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Simple solution of time travel problems

M. Majka[1,2], Md K. Hasan[3], T.M. Majka[4]
[1]*The Henryk Niewodniczanski Institute of Nuclear Physics Polish Academy of Science,*
ul. Radzikowskiego 152, 31-342 Cracow, Poland
[2]*University of Ferrara, Department of Physics and Earth Sciences,*
Via Saragat 1, 44122 Ferrara, Italy
e-mail address: marcin.majka@ifj.edu.pl
[3]*Institute for Materials Research and Innovation, University of Bolton,*
Deane Road, Bolton, BL3 5AB, United Kingdom
Department of Chemistry and Technology of Polymers,
Cracow Universityof Technology, ul. Warszawska 24, 31155 Cracow, Poland

The most desired journey by human being is definitely travel through time. For centuries, people dream about time travel, to be able to go back and fix mistakes of the past. But there are many complications associated with time travel - starting from technological aspects ending with the philosophical paradoxes. Yet, is time travel possible from the technological and philosophical perspectives? How to solve the paradoxes of time travel? It should be noted that realisation of time travel leads not only to the discovery of the nature of time, but also to the understanding how much is unknown about it. In this paper, probability of time travel and solutions to paradoxes will be critically analysed from philosophical perspectives.

Keywords: time travel, wormhole hypothesis, Minkowski light cone, event causality, grandfather paradox, philosophical perspective

I. INTRODUCTION

One of the basic postulates of physics is the lack of an immediate transfer of matter from a distance [1,2]. It is related with the principles of conservation of energy, momentum and angular momentum. However, it is possible to teleport the quantum state of matter [1-8], which requires matter on both sides of the distance. The relationship between the mass and energy can be described by the following formula [9,10]:

$$E = mc^2 \qquad (1)$$

where E is the energy of the system, c is the speed of light in vacuum, and m is the mass. In words, mass is proportional to energy and the factor of proportionality is the square of the speed of light. It is apparent from the equation (1) that the matter can come from energy. The matter can be born from energy at any time and has certain properties described by quantum numbers. In the case of a single particle, it is a small number of data. However, this information is difficult to examine for complex and interacting systems. Heisenberg uncertainty principle [11-14] clearly explains the relation between time and energy measured during the test. But the lack of accuracy makes it impossible to get all necessary information about given matter [14]. Additional difficulty is the degeneration of superposition of states. Each measurement destroys the quantum nature of the matter and reduce the system to one of the states. The knowledge of all information about the quantum states requires an infinite in time measurement, which is not physically.

Matter in the known universe cannot move at a speed greater than the speed of light [9]. The movement in space is bounded above by the speed c [10]. However, there is a hypothesis that, by appropriate bending of space, it is possible to move at the speed of light, even at superluminal speed [15-19]. Moving of the matter in this hypothesis is based on the generation of space-time bubble [15]. The space before the bubble will be squeezed and stretched after it. Because of that, passengers inside the bubble will feel like they are moving at the relativistic speed, but only time and space will move. This solution is purely theoretical and does not explain how to physically create such a space-time bubble.

The movement of matter in space is not a problem, because even a small force acting on the object placed in the vacuum will cause it to move. Such a movement can take place in any direction, no matter how we define the coordinate system associated with the observer. Einstein explains [10] speed of light is not dependent on the motion of the observer. However, when you are moving with speed close to the speed of light, you can observe time dilation and contraction of space. Clock moving with relativistic velocity will change the position of its guidance slower than clock at rest.

The information which we receive about the world are always information about the past. Even if the information carrier is a light wave, it needs a certain period of time to reach us from another place. Because of that, observed picture of the universe, stars, galaxies, are images of their past. The oldest image of the universe is cosmic microwave background radiation (CMBR) [20-23]. Since the end of the dark ages to the present day, photons released from the matter are traveling in space providing information about the past. The fact that we observe only a small part of all stars in the cosmos allowed to hypothesize that the universe had to have a beginning. If the universe was eternal, the light from the farthest corners would take long time to reach the Earth and consequently light up the night sky as the sun in the day.

