

Article

# Fuzzy Algebraic Modeling of Spatiotemporal Timeseries' Paradoxes in Cosmic Scale Kinematics

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**Abstract:** This paper introduces the prototype of a generic fuzzy algebraic framework, that aims to serve as a holistic modeling approach of kinematics. Moreover, it detects paradoxes and uncertainties when the involved features of the timeseries have “unconventional” values. All well accepted models are perfectly capturing and clearly describing the spatiotemporal characteristics of a moving object’s (MO) status, when its actual distance from the observer is conventional, i.e., “insignificant compared to the magnitude of light years”. Let us consider the concept that emerges by the following Boolean expression1 (BE1): “Velocity is significant compared to the speed of light (SIV\_cSL) AND distance between observer and moving body is significant compared to light years (SID\_cLY)”. The only restriction in the above BE1 Boolean expression is that velocity would always be less than C. So far, BE1 is not considered to be true in the models that are employed to build our scientific physics studies. This modeling effort performs mining of kinematics phenomena for which BE1 is true. This approach is quite innovative, in the sense that it reveals paradoxes and uncertainties, and it reaches the following conclusions: When a particle is moving inside hypersurfaces characterized by any type of BE1’s negation, our existing kinematics’ models can survive. In the opposite case, we are gradually led to paradoxes and uncertainties. The gradual and smooth transition from the one state to the other as well as the importance of the aforementioned limitations, can be inferred-modeled by employing fuzzy logic.

**Keywords:** fuzzy algebraic modeling; cosmic scale kinematics; spatiotemporal timeseries; uncertainties and paradoxes; delayed perception; partial time vectors; sliding windows analysis



**Citation:** Iliadis, L. Fuzzy Algebraic Modeling of Spatiotemporal Timeseries' Paradoxes in Cosmic Scale Kinematics. *Mathematics* **2022**, *10*, 622. <https://doi.org/10.3390/math10040622>

Academic Editor: Junseok Kim

Received: 13 January 2022

Accepted: 14 February 2022

Published: 17 February 2022

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## 1. Introduction

In established kinematics theory, either the velocity of the moving object or its distance from the observer DFO (or both) are assigned “trivial” values, compared to the ones observed in the large scale of the cosmos. Lorentz transformation considers “high velocities” (fragments of the speed of light). However, it does not examine the fact that the kinematics phenomenon under consideration, may not be perceived by all observers simultaneously in zero time, due to a large distance (multiple light years) between the moving particle and the observer. Thus, so far, existing transformations have considered that the time vector starts running simultaneously for everyone just when the object starts moving (which does not offer generalization to the kinematics problem). It is significant to examine what happens when the distance between the observer and the reference system is extremely great (e.g.,  $N$  light years where  $N \geq 1$ ).

This paper describes and models significant uncertainties and paradoxes, that are met in “cosmic scale kinematic phenomena” (CoSKiP) characterized by SIV\_cSL and SID\_cLY. More specifically, this paper will prove that the perception of CoSKiP phenomena varies for different observers, which leads to specific uncertainties. It introduces the employment of 4-dimensional vectors of real numbers, required to describe CoSKiP kinematics, under large scale velocity and distance. When a particle is moving inside a hyper-sphere (or hyper surface) in which perception time ( $P_t$ ) of the kinematics’ phenomenon is close to zero, the aforementioned vectors

are minimized to finite ordered pairs, comprising two features, namely distance and time. The following Figure 1 clearly shows the effect of perception time for the existence of separate time vectors between the moving Particle 1 and the two observers.

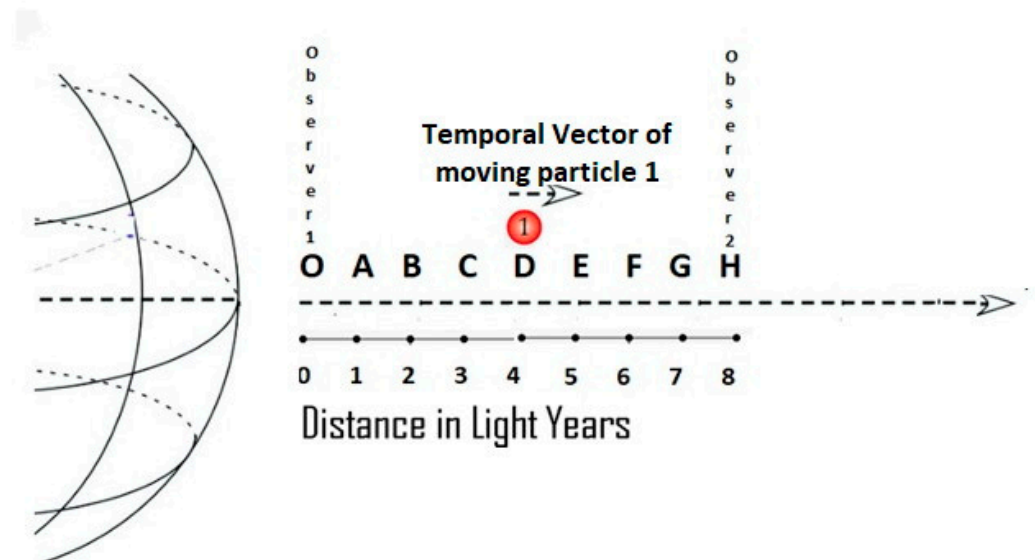


Figure 1. Initial presentation of the problem’s foundation.

Particle 1 has started from O, and it is moving with  $V = 0.5 C$  for 8 years and has reached point D. Observer 1 in O will see Particle 1 in D at temporal point D. When the distance between O and particle 1 is such that perception time  $\rightarrow 0$  there is no “delayed time vector”. When the distance between O and particle 1 is characterized by the fuzzy linguistic “significant fraction of the light year” then the time vector for observer O is under serious delay. It should be noticed that for observer H the time vector for the movement of Particle 1 does not exist, till the distance 1H is such that perception time  $\rightarrow 0$  and there is no delayed time vector. For the first observer, the time vector starts running simultaneously with the time vector of the kinematics of Particle 1, and then its delayed vector emerges and gradually increases till the perception time of the phenomenon is described by the fuzzy linguistic “extremely Past Event”. Observer 2 faces an opposite symmetric evolution of perception, and the same pattern is repeated on and on.

