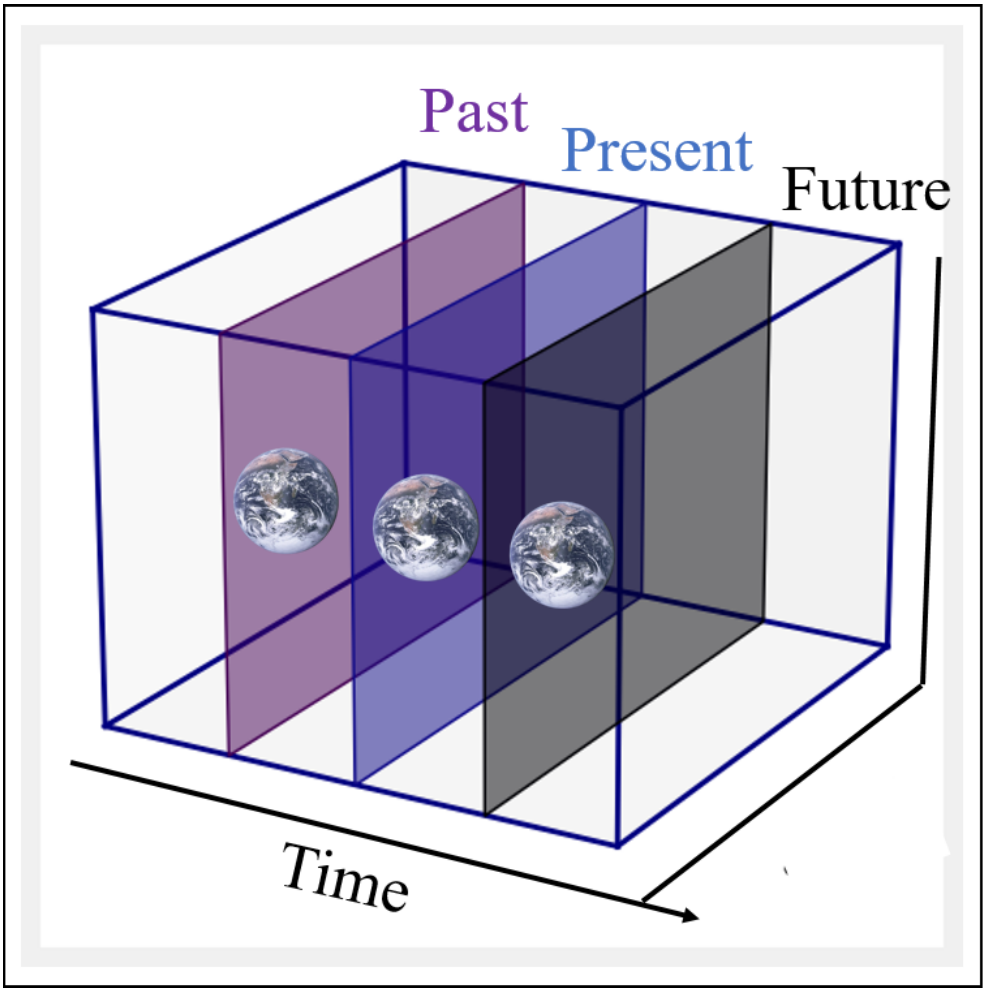


**Fig. 3** A conceptual "block universe" view of spacetime, showing the Earth at different time "slices" (past, present, and future) laid out together in a single four-dimensional continuum.

This non-absolute nature of spacetime gives rise to the phenomenon of time dilation and length contraction. This observation that time flows at different speeds according to observers in the other frames for the same event paved the way for block-universe theory, which asserts that past, present, and future exist simultaneously. Refer to Figure 2 and Figure 3 for the current picturization of cosmology and block universe theory, respectively. However, block-universe conceptualisation leads to asymmetry when applied to explain the existence of two particles with different spacetime coordinates observed simultaneously as elements of reality. These observations raise serious questions that need to be solved by equations and non-conventional interpretations of time. Philosophically, these questions are: "What is now in perspective of time? And "Whose now is considered as a true element of reality?"

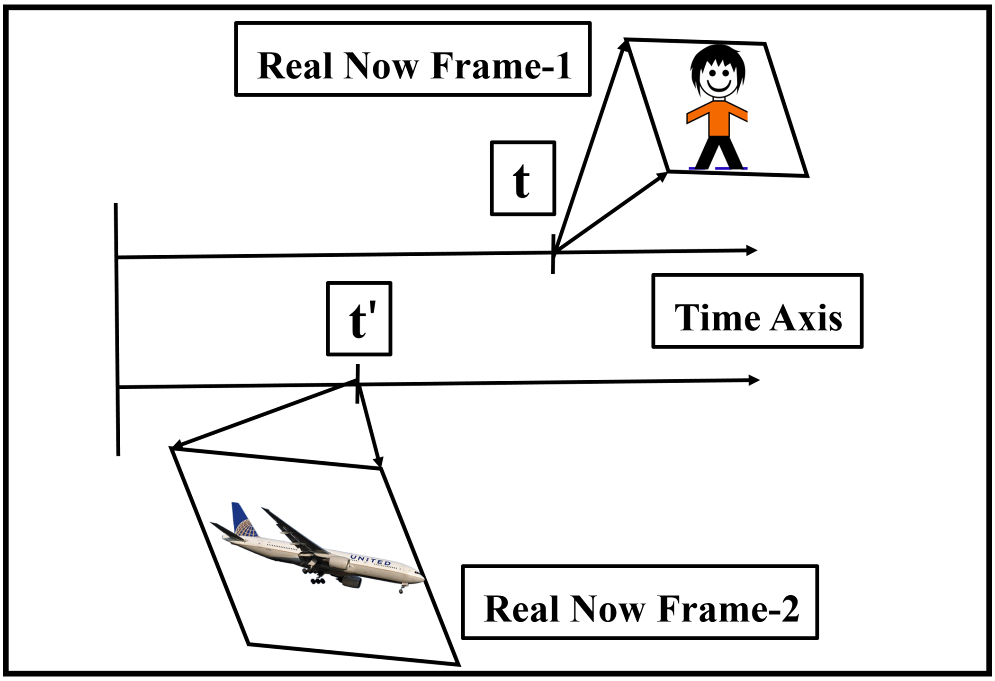


**Fig. 4** An illustrative diagram showing two real "now-time" simultaneously in reference frames—one containing a boy and the other containing a girl in an aeroplane—along a shared time axis. t and t' represent the coordinate of time with respect to the boy and girl in an aeroplane, respectively.

In this article, we elucidate the exact nature of time and elements of reality, which are governed by special relativity and quantum mechanics. The rest of the paper is organised as follows: In section 2, we conjectured and proved that time can be considered $4^{th}$ dimensional imaginary space, contrary to the time coordinate represented by real numbers. Two coordinates or points in spatial dimension have elements of reality and physical existence at any time. We prove that any two coordinates of time also have a simultaneous element of reality and physical existence for any spatial dimension. Section 3 conjectures time as a directional variant quantity, 3- Imaginary Dimensional Space. In Section 4, we develop a new theory concerning spacetime by introducing a 6-dimensional space-time Manifold. Section 5 explains, "What is now in perspective of time? This article proposes a new interpretation concerning the nature of time and the elements of reality governed by special relativity and quantum mechanics. Section

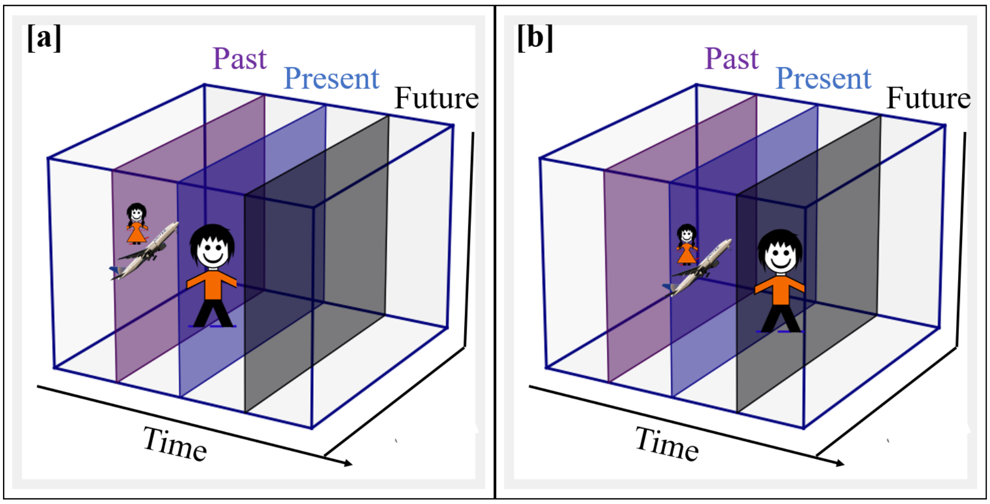


**Fig. 5** Two cubic "block universe" diagrams illustrate how, from the boy's reference frame, the girl (in the aeroplane) appears in his "past" time-slice, while from the girl's frame, the boy appears in the "future." This highlights that the elements of the reality of both times exist simultaneously.