The beginning of the universe took place through the Big Bang [24-27], when all matter, time and space were born. From this moment the three dimensions of space and time, become inseparable. To travel in three-dimensional space, it is necessary to move in the dimension of time. Yet, theoretically it is only possible to move forward in time, to future. But, is it possible to move the matter back in time, to past?

In this paper, hypotheses will be presented for solving the problem with time travel to the past. Chapter "Event causality and time travel" presents causality and its effect on events represented by the Minkowski light cone. In chapter "Wormhole hypothesis" the hypothesis of time travel using wormholes is described. In chapter "Known solutions to Grandfather Paradox" are presented three main solutions of grandfather paradox of time travel. Our thought experiments, which are solving the time travel paradoxes, are described in chapter "Thought experiments". "Conclusions" presents all main findings presented in this paper.

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II. EVENT CAUSALITY AND TIME TRAVEL

Travel back in time seems to be impossible because time moves only in one direction - toward to the future. This is defined by the arrow of time, the direction from the past to the future [28,29]. The existence of an arrow of time stems from the elementary law of physics. It says that in the universe order invariably turns into chaos. During the passage of time, the universe is slowly falling apart. At the beginning of time, the universe was structured, but over time the disorder increases until complete chaos. Any attempt to restore order are related to the activity which increases disorder.

Arrow of time can be curved through a huge mass, or gravity. Therefore, the huge mass can bend the space-time so that the arrow of time will become a loop and events will be constantly repeated. Such an arrow of time loop can allow that events will constantly repeating, but this does not satisfy our reason of traveling in time.

The principle of causality [30,31] clearly defines the relationship between events located on an arrow of time. Hermann Minkowski shows the causality of events using a cone, as shown in Figure 1. Cone is an illustration of the whole future and the past for a specific event in time and space. It can be described by the following formula:

$$c^2t^2 = x^2 + y^2 + z^2 \qquad (2)$$

where c is the speed of light in vacuum, t is the time, and x, y, z are the three coordinates of space. Everything what will happens in the future is located in the upper cone. Everything what happened in the past is located in the lower cone. The present event is located at the intersection of the space and time axis. The edges of the cone are defined by lines of light. Tangent of the angle of sidewall of the cone inclination is equal to the speed of light in a vacuum. This means that all events outside the cone, are events which take place somewhere else, or happen to someone else. Therefore, the speed of light has huge impact on the causality of events. In the case of looping the arrow of time, the upper cone engages with the bottom cone thus forming a closed figure. The future becomes the past, and the past becomes the future. An important consequence of such a loop is no possibility of modifying the past because past become the future. Thus, the past events would take place infinitely and no event can be changed. It must be stressed that the curvature of space-time is compatible with both Einstein's General Relativity and Minkowski light cone. It is enough that Einstein's space-time reminds Minkowski space-time locally.

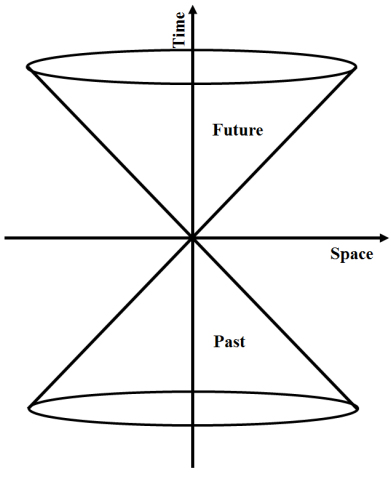

FIG. 1. The Minkowski light cone showing the entire past and entire future of any event in space-time

Event causality does not rule out time travel. However, causality excludes all modifications of events. It is apparent from the light cone that whole future of present event is well defined. The future is not only well defined, but also limited. Hence, it is not possible that for a given point in the present, an event located outside the upper cone can happen. Events can occur only inside the cone. The same applies to the movement. If it would be possible to travel at superluminal speed, the movement would take place outside the light cone, passing only through the point in the present.