This paper introduces a novel fuzzy algebraic prototype, that models CoSKiP spatiotemporal time series. It is argued that time in the way it is typically perceived, is defined in an anthropocentric manner. In some cases, time is not running simultaneously for distinct observers. Its very existence might be under question in CoSKiP phenomena. This means that velocity and distance might be facing the same problem as well. An important “experiment” that was performed in this paper (has proved that the velocity of a moving object can be wrongfully perceived as equal to the speed of light  $C$  by an X observer (XOBS), whereas in fact its actual value is equal to  $0.5 C$ . However, when the same MO is entering the XOBS’s area of zero perception time, he/she can estimate the actual velocity which is equal to  $0.5 C$ . In this case, the XOBS observer is witnessing the reduction of the velocity from  $C$  to  $0.5 C$ . Though velocity has always been equal to  $0.5 C$ , XOBS is witnessing something that is impossible from his/her point of view, since the speed of light  $C$ , can neither be reached nor be reduced (infinite mass).

Moreover, it is shown that in specific cases, it is not possible to estimate both the actual velocity and the position of the object at the same time.

All of the above, might be considered by the scientific community with high skepticism, as its ground truth is far from the current status. However, it is a challenge that needs to be addressed and perhaps it might be a significant contribution to the literature.

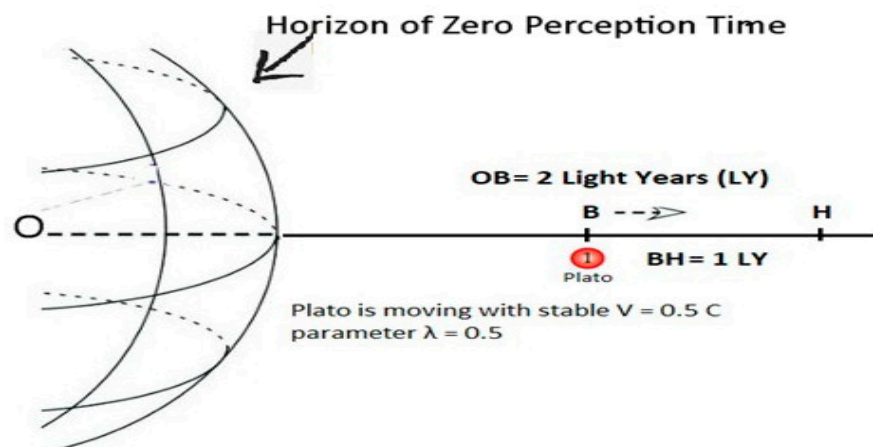
1.1. Defining Local Temporal Vectors

Though time and space are global concepts under cosmic scale, in the cases of CoSKiP phenomena they can be collapsing due to emerging paradoxes and uncertainties. They can be degraded to local concepts (describing very narrow spatiotemporal areas) and they might be characterized by extremely high uncertainty.

- The fuzzy linguistics “extremely high velocity always  $< C$ ” and “extremely high distance” are always defined based on the limitations of the human perspective. It should not be considered that in all kinematics’ phenomena, the arrow of time starts running simultaneously for all observers. This means that the evolution of a phenomenon is perceived in the same way by all observers. As it is shown herein, this argument cannot be supported for specific cosmic scenarios.
- In the cases used to study kinematics, it is generally accepted that the time required for the propagation of the perception ( $PERC_t$ ) of a kinematic phenomenon is insignificant,  $PERC_t \rightarrow 0$ . This means that all trivial cases, examine the “best case scenario” of zero or nearly zero propagation-perception time of a kinematic event. However, at cosmic scale (CoSKiP phenomena) wider and more general scenarios should be considered where the  $PERC_t \neq 0$ .
- Comprehensive modeling should consider the worst-case scenario where the distance from the moving object (DFO) corresponds to several light years and simultaneously the velocity is a significant fragment of the speed of light (CoSKiP phenomenon).

1.2. An Infinite Sequence of Arranged Fours to Specify CoSKiP Kinematics

Albert Einstein and Kurt Gödel had expressed their idea for a world without time [1]. As it has already been mentioned, the existing perspective of kinematics is based on the assumption that the observer (I will call her “Athina”) is always aware (either directly or indirectly) of both the spatiotemporal coordinates and the kinematic status of the moving subject (which I will call “Plato”). Figure 2 depicts a scenario, where the distance between Plato and Athina is 2 light years (LY) and Plato’s velocity is equal to 0.5 C (something theoretically possible) (as seen in Figure 2).



**Figure 2.** The distance  $D$  between the observer  $O$  and the moving particle  $B$ , satisfies the condition  $\lim\left(\frac{D}{1LY}\right) \neq 0$  ( $LY = \text{Light Year}$ ). The subject is moving with velocity  $V$  that satisfies the condition  $\lim\left(\frac{V}{C}\right) \neq 0$ . (Let us accept without harming generality that  $V = \lambda c$  where  $\lambda = 0.5$  and  $D = k$  light years where  $k = 2$ ).

Assumption 1 defining the case: Athina is neither aware of Plato’s initial velocity nor she is aware if Plato is moving with a stable velocity.

Plato starts moving from point  $O$ . On the other hand, Athina will remain stable forever. Since observer Athina should wait for four earth years (EY) till Plato reaches point  $B$  and two EY to receive a signal (sent by Plato from point  $B$ ) traveling with stable velocity  $C$ ,

would Athina be always able to know the status, the existence, and Plato's position at any moment in this case? Would Athina be always aware of his actual position and of his real velocity? Would Athina be able to know even if Plato's velocity was stable (0.5 C), all the way till point B? The answer is as follows. As long as Athina is located at a distance from Plato for which  $PERC_t \rightarrow 0$ , she knows. As Plato keeps moving away from this area, she starts losing track. So, two (2) years after Plato passing from point B (when he has reached point H) which is located 1 LY far from B, Athina will be able to understand that Plato reached point B. She can make her calculations and estimate Plato's average velocity for the distance OB, but she is not really aware of Plato's position at that right moment. Thus, she can estimate his average velocity, but she cannot accurately find his real position at that moment. So, she cannot be 100% certain for both his average velocity, the duration of traveling and the distance covered.

Athina knows that Plato has covered 2 LY in 6 earth years. If she knows that B is 2 LY away, she understands that Plato has traveled with an average speed of 0.5 C because she realizes that Plato reached B in 4 years. However, at the particular moment of six EY (when she realizes that Plato has passed from point B) she is able to guess Plato's actual next position, only under the hypothesis that Plato keeps moving (as agreed) with an average velocity 0.5 C and in the same direction. So, there is a 50% probability that Plato is keeping his velocity stable to 0.5 C and 50% probability for Athina to guess the exact Plato's position H after 6 years.