6 delves into the question, "Whose 'now' is recognised as a true element of physical reality?" by examining the assumptions of quantum mechanics and relativity. In the discussion, we highlight some significant unresolved conflicts between quantum mechanics and relativity, particularly concerning deterministic and non-deterministic views of the universe. In conclusion, we focus on the implications of this work, which some researchers find interesting and helpful for further academic pursuit.

## 2 Time as Imaginary 4$^{\text{th}}$ Dimensional Space

Suppose we have an aeroplane $F'$ frame, an observer girl inside it, and an observer boy on earth ($F$ frame). Initially, both were in standard configuration and synchronised. Boy in the stationary frame, $F$ measures the spacetime coordinates $(t, x, y, z) = (0, 0, 0, 0)$ at the same instance simultaneously; the girl in the frame $F'$, moving with velocity $v_x$, measures the spacetime coordinate $(t', x', y', z') = (0, 0, 0, 0)$. We define this simultaneous measurement of the spacetime coordinate as synchronicity, which is not associated with simultaneous measurement of spacetime coordinate at the same time. *Time has different speeds in different frames, so how can we perform an event of observation of coordinates at the same instance of time?* The measurement of now in one frame differs from now in another. A thought experiment can explain synchronicity. Suppose we have observed a boy in an $F$-frame; he measures the spacetime coordinates and instantaneously sends a signal by quantum entanglement to the girl in frame $F'$, and she instantaneously measures the spacetime coordinates associated with an event. In this thought experiment, we assume that sending signals and all the measurement acts are instantaneous.

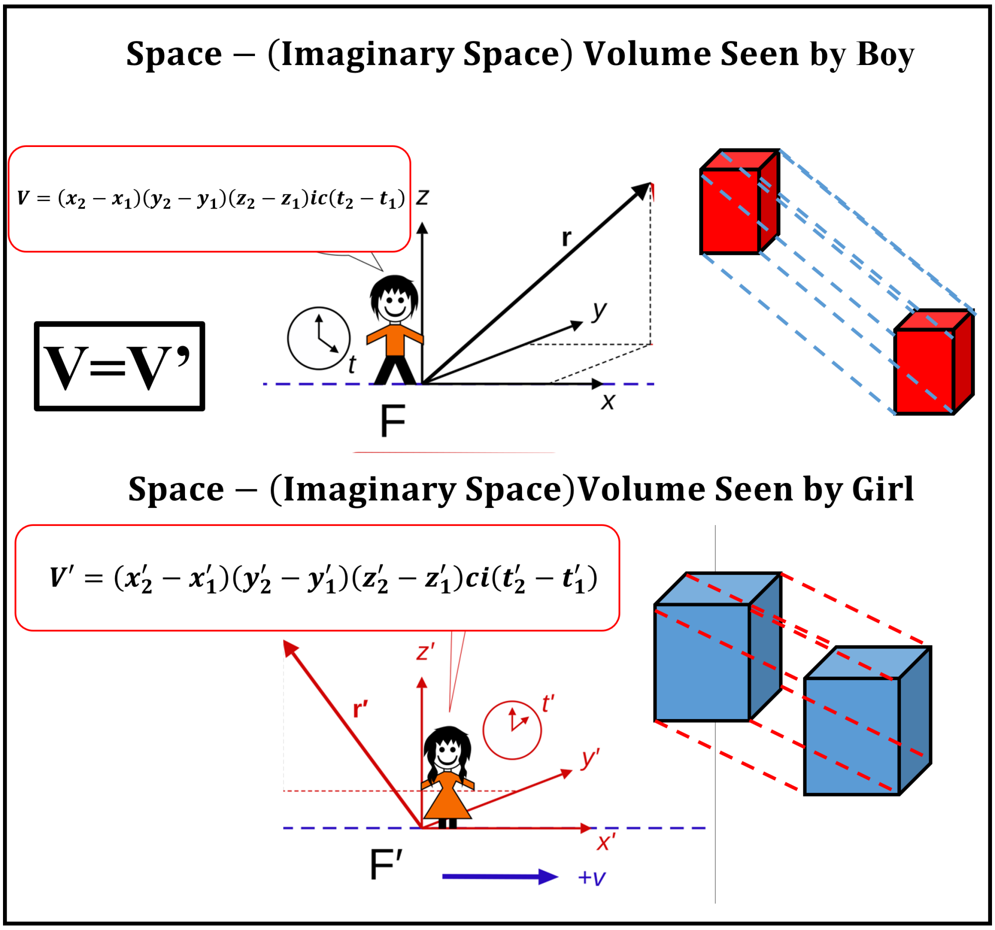


**Fig. 6** As cubic object is placed in F' frame, a schematic showing how each observer (the boy, in frame $F$, and the girl, in frame $F'$) measures a different "slice" of Space-(Imaginary Space) volume: red for the boy and blue for the girl—yet both arrive at the same invariant four-dimensional volume, $V = V'$. This illustrates the Lorentz-invariant nature of 4-dimensional volume when we have Lorentz boost in x direction.

Due to the non-absoluteness of time, the observer boy and girl are indifferent now, times $t$ and $t'$, respectively. Now, the "Now-Time" in the frames of both observers is an element of reality. According to block universe theory, the girl's time coordinate is t' and must be in the past; according to the observer, the boy is in the $F$ frame. Similarly, observer boys must be in the future concerning the observer, the girl in the aeroplane. Refer to Figure 4 and Figure 5 to understand the time frame scenario of the boy and the girl. Both are real, and the "now-time" of both frames are elements of reality. Per our current understanding of time, every moment in time is considered a "now-frame," we perceive a single frame at every instance of time, which results in asymmetry. How can boys and girls co-exist simultaneously and be considered elements of reality in a single now-frame? If the consideration of block universe theory is correct, then one observer has to disappear concerning the other as both are in different now-frames and vice-versa. We are accelerating protons at high speed in the Large Hydron Collider and still measuring every property as a single element of reality. On the contrary, the protons must go into the past and remain undetected for observers, as their speed is 99% of the speed of light, and their time coordinates lie in the past.

The asymmetry that we raised here can be eliminated if we reach a more practical conclusion through the following line of proposition: Consider time as an imaginary space dimension and conventional 3-spatial dimension conjoint to form an imaginary 4-dimensional manifold. We define the volume of this manifold as (For simplicity, we have considered cubic volume)

$$V = (\text{length})\,(\text{breadth})\,(\text{height})\,\big(i\,c\big)\,\big(\text{Time Interval}\big) \tag{3}$$

The length, breadth, and height of the object are dimensions of conventional space and the length of the object in imaginary space is defined as $\big(i\,c\big)\,\big(\text{Time Interval}\big)$. All these four quantities are frame-dependent; we conjecture that their product, i.e. volume, is Lorentz invariant and frame-independent. This result can be derived by considering the coordinates of rigid bodies observed by observers in the different frames of reference. Consider that a cuboid is placed in the $F'$ frame for the time interval $(t_2 - t_1)$ according to a boy in the $F$ frame. The same time interval the girl measures is $\big(t'_2 - t'_1\big)$.