III. WORMHOLE HYPOTHESIS

The space which surrounds us is a four-dimensional space, where we define the three dimensions of space and one dimension of time. Thus, theoretically it is possible to move in all these dimensions simultaneously. Life experience shows that the above assumption is true for three space dimensions, provided that there is enough time to make a move. This means, teleportation of matter, from one point of three-dimensional space to another point of three-dimensional space without moving in time dimension, is not possible. It should be noted, that we are only talking about traveling in time to future. Even if the matter is at rest it moves forward in time.

Einstein found that space-time may be subjected to deflection under enormous mass and The weakest of the forces of nature – gravity – is powerful enough to curve space and time. If it is possible to bend the space-time, it is also possible to perforate it and connect with another part of space. This procedure leads us to wormholes. The existence of wormholes is not excluded by the General Theory of Relativity and it is likely that such tunnels were created in a natural way. Assume that, immediately after the Big Bang, the space-time was so twisted that could produce wormholes which could have stayed until now.

Wormhole itself does not allow to time travel [32]. However, wormholes would allow only travelling from one point to another point in space. To satisfy time traveling using a wormhole, it is necessary to travel from one point the wormhole exit to another point in the arrow of time with a speed close to that of light. It must be noted that theoretically so far it is the easiest method which would allow to travel at a speed close to that of light. Time of a tunnel which is travelling with relativistic speed would pass slower than the time of the object at rest. Hence, one end of the tunnel would be placed in future and the other end in the past. This tunnel may allow time travel, however only between two specified points on the arrow of time. It should be mentioned that the idea of wormholes satisfies the hypotheses of General Relativity. An important ability in this idea is an ability to motion with speed close to the speed of light. Unfortunately, travelling with such speed is still in the realm of dreams.

Stephen Hawking believes that wormholes are unstable and laws of quantum theory prevent their formation [33]. The laws of physics will not allow the existence of closed curves of time [34]. Hawking stated the explanation of wormholes by theories like string theory or quantum field theory must be consistent with the General Theory of Relativity. Hawking wants to create a coherent theory for everything. It cannot be logical that wormholes at the micro level would satisfy one law of physics, while at the macro level would satisfy another law of physics. However, this is the case for wormholes only. The world described by the quantum mechanics is completely different from the world described by classical mechanics. Hence, it should allow for bending a space-time and forming of wormholes [33]. The effect of these closed universes on ordinary particle physics can be described by effective interactions which create or destroy closed universes.

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Formation of wormholes is related to creation of a black hole [33]. It is a massive object with the entire mass is condensed in a small area of space. However, in the case of the Planck scale, such black holes quickly disappear [33]. This does not allow to produce wormhole in the next step. Therefore it is not possible to produce a wormhole and keep it long enough to be able travel through it. Hawking dismisses the possibility of time travel, saying:

"If time travel is possible, where are the tourists from the future?"

We cannot disagree in this case. If travel back in time is possible, we would see time travellers every day. We could use their knowledge and experience, which in turn would bring a paradox.

IV. KNOWN SOLUTIONS TO GRANDFATHER PARADOX

Time travel is not a simple issue from the viewpoint of physics, engineering or philosophy. The philosophical problem arises particularly in the case of travelling to past. If someone goes back in time and changes something in the past, will it affect the future shown in Minkowski cone? If the past can be changed, will it be possible to travel to the future? These questions raise ambiguously solvable paradox of time travel. For example, the famous grandfather paradox. Imagine, a time traveller goes back to the youth ages of his grandfather and stop him meeting his grandmother. As a result, he would not have been born as his grandfather and grandmother could never have children together. Thus he would not be able to travel back in time, a paradox. There are three known solutions to this paradox:

1) The first solution to this problem is simple. Assume, time travel is not possible as nature would not allow the paradox. It must be stressed that there is no contradiction in the universe. The internal logic or lack of contradiction is the basis of the universe, as discussed in the event causality section. However, there is lack of a hypothesis that would explain how nature defends itself against time travel.
2) Another solution to the paradox is the hypothesis of parallel universes. By going back in time, a time traveller is moving to another parallel universe where he can do everything without affecting the events of first universe. It may be quite difficult to imagine such a situation, where time travel requires jumping from one universe to another. However, this approach has even more unknowns than the first one. Does every time travel require jumping from one universe to another? If so, how many universes are there? What physics does govern the choice of the universe, to which time traveller is moving?
3) Let us consider another approach based on the Minkowski light cone. Imagine, time travelling to past cannot change the past events. In other words, even if someone is able to go back in time, he cannot change the events that took place in past. He can passively observe events or try to influence those without modifying the outcomes. This approach is consistent with the Minkowski light cone and can explain why Hawking is not being able to see time travellers from future. This approach may resemble watching a replay of game. Viewers can yell at the players who are playing badly but viewers have no influence on what they are watching. In simple words, viewers can passively watch the game, still result will be the same.

V. THOUGHT EXPERIMENTS

Time is a mystery which mankind has not solved yet. Our imagination drives us to action and finding newer and newer technologies. Solution of the time travel paradoxes leads not only to the discovery of the nature of time, but also to the realization how much we do not know about it. As in the case of quantum mechanics, which can only determine the probability of finding a particle in some states but do not describe anything new except how little we know about the particle. In this section, the validity of the above solutions would be examined in order to predict the probability of time travelling.

As the first solution explicitly denies the possibility of time travel, let us start with the second solution which is based on the hypothesis of parallel universes. Hypothesis of parallel universes can only determine the probability of jumping to a particular universe. Assume, the number of universes is infinite and there is no possibility of returning to the previous universe. Further the probability of jumping to any of the universes is same. Thus, the probability of jumping to a universe can be explained by the following equation:

$$P_i = \frac{1}{\infty} = 0 \tag{3}$$

which means that, the probability of jumping to any universe *i* is equal to zero. If probability of jump between universes is equal to zero, the probability of the time travel is also equal to zero.

Finally, let us consider the most promising solution: a time traveller goes back to past by a most advanced theoretical time machine which would have two points in time – one placed in the future and another in the past. Further assume that he would have no influence on the past events in order to satisfy major philosophical issues. Now, technological issues need to be addressed. It must be noted that time and space are not separable, and planet Earth, solar system as well as galaxy are changing their positions over time. Hence, teleportation of matter from one point in space to another is needed. Without wormholes, such an operation in not possible because matter cannot disappear in one place and appear in another place without a move. The use of wormholes requires to build a tunnel or find an existing one, which in both cases is unattainable with the current technology. Even if the tunnel could be built or found, travelling of matter from one point to another point of space-time is inevitable. It must be stressed that the speed of travelling must be close to the speed of light or higher. Another important issue is teleportation is based on the consideration of three dimensions of space whose coordinates are changing while time is constant. In case of time travelling, it is completely opposite i.e. time is changing while coordinates in space are constant. Moreover, movement of matter with teleportation is not physical. Based on the above discussion, it can be safely concluded that time travelling will not be possible.

VI. CONCLUSIONS

It is difficult to dismiss time travel, because the idea stimulates the imagination. It allows us to dream of opportunities to fix our mistakes of the past or even the whole of humanity. However, considering complications starting from technological aspects of wormholes to philosophical issues, there is no possibility of successful time travelling.

The use of wormholes requires to build a tunnel or find an existing one, which in both cases is unattainable with the current technology. Even if the tunnel could be built or found, travelling from one point to another point of space-time with the speed of light is inevitable. Unfortunately, travelling with such speed is still in the realm of dreams.

In case of philosophical issues, many hypotheses can be presented. However, none of them would support travelling to past. However, every day we travel in time to the future and we have an insight into the past, because each stimulus we perceive is a signal from the past.

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