Thus, theoretically without using sophisticated equipment, just by watching the phenomenon, the movement of Plato should be described at every moment by a vector of infinite arranged fours, of real numbers  $KM = \{(EAV_1, HP_1, PRB_1, CEI_1), \dots, (EAV_k, HP_k, PRB_k, CEI_k)\}$  where  $k = 1$  to  $\infty$ ,  $EAV_k$  stands for the estimated average velocity,  $HP_k$  stands for the hypothetical actual position,  $PRB_k$  is the probability for the  $HP_k$  position to be correct, and  $CEI_k$  is the certainty index. Both  $CEI_k$  and  $PRB_k$  have a value equal to 1, when the moving object is located inside a hyper-surface (that can be defined using fuzzy algebra) where the actual position of Plato can be found by Athina in time T where  $T > 0$ . More specifically, as long as Plato is moving inside a hyper-sphere in which the time required for the propagation and perception of the kinematic phenomenon  $PERC_t \rightarrow 0$ , Athina would be able at any moment to know the actual velocity and the position of Plato (with  $Error_V \rightarrow 0$  and  $Error_P \rightarrow 0$ ). As Plato moves continuously outside and far from this hypothetical hyper-sphere, the perception time ( $PERC_t$ ) grows, and this can cause potential (minor or major) uncertainties of Plato's actual position and velocity. This is a theoretical experiment where only pure kinematics are used.

**NORM:** Plato's position can be considered using a probability of  $a\%$  ( $a \in \mathbb{R}$ ) which depends on whether Plato keeps the magnitude and direction of his velocity stable or not. In *CoSKiP phenomena*, based on pure theoretical physics without using sophisticated equipment, the actual velocity and the actual position of a moving object cannot be inferred with 100% certainty.

It will be clearly shown that the classical kinematics equations can be applied without any inconsistency, only when the system comprising of the moving particle and the observers is located inside a fuzzy hyperspace (FHYP) of "conventional" dimensions (e.g., a Poincare Sphere, POISP). Obviously, the boundaries of such a FHYP are not crisp numbers, following the same logic on which the boundaries of the expanding universe cannot be precisely defined. Nevertheless, the smooth transition from a "conventional hyperspace" (COHYP) where event perception time tends to zero, to a CoSKiP one, can be modeled by employing fuzzy algebra. This paper aims to lay the foundations of a novel approach, that generalizes kinematics.

The global time vector has started running right after the Big Bang. However, there are infinite propagating phenomena running outside a COHYP, and each one of them is correlated to a *distinct temporal vector*. It is not possible for all observers to accurately trace the spatiotemporal coordinates of such events.

## 2. Perception—Uncertainty—C and LI Paradoxes under Extreme V and D Values

### *Recognizing Temporal Sub-Vectors*

The question is what happens when a kinematics phenomenon is taking place outside a “conventional” FHYPP. As has already been mentioned, there will be a “significant” gap between the occurrence of an event and the exact time stamp of its perception. Under what conditions could this occur and what would be its influence in a modeling effort? The following questions ( $Q_i$   $i = 1 \dots 3$ ) should arise for CoSKiP phenomena.

Q1: Can time characterize a CoSKiP event under “unconventional” spatiotemporal dimensions (UnSPTd) as a global feature (having the same starting point for every observer)?

In everyday life, time is a concept that humans have discovered in order to estimate “rates of change” and to calculate the derivatives of functions trying to model our “trivial” real world. In our perception of the cosmos, there is a catholic time vector whose magnitude keeps growing from the first moment of the creation of the cosmos.

Under this vector, there are infinite sub vectors of time, related to every happening, ordered hierarchically. Inside a POISP with “conventional” spatiotemporal dimensions where the perception time for each happening is close to zero, this model runs smoothly. As we are moving more and more outside this region, there might be paradox cases that we cannot consider in our limited world.

From now, the term UnSPTd will be used when a particle is moving with extreme velocity, and the observers are located in extreme distances from it, unlike the ones used in the kinematics of our everyday life (e.g., a Poincare Sphere with dimensions comparable to a planet).

Can time be considered as a global concept always present for all observers under UnSPTd? Since under these conditions each event is running “in real time” only for a subset of the potential observers, can we say that there is a sequence of distinct temporal startup points corresponding to each observer? As it will be shown below, Time can be defined separately and sequentially under different perspectives. This means that for each incident we can have various distinct and not simultaneous local spatiotemporal vectors. Of course, time is a global concept inside our everyday life, running parallel and originating from the same point.

Q2: If the answer to question 1 is negative then following question should be asked: “Is velocity in CoSKiP phenomena, globally applicable and determined in the same way through all over the universe, no matter the magnitude of the distance between the observer and the moving object?” Is there an uncertainty in the estimation of velocity for different unconventional observers?

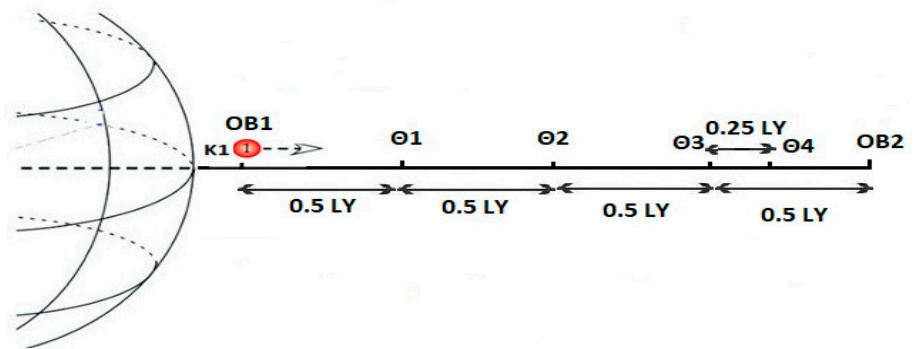
Q3: Would it ever be possible to perceive that a kinematics’ phenomenon is running faster than its propagation towards various observers or even be leading to a paradox?

### 3. An Experiment of Kinematics outside the Horizon of Zero Perception

All of the above and other similar questions may arise, because in a CoSKiP phenomenon (as it has been defined in this paper) the limitations of human senses play a major role in the perception of the world and in the evaluation of kinematics’ metrics (something unlike to happen in conventional distances and conventional velocities, where it is true that  $PERC_t \rightarrow 0$ ). The following Figure 3 depicts a characteristic experiment of moving in UNDs (unconventional distances) with UNVs (unconventional velocities). In other words, it visualizes a CoSKiP phenomenon.

The following paragraphs offer a very detailed description of an interesting typical CoSKiP phenomenon. It considers the case (described in Figure 3), where an observer  $OB_1$  and a vehicle  $K_1$  (traveler) are initially located at the point  $O(0, 0)$  of an  $x$  axis, and another observer  $OB_2$  is located 2 light years far from  $OB_1$  on the same  $x$ -axis. The vehicle  $K_1$  is moving along the  $X$ -axis with constant velocity equal to  $V = 0.5 C$ .