4-dimensional Space-(Imaginary Space) Volume of the cuboid measured by the boy in frame $F$ is

$$V_{4D} = (x_2 - x_1)\,(y_2 - y_1)\,(z_2 - z_1)\,\big(i\,c\big)\,(t_2 - t_1) \tag{4}$$

4-dimensional Space-(Imaginary Space) Volume of the cuboid measured by the girl in frame $F'$ is

$$V'_{4D} = \big(x'_2 - x'_1\big)\,\big(y'_2 - y'_1\big)\,\big(z'_2 - z'_1\big)\,\big(i\,c\big)\,\big(t'_2 - t'_1\big) \tag{5}$$

By using the Lorentz transformation for length and the inverse Lorentz transformation for time, we get

$$x'_2 - x'_1 = \frac{x_2 - x_1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{6}$$

$$y'_2 - y'_1 = y_2 - y_1 \tag{7}$$

$$z'_2 - z'_1 = z_2 - z_1 \tag{8}$$

$$t'_2 - t'_1 = (t_2 - t_1)\sqrt{1 - \frac{v^2}{c^2}} \tag{9}$$

Substituting eq (6,7,8 and 9) in equation (5) we get

$$V' = V \tag{10}$$

$$
\begin{aligned}
V' = i\,c\sqrt{1-\frac{v^2}{c^2}}\,\Big\{ \\
& \underbrace{C_1\,C_2\,C_3\,(x_2-x_1)^3\,t_2}_{\text{Term 1}} + \underbrace{C_1\,C_2\,C_4\,(x_2-x_1)^2\,(y_2-y_1)\,t_2}_{\text{Term 2}} + \underbrace{C_1\,C_2\,C_6\,(x_2-x_1)^2\,(z_2-z_1)\,t_2}_{\text{Term 3}} \\
& + \underbrace{C_1\,C_5\,C_3\,(x_2-x_1)^2\,(y_2-y_1)\,t_2}_{\text{Term 4}} + \underbrace{C_1\,C_5\,C_4\,(x_2-x_1)\,(y_2-y_1)^2\,t_2}_{\text{Term 5}} + \underbrace{C_1\,C_5\,C_6\,(x_2-x_1)\,(y_2-y_1)\,(z_2-z_1)\,t_2}_{\text{Term 6}} \\
& + \underbrace{C_1\,C_4\,C_3\,(x_2-x_1)^2\,(z_2-z_1)\,t_2}_{\text{Term 7}} + \underbrace{C_1\,C_4^2\,(x_2-x_1)\,(y_2-y_1)\,(z_2-z_1)\,t_2}_{\text{Term 8}} + \underbrace{C_1\,C_4\,C_6\,(x_2-x_1)\,(z_2-z_1)^2\,t_2}_{\text{Term 9}} \\
& + \underbrace{C_2^2\,C_3\,(x_2-x_1)^2\,(y_2-y_1)\,t_2}_{\text{Term 10}} + \underbrace{C_2^2\,C_4\,(x_2-x_1)\,(y_2-y_1)^2\,t_2}_{\text{Term 11}} + \underbrace{C_2^2\,C_6\,(x_2-x_1)\,(y_2-y_1)\,(z_2-z_1)\,t_2}_{\text{Term 12}} \\
& + \underbrace{C_2\,C_5\,C_3\,(x_2-x_1)\,(y_2-y_1)^2\,t_2}_{\text{Term 13}} + \underbrace{C_2\,C_5\,C_4\,(y_2-y_1)^3\,t_2}_{\text{Term 14}} + \underbrace{C_2\,C_5\,C_6\,(y_2-y_1)^2\,(z_2-z_1)\,t_2}_{\text{Term 15}} \\
& + \underbrace{C_2\,C_4\,C_3\,(x_2-x_1)\,(y_2-y_1)\,(z_2-z_1)\,t_2}_{\text{Term 16}} + \underbrace{C_2\,C_4^2\,(y_2-y_1)^2\,(z_2-z_1)\,t_2}_{\text{Term 17}} + \underbrace{C_2\,C_4\,C_6\,(y_2-y_1)\,(z_2-z_1)^2\,t_2}_{\text{Term 18}} \\
& + \underbrace{C_2\,C_3^2\,(x_2-x_1)^2\,(z_2-z_1)\,t_2}_{\text{Term 19}} + \underbrace{C_2\,C_3\,C_4\,(x_2-x_1)\,(y_2-y_1)\,(z_2-z_1)\,t_2}_{\text{Term 20}} + \underbrace{C_2\,C_3\,C_6\,(x_2-x_1)\,(z_2-z_1)^2\,t_2}_{\text{Term 21}} \\
& + \underbrace{C_3^2\,C_5\,(x_2-x_1)\,(y_2-y_1)\,(z_2-z_1)\,t_2}_{\text{Term 22}} + \underbrace{C_3\,C_5\,C_4\,(y_2-y_1)^2\,(z_2-z_1)\,t_2}_{\text{Term 23}} + \underbrace{C_3\,C_5\,C_6\,(y_2-y_1)\,(z_2-z_1)^2\,t_2}_{\text{Term 24}} \\
& + \underbrace{C_3^2\,C_4\,(x_2-x_1)\,(z_2-z_1)^2\,t_2}_{\text{Term 25}} + \underbrace{C_3\,C_4^2\,(y_2-y_1)\,(z_2-z_1)^2\,t_2}_{\text{Term 26}} + \underbrace{C_3\,C_4\,C_6\,(z_2-z_1)^3\,t_2}_{\text{Term 27}}\Big\} \\
& - \Big[\text{All of the above 27 products, but each multiplied by } t_1 \text{ instead of } t_2\Big] \\
= i\,c\sqrt{1-\tfrac{v^2}{c^2}}\,&\left[\sum_{n=1}^{27}(\text{Term } n)_{t_2} - \sum_{n=1}^{27}(\text{Term } n)_{t_1}\right].
\end{aligned}
$$

# Where

$$
C_1 = 1 + \frac{\gamma^2\,\beta_x^2}{1+\gamma}, C_2 = \frac{\gamma^2\,\beta_x\,\beta_y}{1+\gamma}, C_3 = \frac{\gamma^2\,\beta_x\,\beta_z}{1+\gamma},
$$

$$
C_4 = \frac{\gamma^2\,\beta_y\,\beta_z}{1+\gamma}, C_5 = 1 + \frac{\gamma^2\,\beta_y^2}{1+\gamma}, C_6 = 1 + \frac{\gamma^2\,\beta_z^2}{1+\gamma}.
$$

**Fig. 7** In the top we present the mathematical formulation of Minkowski Interval in standard four-dimensional spacetime, and in the below proposed six-dimensional intervals, where time is handled as imaginary space and three-dimensional time is treated like a vector. $(ds)^2$ is the generalized spacetime interval in a 6 Dimensional manifold 3 time-like plus, 3 space-like dimensions

We derived this result in the case of Lorentz Boost along the x direction; in a further section, we will check its universality of Lorentz invariant nature of 4-dimensional volume in the case of generalized Lorentz Boost where the $F'$ frame is moving with velocity $\overrightarrow{V} = V_x\hat{i} + V_y\hat{j} + V_z\hat{k}$ with respect to $F$ frame.

## 3 Time as Directional variant quantity , 3-Imaginary Dimensional Space

Previously, we considered the Lorentz Boost in the x direction. But real-time objects occupy 3-dimensional space. 3- The dimensional reality of an object is the actual element of reality, and time is a framework that enables the observation of physical reality by acting as a 4-dimension of spacetime. We conjectured that every object traces the same 4-dimensional volume and is Lorentz invariant, i.e. frame and observer-independent. This result highlights that the length of an object is intimately connected with the time interval, and the object's length is influenced by its duration within a specific frame concerning an observer. It suggests that time dilation and length contraction act like an adjustment to ensure the conservation of 4-dimensional volume; neither phenomenon is independent. Refer to Figure 6 Consider an object with proper length $L_x^0$, proper breadth $L_y^0$ and proper height $L_z^0$. This object is located in the F' frame (An Aeroplane) moving with velocity $\overrightarrow{V} = V_x\hat{i} + V_y\hat{j} + V_z\hat{k}$ with respect to the F frame. Coordinate transformation for generalised Lorentz boost has the form;

$$\begin{pmatrix} ct' \\ x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} \gamma & -\gamma\beta_x & -\gamma\beta_y & -\gamma\beta_z \\ -\gamma\beta_x & 1+\frac{\gamma^2}{1+\gamma}\beta_x^2 & \frac{\gamma^2}{1+\gamma}\beta_x\beta_y & \frac{\gamma^2}{1+\gamma}\beta_x\beta_z \\ -\gamma\beta_y & \frac{\gamma^2}{1+\gamma}\beta_x\beta_y & 1+\frac{\gamma^2}{1+\gamma}\beta_y^2 & \frac{\gamma^2}{1+\gamma}\beta_y\beta_z \\ -\gamma\beta_z & \frac{\gamma^2}{1+\gamma}\beta_x\beta_z & \frac{\gamma^2}{1+\gamma}\beta_y\beta_z & 1+\frac{\gamma^2}{1+\gamma}\beta_z^2 \end{pmatrix} \begin{pmatrix} ct \\ x \\ y \\ z \end{pmatrix}. \quad (11)$$

Where $\boldsymbol{\beta} = \frac{\boldsymbol{v}}{c}$. is the boost vector, $\gamma = \frac{1}{\sqrt{1-\beta^2}}$ and $v = \sqrt{V_x^2 + V_y^2 + V_z^2}$

The four-dimensional volume that the observer boy evaluates in $F$ frame for the object which is placed in $F'$ frame is given by

$$V = (x_2 - x_1)(y_2 - y_1)(z_2 - z_1)\left(i\,c\right)(t_2 - t_1) \quad (12)$$

The four-dimensional volume that the observer girl evaluates in $F'$ frame for the object which is placed in her frame, she will determine the proper length, proper breadth and proper height of the object

$$V' = \left(x'_2 - x'_1\right)\left(y'_2 - y'_1\right)\left(z'_2 - z'_1\right)\left(i\,c\right)\left(t'_2 - t'_1\right) \quad (13)$$

Given that

$$L_x^0 = \left(x'_2 - x'_1\right) \quad (14)$$

$$L_y^0 = \left(y'_2 - y'_1\right) \quad (15)$$

$$L_z^0 = \left(z'_2 - z'_1\right) \quad (16)$$

The length of an object is evaluated at the same time; by the coordinate transformation, we get

$$x_2' - x_1' = \left(1 + \frac{\gamma^2 \beta_x^2}{1+\gamma}\right)(x_2 - x_1) + \frac{\gamma^2 \beta_x \beta_y}{1+\gamma}(y_2 - y_1) + \frac{\gamma^2 \beta_x \beta_z}{1+\gamma}(z_2 - z_1) \tag{17}$$

The breadth of an object is evaluated at the same time; by the coordinate transformation, we get

$$y_2' - y_1' = \frac{\gamma^2 \beta_x \beta_y}{1+\gamma}(x_2 - x_1) + \left(1 + \frac{\gamma^2 \beta_y^2}{1+\gamma}\right)(y_2 - y_1) + \frac{\gamma^2 \beta_y \beta_z}{1+\gamma}(z_2 - z_1) \tag{18}$$

The height of an object is evaluated at the same time; by the coordinate transformation, we get

$$z_2' - z_1' = \frac{\gamma^2 \beta_x \beta_z}{1+\gamma}(x_2 - x_1) + \frac{\gamma^2 \beta_y \beta_z}{1+\gamma}(y_2 - y_1) + \left(1 + \frac{\gamma^2 \beta_z^2}{1+\gamma}\right)(z_2 - z_1) \tag{19}$$

For the calculation of time interval, we used Generalized Inverse Lorentz transformation that takes the form

$$\begin{pmatrix} ct \\ x \\ y \\ z \end{pmatrix} = \begin{pmatrix} \gamma & \gamma\beta_x & \gamma\beta_y & \gamma\beta_z \\ \gamma\beta_x & 1 + \frac{\gamma^2}{1+\gamma}\beta_x^2 & \frac{\gamma^2}{1+\gamma}\beta_x\beta_y & \frac{\gamma^2}{1+\gamma}\beta_x\beta_z \\ \gamma\beta_y & \frac{\gamma^2}{1+\gamma}\beta_y\beta_x & 1 + \frac{\gamma^2}{1+\gamma}\beta_y^2 & \frac{\gamma^2}{1+\gamma}\beta_y\beta_z \\ \gamma\beta_z & \frac{\gamma^2}{1+\gamma}\beta_z\beta_x & \frac{\gamma^2}{1+\gamma}\beta_z\beta_y & 1 + \frac{\gamma^2}{1+\gamma}\beta_z^2 \end{pmatrix} \begin{pmatrix} ct' \\ x' \\ y' \\ z' \end{pmatrix}. \tag{20}$$

Time interval is calculated at the exactly same location, and by the above transformation, it takes the form

$$t' = \left[\frac{t}{\gamma} - \frac{\beta_x x'}{c} - \frac{\beta_y y'}{c} - \frac{\beta_z z'}{c}\right] \tag{21}$$

$$(t_2' - t_1') = (t_2 - t_1)\sqrt{1 - \frac{v^2}{c^2}} \tag{22}$$

Four-dimensional volume $V'$ can be expressed as

$$V' = \left[\left(1+\frac{\gamma^2\beta_x^2}{1+\gamma}\right)(x_2-x_1)+\frac{\gamma^2\beta_x\beta_y}{1+\gamma}(y_2-y_1)+\frac{\gamma^2\beta_x\beta_z}{1+\gamma}(z_2-z_1)\right]\times$$
$$\left[\frac{\gamma^2\beta_x\beta_y}{1+\gamma}(x_2-x_1)+\left(1+\frac{\gamma^2\beta_y^2}{1+\gamma}\right)(y_2-y_1)+\frac{\gamma^2\beta_y\beta_z}{1+\gamma}(z_2-z_1)\right]\times$$
$$\left[\frac{\gamma^2\beta_x\beta_z}{1+\gamma}(x_2-x_1)+\frac{\gamma^2\beta_y\beta_z}{1+\gamma}(y_2-y_1)+\left(1+\frac{\gamma^2\beta_z^2}{1+\gamma}\right)(z_2-z_1)\right]\times$$
$$\left[ic(t_2-t_1)\sqrt{1-\frac{v^2}{c^2}}\right] \tag{23}$$

After evaluation, we find $V' \neq V$ for detail analysis; refer to Figure 7. Numerical simulation was done when the velocity $V_x = c/9$, $V_y = c/10$ and $V_z = c/11$.

Proper length $L_x^0 = \left(x_2' - x_1'\right) = 3$, proper breadth $L_y^0 = \left(y_2' - y_1'\right) = 4$ and proper height $L_z^0 = 5$. We set $t_2 - t_1 = 1$. Length, breadth, Height and Time interval measured by girl in $F'$ frame

$$L_x^0 = \left(x_2' - x_1'\right) = 3 \tag{24}$$

$$L_y^0 = \left(y_2' - y_1'\right) = 4 \tag{25}$$

$$L_z^0 = \left(z_2' - z_1'\right) = 5 \tag{26}$$

$$\tau^0 = \left(t_2' - t_1'\right) = 0.984575977875 \tag{27}$$

Length, breadth, Height and Time interval measured by boy in $F$ frame

$$L_x = \left(x_2 - x_1\right) = 2.936479350542 \tag{28}$$

$$L_y = \left(y_2 - y_1\right) = 3.942831423967 \tag{29}$$

$$L_z = \left(z_2 - z_1\right) = 4.948028555174 \tag{30}$$

$$t = \left(t_2 - t_1\right) = 1 \tag{31}$$

4-Dimensional volume measured by boy $V = 57.288487669694\iota c$ and the 4-Dimensional volume measured by girl $V' = 59.07455867325\iota c$. The magnitude of both volumes is not the same if we consider spacetime as a 4-D manifold.

$$V_{4D} \neq V'_{4D} \tag{32}$$

We apply a mathematical trick by introducing time dilation separately along y direction and z direction, assuming time has 3-dimension, mathematically it can be expressed as

$$V_{6D} = (x_2' - x_1')(y_2' - y_1')(z_2' - z_1')(t_2' - t_1')\left[(t_2' - t_1')(t_2' - t_1')\right] ic = 57.2662774931297\iota c \quad (33)$$

We can observe that $V_{6D}$ is approximately close to the $V$. This calculation indicates that time has a vector nature, and Lorentz transformation, which involves a one-time dimension of time, may not be accurate.

# 4 Six Dimensional Space-time Manifold

Our calculation indicated time's 3-dimensional and vector behaviour in the previous section. Lorentz coordinate transformations can be derived by Minkowsky's 4-dimensional space-time interval that can be expressed as

$$ds^2 = [ict_2 - ict_1]^2 + [x_2 - x_1]^2 + [y_2 - y_1]^2 + [z_2 - z_1]^2 \quad (34)$$

$$ds'^2 = [ict_2' - ict_1']^2 + [x_2' - x_1']^2 + [y_2' - y_1']^2 + [z_2' - z_1']^2 \quad (35)$$

This interval is Lorentz invariant, mathematically

$$ds^2 = ds'^2 \quad (36)$$

We propose a 6-dimensional spacetime manifold with a 6D synchronicity interval refer to Figure 8 for comparing it with Minkowsky interval can be expressed mathematically

$$ds_{6D}^2 = [ict_2^x - ict_1^x]^2 + [x_2 - x_1]^2 + [ict_2^y - ict_1^y]^2 + [y_2 - y_1]^2 + [ict_2^z - ict_1^z]^2 + [z_2 - z_1]^2 \quad (37)$$