HORIZON OF ZERO PERCEPTION



**Figure 3.**  $K_1$  (collocated with observer  $OB_1$ ) is moving towards observer  $OB_2$  along the X-axis (outside the horizon of zero perception) in a distance of  $2\text{ LY}$ , with velocity equal to  $V = 0.5\text{ C}$ .

This chapter will consider the respective values of the most critical features, during the evolution of the experiment described in Figure 3. The velocity of the moving particle (MPA)  $K_1$  is  $V_{K1} = 0.5\text{ C}$ , which is always constant.

In the beginning, the temporal vector  $T_{K11}$  related to the movement of  $K_1$  as seen by  $OB_1$  is equal to zero earth years (EYs). There is also no time vector for observer  $OB_2$ , as the initiation of the kinematics phenomenon has not been realized by  $OB_2$ . However,  $OB_1$  sends a signal traveling at the speed of light  $C$  towards  $OB_2$ .

When  $K_1$  reaches position  $\Theta_1$  (it has moved for 1 EY) the value of its temporal vector  $T_{K11}$  is equal to 1 earth year, and its actual distance from  $OB_1$  ( $OB_1K_1$ ) is equal to  $0.5\text{ light years (LY)}$ .  $OB_2$  has not been informed that  $K_1$  is moving yet.

The second EY (of the movement of  $K_1$ ) is a milestone, because the signal that was emitted by  $OB_1$  at  $T_{K11} = 0$ , travelled with velocity  $C$  and after 2 EY it reached observer  $OB_2$  (it takes 2 EY to travel with the speed of light from  $OB_1$  to  $OB_2$ ). Thus,  $OB_2$  has just been informed that  $K_1$  has started moving from point  $OB_1$  towards its direction. Thus, the temporal vector  $T_{K22}$  for  $OB_2$  has just been initiated with a value  $T_{K22}$  equal to zero. Exactly at this specific moment, the particle  $K_1$  has reached point  $\Theta_2$  which is  $1\text{ LY}$  away from  $OB_1$  (covering the distance  $\Theta_1\Theta_2$  in 1 EY) and emits a signal traveling with velocity  $C$  towards  $OB_2$ . However, when  $K_1$  has travelled for 2 EY and  $OB_2$  is not aware that  $K_1$  has reached  $\Theta_2$  yet.  $OB_2$  knows that  $K_1$  has just started moving with unknown velocity.

In the third earth year,  $T_{K11} = 3\text{ EY}$ , the particle  $K_1$  has already been moving for three EY (from the beginning) and it has reached point  $\Theta_3 = 1.5\text{ LY}$  distant from  $OB_1$ , covering the distance  $\Theta_2\Theta_3$  in 1 EY with  $V = 0.5\text{ C}$  and emits a signal traveling towards  $OB_2$ . However,  $OB_2$  is not aware of the actual position of  $K_1$  yet. At this temporal moment ( $T_{K11} = 3\text{ EY}$  for  $OB_1$  and  $T_{K22} = 1\text{ EY}$  for Observer  $OB_2$ ), the light signal that was emitted from  $\Theta_2$  in the previous step, has already traveled from  $\Theta_2$  to  $OB_2$  and has reached  $OB_2$  in 1 EY. This means that  $OB_2$  sees that  $K_1$  is located in  $\Theta_2$ . Thus,  $OB_2$  concludes that  $K_1$  covered the distance  $OB_1\Theta_2$  of  $1\text{ LY}$  in 1 earth year (the velocity  $V$  is wrongfully estimated to be equal to  $C$ ).

After  $K_1$  has traveled for  $0.5\text{ EY}$  (at the  $3.5\text{ EY}$  of the travel), the signal that was emitted from  $\Theta_3$  in the previous step has reached  $OB_2$ . Observer  $OB_2$  sees that  $K_1$  is located in  $\Theta_3$  and  $T_{K22} = 1.5\text{ EY}$ . In fact,  $K_1$  has reached  $\Theta_4$  which is  $1.75\text{ LY}$  from the origin (but  $OB_2$  is not aware of it) and emits a signal towards from  $\Theta_4$  towards  $OB_2$ . Thus,  $OB_2$  believes that  $K_1$  has traveled  $0.5\text{ LY}$  (from  $\Theta_2$  to  $\Theta_3$ ) in  $0.5$  earth years (again the velocity  $V$  is wrongfully estimated to be equal to  $C$ ).

At the 4th EY of the travel, the signal that was emitted from  $\Theta_4$  at  $T_{K11} = 3.5\text{ EY}$  will travel with  $V = C$  and it will reach  $OB_2$  after  $0.25\text{ EY}$ . Thus, at  $T_{K11} = 3.75\text{ EY}$  and  $T_{K22} = 1.75\text{ EY}$ ,  $OB_2$  will see that  $K_1$  is located at  $\Theta_4$  (at the  $3.75\text{ EY}$  of the travel). However,  $K_1$  was already in  $\Theta_4$  in the previous step at  $T_{K11} = 3.5\text{ EY}$  and traveling with  $V = 0.5\text{ C}$  will reach  $OB_2$  after  $0.5\text{ EY}$  at  $T_{K11} = 4\text{ EY}$   $T_{K22} = 2\text{ EY}$ . Thus,  $OB_2$  sees the following:  $K_1$  has travelled from  $\Theta_4$  to  $OB_2$   $0.25\text{ EY}$  in  $0.5\text{ EY}$ . Thus,  $OB_2$  sees the actual velocity of  $K_1$  which is  $0.5\text{ C}$ .

Concluding, it is obvious that a series of extreme paradox states are emerging. Moreover, based on Figure 3, it can be inferred that after two earth years, the observer OB2 cannot define the status of K1. The temporal vector starts running for the observer OB2 on the second EY, whereas another temporal vector is already running for the moving object K1.

The above Figure 3 clearly describes potential uncertainties and paradoxes that can be met in a CoSKiP kinematics phenomenon.

The first paradox is that OB2 wrongfully perceives the velocity of K1 equal to C twice (which is of course wrong!).

There is also another paradox. Based on the Theory of Special Relativity, if something is moving with velocity equal to the speed of light, it has infinite mass and thus its velocity cannot change. This is also true in the experiment described above. However, as far as OB2 is concerned he/she (wrongfully) estimates that the velocity has changed from C to 0.5 C! (Both estimations are wrong!).

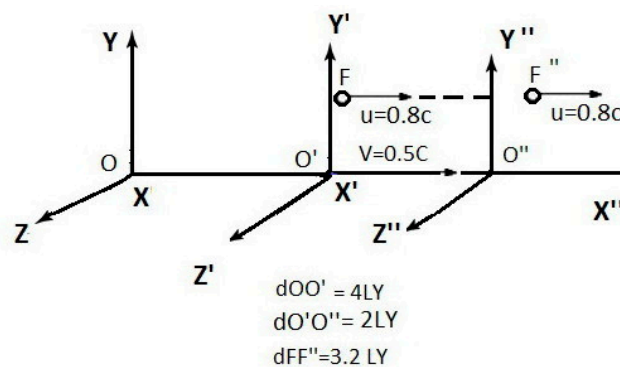
To avoid misunderstandings, this paper does not suggest that a particle can move with velocity equal to the speed of light! However, it is a fact that the observer OB2 cannot figure out what has actually happened, and he/she is misled. This is another clue that in such phenomena there might exist some serious limitations. The perception of observer 2 is misleading; however, it is a paradox. As it will be shown below, in specific cases the observer is limited to estimating either the position of the moving object or its velocity accurately, but not both of them.

#### 4. Running a CoSKiP Phenomenon under a Lorentz Coordinate System

Let us consider Lorentz transformation [2] for the case of a CoSKiP phenomenon where the distance  $d$  between the two reference systems is equal to 4 light years and  $X'O'Y'Z'$  is moving with  $u = 0.5 C$  far from  $XOYZ$  along the X axis. In this case, observer O does not know that F and  $X'O'Y'Z'$  have started moving for a period of 4 years. Thus, the arrow of time starts running for O with a delay of 4 years.

- A) During this period, the actual velocity and the position of F related to  $XOYZ$ ,  $V_{FXOYZ}$  and  $D_{FXOYZ}$  are unknown. Thus, the Lorentz transformation cannot be applied.

An experiment described in the following Figure 4, aims to study a CoSKiP case for a Lorentz transformation coordinate system [2]. F is a particle, initially located at point  $O'$  which is the origin of a  $X'O'Y'Z'$  reference system. The reference system  $X'O'Y'Z'$  is moving with a velocity equal to  $V = 0.5 C$  regarding  $XOYZ$  and particle F is moving with a velocity equal to  $u = 0.8 C$  regarding  $X'O'Y'Z'$ , which is located 4 light years away from  $XOYZ$ . However, O is far away and cannot perceive the initiation of the kinematics phenomenon in zero time (the fact that particle F has started moving).



$X'O'Y'Z'$  moves with  $V=0.5C$  regarding  $XOYZ$ . Particle F moves with  $u=0.8C$  regarding  $X'O'Y'Z'$

**Figure 4.** A CoSKiP phenomenon under Lorentz coordinate systems.

Both F and  $X'O'Y'Z'$  have started moving at the same moment. If at temporal point  $T = 0 s$ , both  $O'$  and particle F send a signal traveling along the X axis with the speed of

light towards O in order to warn O that they have started moving, then O will acknowledge the initiation of movement for F and X'O'Y'Z', right after 4 years. During those 4 EY, O is not aware of any kinematics phenomenon. Thus, kinematics perception time for O is  $T_{11} P_{10} = 4$  EY. During this 4 years' period, F has reached position F'' and X'O'Y'Z' has reached X''O''Y''Z''. Let us suppose without harming the generality, that during these 4 years, F has travelled with a stable velocity equal to 0.8 C far from O' (which is not known by O) and thus F has covered a distance = 3.2 light years far from the initial position O', reaching F''. Respectively, X'O'Y'Z' has covered a distance of 2 LY reaching O''; however, O is also not aware of this kinematics phenomenon either.

- B) Only when F reaches F'', O realizes that F has started moving. However, at this moment O does not know the actual velocity of F related to all coordinate systems; it does not know its position related to all coordinate systems and how long F will continue moving. Thus, for all this period of time, the Lorentz transformation cannot be employed.

Let us suppose that particle F'' and O'' are sending one signal each, traveling at the speed of light towards O, when they are at the aforementioned locations (3.2 LY and 2 LY far from their initial positions F and O' respectively).

The signal from F'' will reach O, exactly 7.2 earth years after the arrival of F to F''.

- C) Moreover, it takes 7.2 additional EY for O to realize the first position F''. However, all calculations that O makes are related to the past and not to the current status of F. It is true that O can infer that F has moved 3.2 LY in 4 EY, and thus its velocity was equal to 0.8C when it moved from F to F''. The status of particle F will be evaluated always with a severe delay. It is important that for major time periods the actual position and velocity of F will be unknown, and for specific time points, outdated details will be calculated. It is not known in present time, when F and X'O'Y'Z' will stop moving and if their velocity will be always stable.

If the above problems did not exist, the following Lorentz transformation Equation (1) [2–4] would always be applicable

$$U' = \frac{U + V}{1 + \frac{U \cdot V}{C^2}} \tag{1}$$

If Equation (1) is applied, the velocity of F with respect to XOYZ, is equal to  $V_{F_{XOYZ}} = 0.928571C$  ( $V_{F_{XOYZ}} = (0.8 C + 0.5 C) / [1 + (0.8 C \times 0.5 C) / C^2] = 1.3 C / 1.40 = 0.928571 C$ ). This paper does not question Lorentz transformation (LT) in any way. The above experiment shows that generalization of LT for CoSKip kinematics under both “unconventional” distances and velocities is not certain, due to potential significant unexpected inconsistencies that may arise. This is due to the fact that in Lorentz transformation the arrows of time for the reference systems and for the moving particle start running simultaneously without any delay as the perception time for every phenomenon equals zero. However, when employing Lorentz transformation for an “unconventional” CoSKip kinematics phenomenon, the actual position F'' of the moving particle cannot be known by observer O for a certain period of time.

### 5. Overlapping Sliding Windows for Spatiotemporal Time Series

In the previous sections, we have seen that the observers were witnessing uncertainties and paradoxes. Moreover, their view of a CoSKip kinematics event was not always up to date and its perception was severely delayed. Even worse, there was no way for the observer to realize the paradox and the depth of the emerging uncertainty.

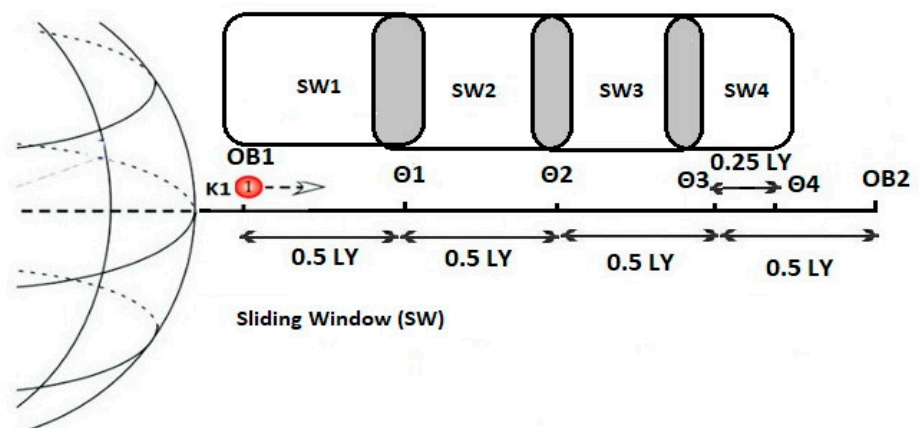
The kinematics modeling would be normalized, if the time required for the perception of the actual position of the moving particle, was insignificant. More specifically, this would be the case, when the moving particle would enter the “horizon of zero perception time”



(HZPT). Such a space could be represented by a virtual Poincare Sphere of “conventional” dimensions, where perception time is limited close to 0.