This equation treats time as a vector, and 3-timelike dimension is hypothesized to solve the asymmetry discussed in the previous section. $t^x$, $t^y$ and $t^z$ correspond time associated with space-like x,y and z dimension respectively. Consider two inertial frames, $F$ and $F'$. Frame $F'$ moves with velocity $\overrightarrow{v} = V_x\hat{i} + V_y\hat{j} + V_z\hat{k}$ with respect to $F$ frame.Initially, the origins of $F$ and $F'$ coincided in standard configuration. Observer boy $F$ measures the spacetime coordinates $(t, x, y, z) = (0, 0, 0, 0)$ and observer girl in $F'$ measure spacetime coordinate $(t', x', y', z') = (0, 0, 0, 0)$. A light signal source emits radiation with spherical wavefronts from a common origin. Consider a point O at a distance $\overrightarrow{r}$ and $\overrightarrow{r'}$ on the spherical wavefronts from the origin of $F$ and $F'$. Following the second postulate of special relativity, light travels at speed $c = (c_x, c_y, c_z)$ independent of the frame of reference, so for point O, we get

$$\vec{r} = c_x t_x \hat{i} + c_y t_y \hat{j} + c_z t_z \hat{k} \quad (38)$$

$$\vec{r'} = c_x t_x' \hat{i} + c_y t_y' \hat{j} + c_z t_z' \hat{k} \quad (39)$$

We have assumed time as a vector quantity whose magnitude depends upon the directions of spatial dimension, as we have spherical wavefronts so the equation for the $F$ frame is given by

$$x^2 + y^2 + z^2 = r^2. \tag{40}$$

$$x^2 + y^2 + z^2 = c_x^2 t_x^2 + c_y^2 t_y^2 + c_z^2 t_z^2 \tag{41}$$

Similarly, we have spherical wavefronts in the $F'$ frame, so the equation for the sphere given by

$$x'^2 + y'^2 + z'^2 = r'^2. \tag{42}$$

$$x'^2 + y'^2 + z'^2 = c_x^2 t_x'^2 + c_y^2 t_y'^2 + c_z^2 t_z'^2 \tag{43}$$

The transformed coordinate $x'$ must vary linearly with $x$ and $t$. Therefore, the transformation takes the form:

$$x' = \gamma_x x + \sigma_x t_x. \tag{44}$$

For the origin of $O'$, the coordinates $x'$ and $x$ are given by:

$$\begin{aligned} x' &= 0, \\ x &= v_x t_x, \end{aligned} \tag{45}$$

So, for all $t_x$, we have:

$$0 = \gamma_x V_x t_x + \sigma_x t_x \tag{46}$$

Therefore

$$\sigma_x = -\gamma_x V_x. \tag{47}$$

Transformation simplified to

$$x' = \gamma_x (x - V_x t_x) \tag{48}$$

We need to determine $\gamma_x$, inverse Lorentz transformation takes the form

$$x = \gamma_x (x' + V_x t_x') \tag{49}$$

From the above two equations, we obtain the relationship between $t_x$ and $t_x'$ as:

$$x = \gamma_x \left[ \gamma_x (x - V_x t_x) + V_x t_x' \right] \tag{50}$$

or

$$t_x' = \gamma_x t_x + \frac{(1 - \gamma_x^2) x}{\gamma_x V_x} \tag{51}$$

following exactly the same calculation for $y$ we get

$$y' = \gamma_y (y - V_y t_y) \tag{52}$$

$$t_y' = \gamma_y t_y + \frac{(1 - \gamma_y^2) y}{\gamma_y V_y} \tag{53}$$

following exactly the same calculation for $z$ direction we get

$$z' = \gamma_z(z - V_z t_z) \tag{54}$$

$$t'_z = \gamma_z t_z + \frac{(1-\gamma_z^2)z}{\gamma_z V_z} \tag{55}$$

Substituting $x'$, $y'$, $z'$, $t'_x$, $t'_y$ and $t'_z$ into the spherical wavefront equation in the $F'$ frame, we obtain:

$$x'^2 + y'^2 + z'^2 = c_x^2 t_x'^2 + c_y^2 t_y'^2 + c_z^2 t_z'^2 \tag{56}$$

This equation reduces in terms of $x$. $y$, $z$, $t_x$, $t_y$ and $t_z$ and takes the form

$$\begin{aligned}
&\gamma_x^2(x - V_x t_x)^2 + \gamma_y^2(y - V_y t_y)^2 + \gamma_z^2(z - V_z t_z)^2 \\
&= c_x^2\left[\left(\gamma_x t_x + \frac{(1-\gamma_x^2)x}{\gamma_x V_x}\right)^2 + c_y^2\left(\gamma_y t_y + \frac{(1-\gamma_y^2)y}{\gamma_y V_y}\right)^2\right. \\
&\quad \left. + c_z^2\left(\gamma_z t_z + \frac{(1-\gamma_z^2)z}{\gamma_z V_z}\right)^2\right]
\end{aligned} \tag{57}$$

By comparing the coefficient of $t_x^2$, $t_y^2$ and $t_z^2$ from equation (55) & (56) we get

$$c_x^2\gamma_x^2 - V_x^2\gamma_x^2 = c_x^2 \tag{58}$$

$$c_y^2\gamma_y^2 - V_y^2\gamma_y^2 = c_y^2 \tag{59}$$

$$c_z^2\gamma_z^2 - V_y^2\gamma_z^2 = c_z^2 \tag{60}$$

By rearranging the above equations, we get

$$\gamma_x = \frac{1}{\sqrt{1-\frac{V_x^2}{c_x^2}}}, \gamma_y = \frac{1}{\sqrt{1-\frac{V_y^2}{c_y^2}}}, \gamma_z = \frac{1}{\sqrt{1-\frac{V_z^2}{c_z^2}}} \tag{61}$$

Now, the modified 6-dimensional transformation results in $x$, $y$ and $z$ direction

$$t'_x = \gamma_x\left(t_x - \frac{V_x x}{c_x^2}\right) \tag{62}$$

$$t'_y = \gamma_y\left(t_y - \frac{V_y y}{c_y^2}\right) \tag{63}$$

$$t'_z = \gamma_z\left(t_z - \frac{V_z z}{c_z^2}\right) \tag{64}$$

$$x' = \gamma_x(x - V_x t_x) \tag{65}$$

$$y' = \gamma_y(y - V_y t_y) \tag{66}$$

$$z' = \gamma_z(z - V_z t_z) \tag{67}$$

This transformation unequivocally demonstrates the fundamental symmetry of spacetime across all three spatial directions and all three time-like dimensions. Substitution of these transformed coordinates preserves a 6-dimensional synchronicity interval, mathematically

$$\begin{aligned}&[ic_x t_2^x - ic_x t_1^x]^2 + [x_2 - x_1]^2 + [ic_y t_2^y - ic_y t_1^y]^2 + [y_2 - y_1]^2 + [ic_z t_2^z - ic_z t_1^z]^2 + [z_2 - z_1]^2 \\ &= [ic_x t_2'^x - ic_x t_1'^x]^2 + [x_2' - x_1']^2 + \left[ic_y t_2'^y - ic_y t_1'^y\right]^2 + [y_2' - y_1']^2 + [ic_z t_2'^z - ic_z t_1'^z]^2 + [z_2' - z_1']^2\end{aligned} \tag{68}$$

$$ds_{6D}^2 = ds_{6D}'^2 \tag{69}$$

This transformation also preserved the 6-dimensional, 3-Spacelike - (3-Imaginary Space) volume of an object observed by a boy in $F$ frame and a girl in $F'$ when the object is placed in a girl's frame. Mathematically, it can be expressed as

The 6-dimensional, 3 Space-like-(3-imaginary Space) Volume of the cuboid measured by the boy in frame $F$ is

$$V_{6D} = (x_2 - x_1)(y_2 - y_1)(z_2 - z_1)\left(i\,c_x\right)(t_2^x - t_1^x)\left(i\,c_y\right)(t_2^y - t_1^y)\left(i\,c_z\right)(t_2^z - t_1^z) \tag{70}$$

6-dimensional Space-(Imaginary Space) Volume of the cuboid measured by the girl in frame $F'$ is

$$V = (\text{length})\,(\text{breadth})\,(\text{height})\,\left(i\,c_x\right)\Delta T_x, \left(i\,c_y\right)\,\Delta T_y, \left(i\,c_z\right)\,\Delta T_z \tag{71}$$

$$V_{6D}' = \left(x_2' - x_1'\right)\left(y_2' - y_1'\right)\left(z_2' - z_1'\right)\left(i\,c_x\right)\left(t_2'^x - t_1'^x\right)\left(i\,c_y\right)\left(t_2'^y - t_1'^y\right)\left(i\,c_z\right)\left(t_2'^z - t_1'^z\right) \tag{72}$$

We can easily prove by following the mathematical approach that we used in the section (2) that

$$V_{6D} = V_{6D}' \tag{73}$$

When $v \ll c$ time component along $x$, $y$ and $z$ direction is identical, and in common calculation it doesn't show asymmetry. 6-dimensional reality preserves the symmetry of physical laws to be treated independently along each spatial dimension with its corresponding time.