Moreover, it is clearly concluded that the whole time series of spatiotemporal data related to the movement from one point to another, can be studied and modeled by following a parallel Sliding Windows ( $SW_1, SW_2, \dots, SW_i$ ) approach as shown in Figure 5. The SW division can be done either in equal intervals by following the  $k$ -fold ( $k = 1 \dots i$ ) approach, or by applying increasing steps. This is a novel approach that considers the whole kinematics phenomenon as a sequence of parallel overlapping sliding windows. Each sliding window can be assigned a separate Lorentz Transformation Coordinate System, in order to perform partial modeling of the kinematic phenomenon for each window.

**HORIZON OF ZERO PERCEPTION**



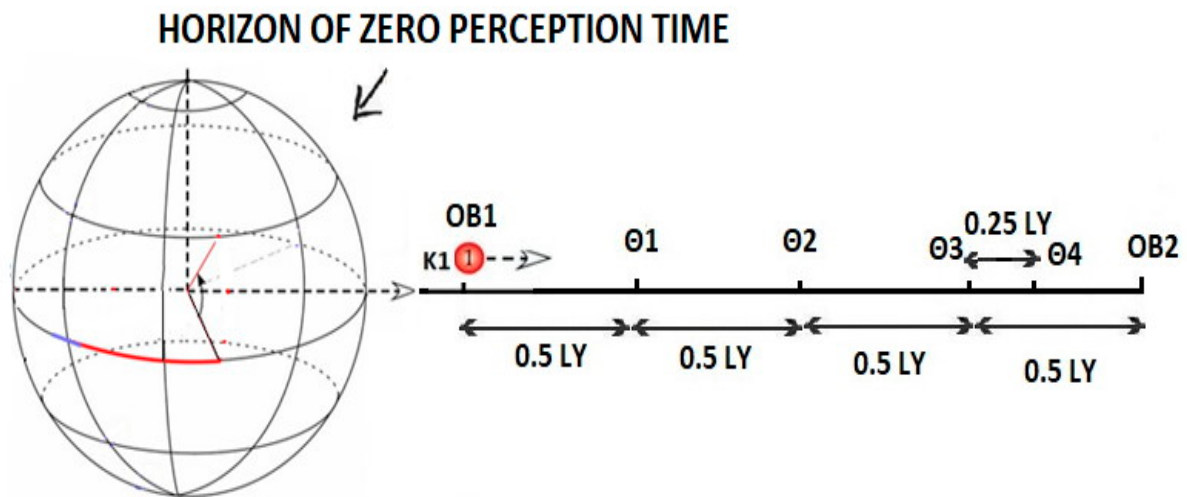
**Figure 5.** Sliding Windows (SW) in large scale kinematics.

Concluding, it has been discussed that a potential limitation of all transformations is that they are indirectly based on assumptions that are limiting their own generalization capacity. Moreover, they are accepting that the phenomenon under study is perceived in zero time and that the observers know the exact position and velocity of the moving particle at any single moment. Also, it is assumed that there is always a stable reference frame (e.g., planet Earth) another moving frame and an object moving far from the 2nd moving frame. However, it is not considered that under cosmic scale, the “stable reference frame”, namely planet Earth, is moving in its own trajectory inside space. Thus, in the case of a CoSKip phenomenon this is something that can harm the generalization capacity of the model.

It should also be considered that there is nothing stationary in the universe. Thus, if the object is moving in a distance of several light years with high velocity (e.g., 0.5 C) then its distance from the stable reference frame (RF) will keep increasing not only because it moves far from it but also because the position of the RF (e.g., a planet) is constantly changing as the CoSKip phenomenon is evolving.

**6. The Poincare Sphere Kinematics’ Model**

The kinematics are following a straightforward process (with standard spatiotemporal characteristics for all observers) when a particle is moving in a Poincare Sphere of “conventional dimensions”, where the distances and velocities are limited to the ones experienced in everyday life (Figure 6). Perception of the spatiotemporal kinematic status of a moving object K1 is following an approach which can be called “cosmic kinematics” (COK) employing a sliding windows’ mode when the particle is moving with high “unconventional” velocity in “unconventional” cosmic distances.

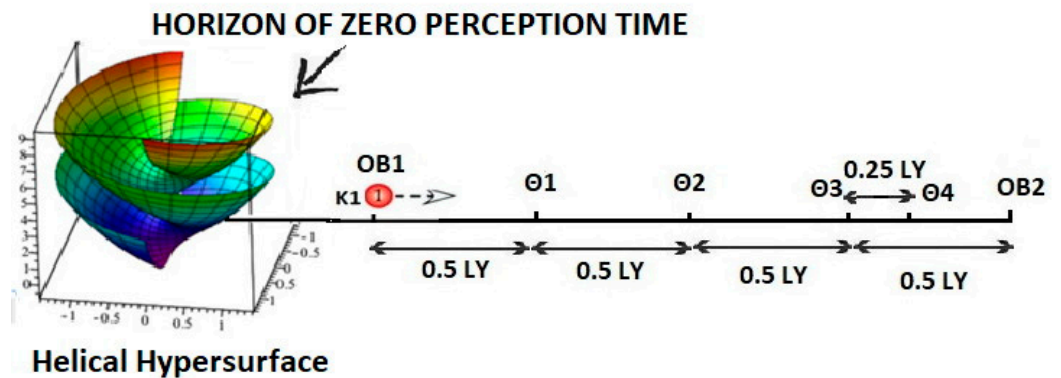


**Figure 6.** Translation from a limited Poincare Sphere of conventional dimensions to cosmic dimensions (where a CoSKiP phenomenon can occur).

The COK are gradually translated to the well-known typical mode (which can be called earth kinematics-EAK), when the moving object K1 has reached closely to the observer OB2 and the K1OB2 distance has become “very low” for cosmic standards. This happens inside a Poincare Sphere with dimensions such as the ones required for almost zero perception time (e.g., of planet-like dimensions) (Figure 6).

The model of such a Poincare Sphere has been employed because it is symmetric and very close to the analogy of a planet. Moreover, it has been also used in other research efforts related to Lorentz transformations [5] in the literature.

Alternatively, a hyperplane or a hypersurface can be used instead. For example, it could be a helical hypersurface in Minkowski Geometry [6] as shown in Figure 7.



**Figure 7.** Translation from cosmic dimensions (where a CoSKiP phenomenon can occur) to helical hypersurfaces of typical dimensions where perception time  $\rightarrow 0$ .

**7. Fuzzy Modeling of a CoSKiP Phenomenon**

Fuzzy logic has been introduced by Zadeh [7], in an effort to model logical reasoning with imprecise or vague terms. It is a fact that fuzzy algebra has already been used in earth and space sciences [8]. Moreover, fractal logic has been effectively applied to quantum physics and astronomy [9]. In the modeling effort presented herein, various fuzzy membership functions (FMF) can be used to determine the fuzzy sets (linguistics): “very low distance”, “low distance”, “average distance”, “high distance”, “extreme distance”.

Every value of distance between the observer and the phenomenon, can belong to all relative linguistics with a different degree of membership. The same stands for velocity. The indicative values of the x axis in the above Figure 7, are related to the coefficient of the

distance in light years (e.g., 0.5 LY, 1 LY, 1.5 LY and so on). A general form of a sigmoid fuzzy membership function is presented in the following Equation (2):

$$f(x; a, c) = \frac{1}{1 + e^{-a(x-c)}} \tag{2}$$

Equation (2): General type of a sigmoid membership function.

The parameter  $a$  is used to determine the curve’s peak,  $b$  is the position of the center of the peak,  $\sigma$  is the standard deviation,  $e$  is Euler’s number. Mathematical modeling tries to formally describe a real-world case, by overcoming obstacles imposed due to complexity and uncertainty. Fuzzy algebra manages to offer formal representation of ambiguity and subjectivity. Gaussian membership functions (GMF) have the advantages of smoothness and concise notation.

The GMF [10,11] applied to a crisp value  $X$  in order to determine the membership value of  $X$  to a fuzzy set  $A^\sim$  is given by the following Equation (3). It is a continuous monotonic mapping of the input into a value between 0.0 and 1.0.

$$f(x, \sigma, c) = e^{-\frac{(x - c)^2}{2\sigma^2}} \tag{3}$$

Equation (3): Gaussian fuzzy membership function.

where  $C_i$  and  $\sigma_i$  are the center and the width of the  $i$ th Fuzzy set  $\tilde{S} = \{(x, \mu_s(x))/x \in U\}$ . The aim of the fuzzy model presented in Figure 8, is to employ a smooth transition from one linguistic to another and from one kinematics situation to the next. Based on the above Equation (3) this transition is done smoothly, and a cosmic distance  $D$  can belong to two fuzzy sets (linguistics) with a different degree of membership for each one. For example,  $D = 3$  LY belongs to the linguistic “average distance” with a degree of membership (DOM) equal to 0.1 (where max equals 1) and to the linguistic “high distance” with a DOM = 1. Figure 8 presents a set of Gaussian fuzzy membership functions for distances 0 to 4 LY. Of course, this can be expanded for as high distances as required. A researcher would be especially interested in searching for uncertainties for the cases of the linguistics “high distance” and “extreme distance”. However, it is up to the researcher to define the boundaries of each Gaussian fuzzy set depending on the phenomenon.

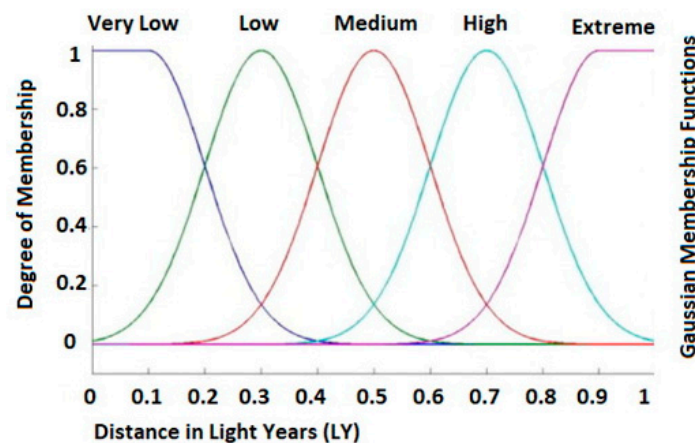


Figure 8. An indicative fuzzy Gaussian model to define linguistics related to distance in LY.

7.1. A Fuzzy Algebra Specification and Modeling of a CoSKip Phenomenon

A robust model has to smoothly harness the fuzzy nature of the transition boundaries between a conventional kinematics phenomenon and a CoSKip one. It would be interesting to consider a more “tangible” model, able to offer a more rational definition to the fuzzy transition boundaries (FTRB) of the aforementioned Poincare Sphere. The treatment of precision when the complexity is high can be achieved by employing “linguistic” variables

which correspond to fuzzy sets. Their values are obtained by employing fuzzy membership functions [10,11].

Defining respective overlapping fuzzy membership functions (FMF) would be the first step. However, in this modeling effort, the transition from one linguistic to the other, should be soft and gradual. Due to the fact that the linguistic “unconventional distances” are the key factor for the occurrence of CoSKip phenomena, it would be interesting to develop respective fuzzy algebraic models. Such a model should employ the following fuzzy linguistics: “conventional distances” (defined by a semi-trapezoidal FMF) “less conventional distances”, “almost unconventional distances” (both defined by typical triangular FMFs) “Totally unconventional distances” (defined by a semi-trapezoidal FMF). Each membership function corresponds to a fuzzy set (as shown in Figure 9) based on Equations (4) and (5) [10,11]. The number of the linguistics depends on the magnitude of the distances used in the particular problem. The following Figure 9 presents a hybrid fuzzy model comprising of two semi-trapezoidal and five triangular membership functions corresponding to the conventional/unconventional distance linguistics. This is a prototype, and it can be adjusted according to the case. For example, MF1 can correspond to conventional distance, and MF7 to “totally unconventional”, whereas all other MFs can correspond to intermediate classes. A respective fuzzy model can be developed for the velocity.