# 5 What is "Now-Time" in Perspective of Element of Reality

Consider we have two inertial frames $F$ and $F'$, $F'$ (An Aeroplane) is moving with velocity $V_x$ along $x$ direction with respect to $F$. We have an observer boy in $F$ and

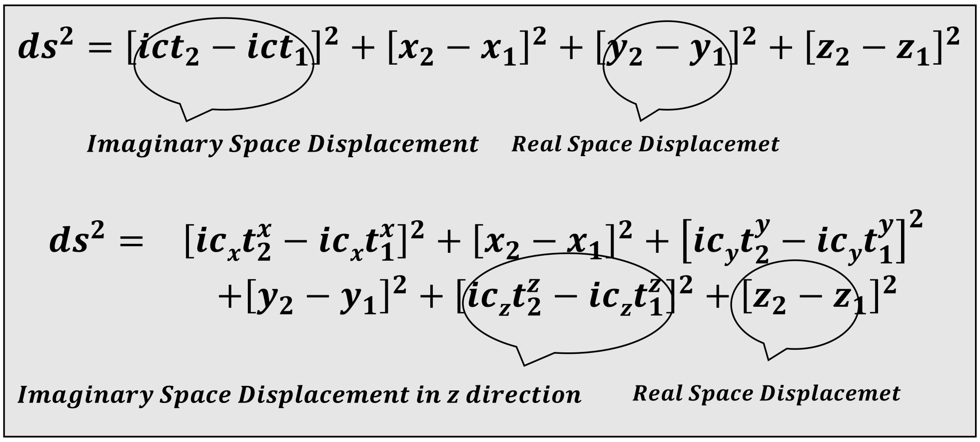


**Fig. 8** A schematic illustrating a quantum-entangled photon shared between two observers in different reference frames (the boy at time $t$, the aeroplane at time $t'$). It poses the question of whether the "signal" is received instantaneously or only when $t = t'$, highlighting the tension between entanglement and the relativity of simultaneity.

an observer girl in $F'$. We have a device in both frames to generate two pairs of entangled photons. Quantum entanglement establishes that a particle can behave like a single entity even after separation. Professor Anton Zeilinger's experiments have confirmed this. Initially, both the systems are in standard configuration with spacetime coordinate for the boy $(t, x, y, z) = (0, 0, 0, 0)$ and spacetime coordinate for the girl $(t', x', y', z') = (0, 0, 0, 0)$. After a time interval, the spacetime coordinate measured by boy and girl is $t$ and $t'$ respectively. We already have two entangled pairs of photons, and we are testing the polarization property of photons. Refer to Figure 9. When the time is ticking exactly $t$ in the boy frame, he changes this polarization state of the photon in his frame. Now, what do you think? When will the entangled photon in the girl's frame change its polarization state?

- "Is it instantaneously?" i.e. at $t' = \gamma\left(t - \frac{vx}{c^2}\right)$" To do so, effects have to travel backwards in time! As the time coordinate in the girl's frame is in the past with respect to the observer boy.
- "Is it after $\delta$ time interval passes in girl's frame and $t' = t$ " If this occurs, how can we say we have an entangled photon as effects are not simultaneous?

When the time is ticking exactly $t' = \gamma\left(t - \frac{vx}{c^2}\right)$ in the girl's frame, she changes this polarization state of the photon in his frame. Now, what do you think? When will the entangled photon in the boy's frame change its polarization state?

- "Is it instantaneously?" i.e. when the clock is in the boy's frame ticks $t$ " To do so, effects must travel future in time! The time coordinate in the boy's frame is in the future with respect to the observer girl.
- "Does polarization state will never be changed as the arrow of time is in the forward direction and the time in boy's frame is $t \succ t'$"

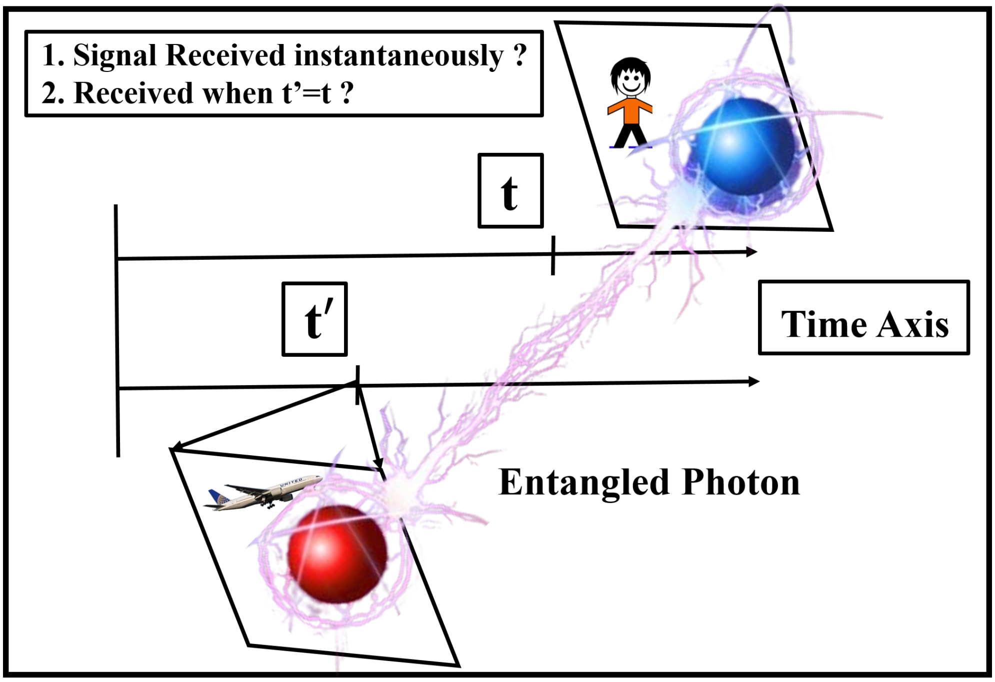


**Fig. 9** A 3D surface map illustrates how the system evolves in time (the colour-coded fourth spatial dimension). At the same time, the bold red slice represents an "imaginary now" frame cutting through that evolving landscape to highlight a single instant. This underscores the fluid, wavy and imaginary nature of time as a dimension in the model.

- "The polarization state was already changed when the clock in time in boys frame was ticking $t = t' = \gamma\left(t - \frac{vx}{c^2}\right)$. This will violate simultaneity because when the polarization state was changed in the girl's frame at $t'$, the boy's clock was ticking $t$; how can events in the boy's frame run backwards?

Contemplating this thought experiment results in the paradoxes. As mentioned in section (2), every now-time is real, but according to block universe theory, now is associated with a single time frame. It leads to asymmetry that protons in the Large Hydron Collider's experiments should vanish in the past and remain undetected. Aeroplanes should vanish from our current time frame as $t' \prec t$.

To solve this puzzle, we propose that the property of time can be treated as imaginary space. Events can be expressed with imaginary numbers (The Time). In mathematics, we have inequality for real numbers, for example, $4 \succ 3$, but we cannot assign inequality in the case of imaginary numbers. $4\iota$ is not greater or less than $3\iota$. This explains that $t$ and $t = t' = \gamma\left(t - \frac{vx}{c^2}\right)$ have inequality signatures according to real numbers, but if both are represented in imaginary numbers, then this inequality dissolves. The now isn't a single frame. On the contrary, it is a $\iota\delta$ interval, which serves as an interval for the co-existence of multiple now frames in a single instant of time. Refer to Figure 10.

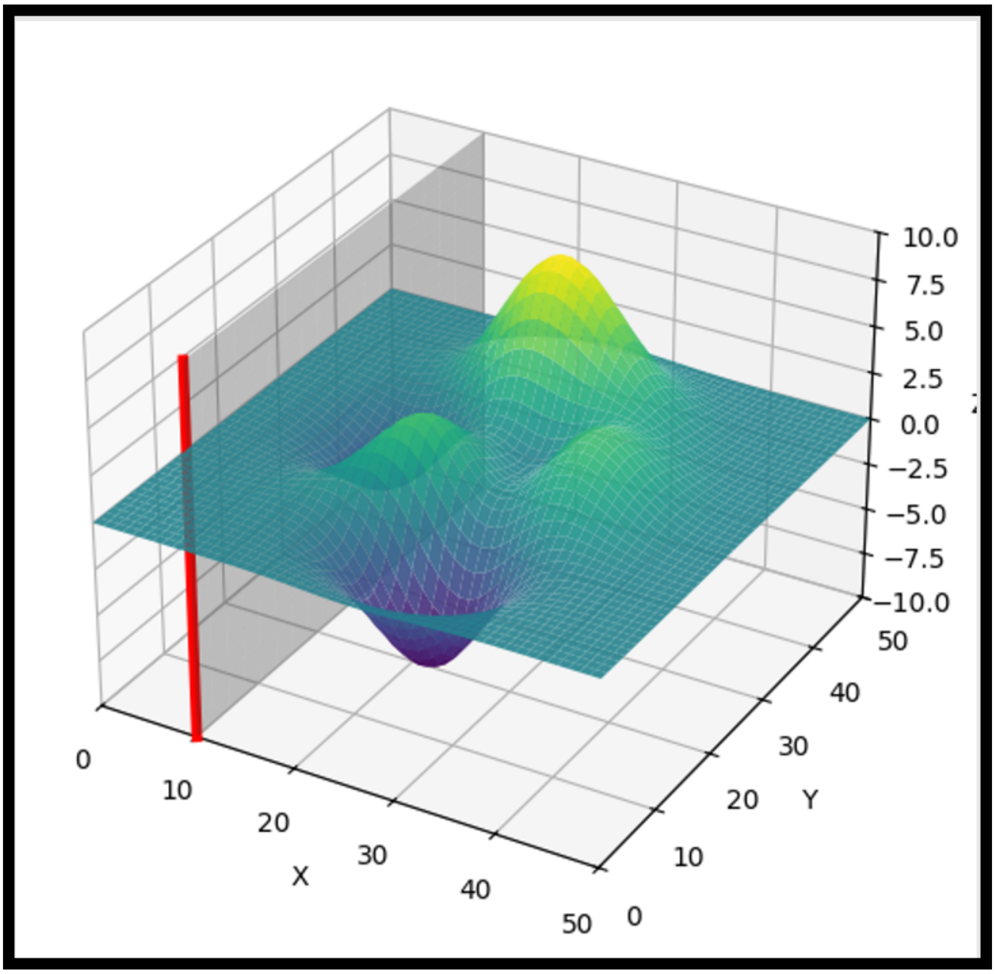


**Fig. 10** Illustrive diagram to represent now frame (In red), which encapsulates various now-time in a single frame characterizing imaginary behaviour of Time. Green Manifold represents imaginary space ( time)

## 6 "Whose 'Now' is Recognised as True Element of Physical Reality"

Consider that we have 3 inertial frames; the $1^{st}$ frame is a hypothetical frame, which is assumed to be at rest. the earth is $2^{nd}$ frame moving with velocity $V_e$ with respect to $1^{st}$ frame (We have assumed the motion of the earth is in a straight line). the aeroplane is $3^{rd}$ frame and moving with velocity $V_a$ with respect to $1^{st}$ frame. Initially, all the frames are in standard configuration. The time coordinates of all these frames will be after some interval $t^{1^{st}}$, $t^{2^{nd}}$ and $t^{3^{rd}}$ when the time coordinates are measured simultaneously concerning three observer A, B, and C inside each frame respectively.

The functional form of these time coordinates is when the Lorentz boost is applied in the $x$ direction.

$$t_x^{1^{st}} = t_x \tag{74}$$

$$t_x^{2^{nd}} = \gamma_x \left( t_x - \frac{V_e x}{c^2} \right) \tag{75}$$

$$t_x^{2^{nd}} = \gamma_x \left( t_x - \frac{V_a x}{c^2} \right) \tag{76}$$

We are given $V_a \succ V_e$

$$t_x \succ \gamma_x \left( t_x - \frac{V_e x}{c^2} \right) \succ \gamma_x \left( t_x - \frac{V_a x}{c^2} \right) \tag{77}$$

Equation (75) shows all the observers in a 3-frame are in different now-time frames, and all have actual elements of physical reality. The Observer A in the hypothetical $1^{st}$ frame is in future concerning Observer B on the earth. This observation is explained concerning block universe theory as past-present and the future exist simultaneously! In the previous section, we elucidated what is "now-time" in the perspective of time and explained that time acts like three time-like imaginary spaces with the physical fabric of time. On the contrary, Carlo Rovelli, a key proponent of Loop Quantum Gravity (LQG), argues that time does not have an absolute physical existence. It emerges from quantum interaction and correlation between the physical process. Indeed, all three new frames are fundamental elements of physical reality, but the stretching of time results in space compression. We explained this behaviour by preserving the 6-dimensional volume.