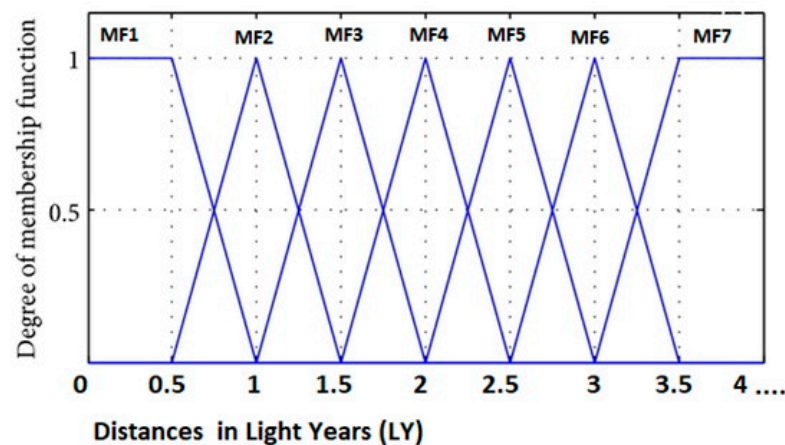


Figure 9. A hybrid fuzzy model comprising of semi-trapezoidal and triangular fuzzy linguistics.

$$\mu_s(X) = \begin{cases} 0, & \text{if } X \leq a \\ (X - a)/(m - a), & \text{if } X \in (a, m) \\ 1, & \text{if } X \in [m, n] \\ (b - X)/(b - n), & \text{if } X \in (n, b) \\ 0, & \text{if } X \geq b \end{cases} \tag{4}$$

Equation (4): General form of a fuzzy trapezoidal membership function.

$$\mu_s(X) = \begin{cases} 0 & \text{if } X < a \\ (X - a)/(c - a) & \text{if } X \in [a, c) \\ (b - X)/(b - c) & \text{if } X \in [c, b] \\ 0 & \text{if } X > b \end{cases} \tag{5}$$

Equation (5): General form of a fuzzy triangular membership function.

In the case of the trapezoidal FMF (Equation (4)) there would be a tolerance interval [m, n] for which all values would be assigned the absolute maximum membership value equal to 1. The magnitude of this interval is quite subjective, and this might cause some level of “noise” to the validity of the introduced model. For this reason, the triangular FMFs were chosen for the linguistics 1,2,3. The left branch of the semi-triangular FMF of the linguistic “conventional distances” has been assigned an additional dummy branch

with negative input, just for technical reasons, which will never be used and will never have a practical purpose (as no negative values will ever be used).

It should be clarified that for the fuzzy linguistic “unconventional distances” a semi-trapezoidal FMF was employed, as for every distance value higher than 5 light years, the degree of membership will be equal to 1. It cannot be suggested that for 5 years we have an unconventional distance, whereas this is not the case for higher distances. Thus, for this FMF the tolerance interval with membership value equal to 1 will be extended for any value  $X \geq b$ . The membership value to the linguistic unconventional distance, will be equal to 1 (maximum value) for any distance  $X \geq b$ . In this case, the semi-trapezoidal function for the linguistic unconventional distance will be described by the following Equation (6) [10,11].

$$\mu_{\tilde{A}}(X) = \begin{cases} 0 & \text{if } X < a \\ \frac{X-a}{b-a} & \text{if } a \leq X \leq b \\ 1 & \text{if } X \geq b \end{cases} \tag{6}$$

Equation (6): Fuzzy semi-trapezoidal membership function “unconventional distances”.

The values of the hyperparameters used to define the FMFs are always determined in a trial-and-error approach according to the designer’s intuition. Fuzzy models are designed to be flexible and not pure deterministic.

It is well known from the literature that the choice of the proper FMF (between a trapezoidal and a Gaussian FMF) can be done based on twelve robust criteria, namely: representation, construction, optimization, adaptiveness, novelty, analytical structure, continuity, monotonicity, stability, robustness, computational cost, control performance [12]. However, this optimization effort is a complicated task, which is out of the scope of this paper. It will be the main target of another extended research effort.

### 7.2. Foundations of a CoSKiP Phenomenon

As it has already been mentioned, a CoSKiP phenomenon is defined on the basis of the following Boolean Expression BE1.

BE1: “Velocity is significant compared to the speed of light (SIV\_cSL) AND Distance between observer and moving body is significant compared to light years (SID\_cLY)”.

Restriction1: The only restriction in the above BE1 Boolean expression is that velocity would always be less than C.

Obviously BE1 comprises of two fuzzy linguistics, namely:

Fuzzy Set  $\tilde{A}$  = Significant velocity compared to the speed of light (following Restriction1). Fuzzy Set  $\tilde{B}$  = Distance between observer and moving body is significant compared to light years.

The above two fuzzy sets are unified in a single fuzzy linguistic, by employing the “Einstein fuzzy conjunction operator” (T-Norm) presented in the following Equation (7) [4] where  $\mu_{\tilde{A}}(x)$  is the degree of membership (DOM) to the fuzzy set  $\tilde{A}$  and  $\mu_{\tilde{B}}(x)$  is the DOM to the fuzzy set  $\tilde{B}$ .

$$\tilde{A} \cap \tilde{B} = \frac{\mu_{\tilde{A}}(x)\mu_{\tilde{B}}(x)}{2 - [\mu_{\tilde{A}}(x) + \mu_{\tilde{B}}(x) - \mu_{\tilde{A}}(x)\mu_{\tilde{B}}(x)]} \tag{7}$$

Equation (7): Einstein T-Norm

This integrates the developed model for the existence of a CoSKiP phenomenon. The CoSKiP case has been defined based on a robust model and the holistic degree of membership of a kinematics phenomenon to the above fuzzy set  $\tilde{A} \cap \tilde{B}$  will be determined based on the Einstein T-Norm. Based on this DOM the phenomenon will be facing slight or major distortions. Obviously, a robust model has been built, overcoming the intuitive nature of the case.

## 8. Conclusions and Future Extensions

This paper aims to offer a generalization of the kinematics in a cosmic scale, for cases characterized by “non-trivial” values of velocities and distances. It introduces the basic foundations of a new perception of kinematics, for cases where the phenomenon is not perceived in zero time. It does not question Lorentz transformation, but it shows that it cannot generalize in the case of CoSKiP kinematics. More specifically, a supportive modeling approach is required when the distance between the reference systems is of the order of several light years and the velocity of the moving particle is a significant fraction of  $C$ . There is no conflict or overlapping between what is presented herein and Lorentz transformation. Thus, it cannot be suggested that this approach is controversial to the relativity theory or that it repeats what has already been said. It aims to initiate discussion of kinematics under a more general perspective. This document is trying to extend the way of seeing kinematics phenomena. It does not aim of to determine and support the optimal global fuzzy model to be applied more efficiently under cosmic scale. A future research effort can work towards a more general direction, in order to determine the smoothest and more rational fuzzy model which could employ different FMFs in a hybrid approach. Moreover, research will be directed towards the optimization of the introduced membership functions and towards the choice of the most efficient and flexible FMF for each case.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The author declares no conflict of interest.

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