We now have a conflicting scenario: special relativity advocates the deterministic behaviour of events, while LQG advocates time as a temporal dimension emerging from correlation. To resolve this conflict, let us take an example of the molecular dynamics simulation code used to predict the equilibrium geometry of nickel clusters. We perform this computation on two computers; let system 1 be a standard laptop and system 2 be a supercomputer. Suppose we are interested in the structure and energy after a specific MD step. Results are the same on every system, but the supercomputer will arrive at the same result in less time. This elucidates the deterministic behaviour of reality and the temporal behaviour of time for every system. The obtained results were confined to the emergence of time and did not have an absolute physical existence until the calculation was executed in specific system. This can be verified by executing the code given below.

```
import numpy as np
import csv  # Import the csv module

# Constants
kb = 0.86173533e-4  # Boltzmann constant in chosen units
ut = 10.210029  # Arbitrary energy unit

# Parameters
```

```
mdsteps = 100000  # Number of MD steps
interval = 100  # Interval for output
natoms = 13 # Number of atoms
mass = 58.6934  # Mass of argon atom in atomic mass units
boxl = 10.0  # Length of cubic box
dt = 0.0001  # Time step for integration
tref = 300  # Initial target temperature (in Kelvin)
temperature_ramp = np.arange(300, 4000, 100)  # Temperature range for analysis

# Sutton-Chen parameters
a_value = 3.52
c_value = 39.432
epsilon_value = 1.5707E-2

# Auxiliary Variables
dt_sq = dt * dt
dt_sq_b2 = dt_sq / 2.0
dt_b2 = dt / 2.0

# Initial Positions (from provided coordinates)
initial_positions = np.array([[1.759600076184609, -0.33839739182718903, 0.677170827760568],
 [0.803346251033555, -2.2765827088800816, -0.3420960492333514],
 [-0.545409385837611, 0.8125543304483699, 2.2574801145337378],
 [0.8101702888831707, 1.7784645296210972, 0.65817876426052],
 [-0.7840614841701525, 1.7459463625530274, -1.1352320756737475],
 [-2.2514548635599625, 1.8662231183335198, 0.7000736753941957],
 [-2.756136938714094, 0.14625555154904407, -0.7279628037670304],
 [-0.09333093120744512, -1.4373449831720384, 1.8606765363215414],
 [-2.4141958945778845, -0.49000759445431263, 1.5254938164073737],
 [-0.9985942398237538, -1.496164059610678, -1.5512446098478059],
 [2.6411487640061857, -1.4419583750367615, -1.1624267260241294],
 [-0.5380553287718522, -0.14097877968996175, 0.11729780023378392],
 [1.1832673528637287, 0.5616378650533341, -1.3620519150514558]])

# Initial Velocities
initial_vx = np.zeros(natoms)
initial_vy = np.zeros(natoms)
initial_vz = np.zeros(natoms)
initial_vx[0], initial_vx[1] = 0.1, -0.1

# Initialize forces
fx = np.zeros(natoms)
fy = np.zeros(natoms)
fz = np.zeros(natoms)
```

```
def apply_periodic_boundary(dx, boxl):
    return dx - boxl * np.round(dx / boxl)

def sutton_chen_force(a, c, epsilon, positions):
    fx = np.zeros(len(positions))
    fy = np.zeros(len(positions))
    fz = np.zeros(len(positions))

    for i in range(len(positions)):
        roh = np.zeros(len(positions))
        roh2 = np.zeros(len(positions))
        Vij = 0.0

        for j in range(len(positions)):
            if i == j:
                continue

            dx = apply_periodic_boundary(positions[i][0] - positions[j][0], boxl)
            dy = apply_periodic_boundary(positions[i][1] - positions[j][1], boxl)
            dz = apply_periodic_boundary(positions[i][2] - positions[j][2], boxl)
            r_ij = np.sqrt(dx**2 + dy**2 + dz**2)

            roh[i] += (a / r_ij) ** 6
            roh2[i] += (a ** 6) / (r_ij ** 7)
            Vij += (a / r_ij) ** 10

        Vij = abs(Vij)
        F_i = epsilon * (-0.5 * Vij * 9 / a + c * 6 / (2 * np.sqrt(roh[i])) * roh2[i])

        for j in range(len(positions)):
            if i == j:
                continue

            dx = apply_periodic_boundary(positions[i][0] - positions[j][0], boxl)
            dy = apply_periodic_boundary(positions[i][1] - positions[j][1], boxl)
            dz = apply_periodic_boundary(positions[i][2] - positions[j][2], boxl)
            r_ij = np.sqrt(dx**2 + dy**2 + dz**2)

            F = F_i / r_ij
            fx[i] += F * dx
            fy[i] += F * dy
            fz[i] += F * dz

    return fx / mass, fy / mass, fz / mass
```

```
def sutton_chen_potential(a, c, epsilon, positions):
    total_energy = 0.0
    nat = 0.0
    for i in range(len(positions)):
        roh = np.zeros(len(positions))
        Vij = 0.0
        nat += 1
        for j in range(len(positions)):
            if i == j:
                continue

            r_ij = np.linalg.norm(np.array(positions[i]) - np.array(positions[j]))

            roh[i] += (a / r_ij) ** 6
            Vij += (a / r_ij) ** 9

        pot_en = epsilon * (0.5 * Vij - c * np.sqrt(roh[i]))
        total_energy += pot_en

    return total_energy / nat

# Initialize a list to store simulation results
simulation_results = []

# Initialize positions and velocities
positions = initial_positions.copy()
vx = initial_vx.copy()
vy = initial_vy.copy()
vz = initial_vz.copy()

# MD Simulation loop
av_temp, av_kine, av_pote = 0.0, 0.0, 0.0

trajectory = []  # Store the trajectory

for step in range(mdsteps):
    # Position update
    positions[:, 0] += vx * dt + fx * dt_sq_b2
    positions[:, 1] += vy * dt + fy * dt_sq_b2
    positions[:, 2] += vz * dt + fz * dt_sq_b2

    # Velocity update (first half-step)
    vx += fx * dt_b2
    vy += fy * dt_b2
    vz += fz * dt_b2
```

```
    # Compute forces and potential using Sutton-Chen potential
    fx, fy, fz = sutton_chen_force(a_value, c_value, epsilon_value, positions)
    pot_en = sutton_chen_potential(a_value, c_value, epsilon_value, positions)

    # Velocity update (second half-step)
    vx += fx * dt_b2
    vy += fy * dt_b2
    vz += fz * dt_b2

    # Kinetic energy and temperature
    ke2 = mass * np.sum(vx**2 + vy**2 + vz**2)
    ke = ke2 / 2.0
    temp = ke2 / (3.0 * natoms * kb)
    tot_en = pot_en + ke

    # Accumulate averages
    av_temp += temp
    av_pote += pot_en
    av_kine += ke

    # Output at specified intervals
    if (step + 1) % interval == 0:
        print(f"Step: {step + 1}, Temp: {temp:.3f}, KE: {ke:.3f}, PE: {pot_en:.3f}, Total

        # Append the current step data to the results list
        simulation_results.append([step + 1, temp, ke, pot_en, tot_en])

        # Velocity rescaling for temperature control
        scaling_factor = np.sqrt(tref / temp)
        vx *= scaling_factor
        vy *= scaling_factor
        vz *= scaling_factor

    # Append coordinates to trajectory
    trajectory.append(positions.copy())

# Average quantities
av_temp /= mdsteps
av_kine /= mdsteps
av_pote /= mdsteps

print(f"Average Temperature: {av_temp:.3f}, Average KE: {av_kine:.3f}, Average PE: {av_pot
print("Simulation Complete.")

# Write the simulation results to a CSV file
```

```
csv_filename = 'simulation_results.csv'
with open(csv_filename, mode='w', newline='') as csvfile:
    csv_writer = csv.writer(csvfile)
    # Write the header
    csv_writer.writerow(['Step', 'Temp', 'KE', 'PE', 'Total E'])
    # Write the data rows
    csv_writer.writerows(simulation_results)

print(f"Simulation data has been saved to {csv_filename}")

# Save trajectory to a file
np.save('trajectory.npy', trajectory)

# Analyze phase transitions
results = []

for temp in temperature_ramp:
    # Reset positions and velocities to initial values
    positions = initial_positions.copy()
    vx = initial_vx.copy()
    vy = initial_vy.copy()
    vz = initial_vz.copy()
    fx = np.zeros(natoms)
    fy = np.zeros(natoms)
    fz = np.zeros(natoms)

    # Scale velocities to the current temperature
    scaling_factor = np.sqrt(temp / tref)
    vx *= scaling_factor
    vy *= scaling_factor
    vz *= scaling_factor

    pot_energies = []
    tot_energies = []

    for step in range(mdsteps):
        # Position update
        positions[:, 0] += vx * dt + fx * dt_sq_b2
        positions[:, 1] += vy * dt + fy * dt_sq_b2
        positions[:, 2] += vz * dt + fz * dt_sq_b2

        # Velocity update (first half-step)
        vx += fx * dt_b2
        vy += fy * dt_b2
        vz += fz * dt_b2
```

```
        # Compute forces and potential using Sutton-Chen potential
        fx, fy, fz = sutton_chen_force(a_value, c_value, epsilon_value, positions)
        pot_en = sutton_chen_potential(a_value, c_value, epsilon_value, positions)

        # Velocity update (second half-step)
        vx += fx * dt_b2
        vy += fy * dt_b2
        vz += fz * dt_b2

        # Kinetic energy and temperature
        ke = 0.5 * mass * np.sum(vx**2 + vy**2 + vz**2)
        tot_en = ke + pot_en

        pot_energies.append(pot_en)
        tot_energies.append(tot_en)

    mean_energy = np.mean(tot_energies)
    mean_energy_sq = np.mean(np.square(tot_energies))
    heat_capacity = (mean_energy_sq - mean_energy**2) / (kb * temp**2)

    results.append((temp, heat_capacity))

    # Print the specific heat at this temperature
    print(f"Temperature: {temp} K, Specific Heat: {heat_capacity}")

    # Check for phase transition (optional)
    if len(results) > 1:
        if results[-1][1] > results[-2][1]:
            print(f"Phase transition detected at T = {temp} K")

print("Simulation and phase transition analysis complete.")

# Append the specific heat data to the existing CSV file
with open(csv_filename, mode='a', newline='') as csvfile:
    csv_writer = csv.writer(csvfile)
    # Write a header for the new data section
    csv_writer.writerow([])
    csv_writer.writerow(['Temperature', 'Specific Heat'])
    # Write the specific heat data
    csv_writer.writerows(results)

print(f"Specific heat data has been appended to {csv_filename}")
```

# 7 Discussion: Unresolved Conflicts Between Quantum Mechanics and Relativity, Particularly Concerning Deterministic and Non-Deterministic Views of The Universe.

In the previous section, we discussed that time may exist as a temporal construct emerging from correlations. However, we encounter randomness and a probabilistic version of reality when performing quantum mechanical molecular dynamics simulations. In this approach, we deal with the superposition state of the particle's coordinates, which leads to varying results after each MD interval—contrary to the deterministic nature of classical molecular dynamics. Relativity suggests a deterministic version of reality, whereas quantum mechanics implies a non-deterministic view unless hidden variables exist. In our previous MD code, when executed with an input coordinate of a known configuration, the results were always the same. However, when using a randomly generated initial configuration, we consistently obtained different results, reflecting a non-deterministic version of reality. Yet, when we examine the process of generating random coordinates, they are indeed produced by a function. The function of the previous coordinate correlates with every randomly generated coordinate in the future step. This observation suggests the possible existence of hidden variables in the quantum realm. Physical reality is always intertwined with the question of whether we have free will or not—a topic still under debate. We conclude our discussion by acknowledging these possibilities.

1. Universe is predetermined according to relativistic principles, and present and future exist simultaneously; we do not have free will.
2. The Universe is non-deterministic; we have free will and quantum principles govern the universe.
3. The Universe is deterministic, hidden variable theory is correct, and we do not have free will.
4. We have free will; the universe is deterministic, and free will is the process of evolution. The observer creates the reality with his consciousness concerning his observation, but the universe itself is a simulation.
5. We have free will; the universe is non-deterministic, and free will is the process of evolution. The observer creates the reality with his consciousness concerning his observation, but the universe itself is a simulation.

The author personally believes $5^{th}$ possibility as time is an emergent property of consciousness; time is not a fundamental background parameter but something that arises from the correlations between different physical processes.

# 8 Conclusion

In conclusion, we present the directional behaviour of time as a prerequisite to introducing the symmetry in the Lorentz Transformation and preserving the Six-Dimensional volume of a 6-D Manifold. We propose time as three imaginary spacelike dimensions to elucidate the temporal nature of time where now is recognised as $\iota\delta$ interval, not a fixed single frame.


## Acknowledgements

We acknowledge IIT Bhubaneswar & IIT Mandi for providing an advanced lab with a high-end computational research facility. I personally thank Pratik Jaiswal and Raju Dhuli for their valuable suggestion.


## Declarations


- Council of Scientific & Industrial Research (CSIR) : Grant No. 09/1059(11052)/2021-EMR-I for funding to support this research.
- Conflict of interest: Not applicable
- "All research protocols were ethically conducted, and the content of this article represents original work by the authors."
- Consent for publication
- Data availability: Not applicable
- Materials availability: Not applicable
- Code availability: Not applicable
- Author contribution: "I conceived the research idea, designed the methodology, collected and analyzed all data, and wrote the manuscript."


## References


[1] Einstein, A.: On the electrodynamics of moving bodies (1905)