Is time travel fact or science fiction?

‘Today's science fiction is tomorrow's science fact’ - Issac Asimov

Introduction

The essay that you are currently reading has travelled through time. This is not even in the boring sense that most people would fall into the misconception of accepting. It is, yes, going into the future as we all are, but not only that, the series of binary digits that make it up have been sent through a combination of electrical signals and electromagnetic waves. This is a more interesting and different type of time travel. The difference would be the same if you ran up and down a corridor with it in your hands. Why? Time travel is not what you think* (see relativity, 2.2).

The purpose of this essay is to look at and explain time travel in life and then evaluate its uses for the future, science fact or fiction and the justification of this. It is therefore important to clarify the title. It means, how can time travel be used to make fiction a reality and what are the ways in which it is misrepresented.

The way in which the essay explores time travel is through the topics as listed: Entropy, Relativity and Quantum mechanics. These will be broken down into sub-topics which will be explained and evaluated. They will be evaluated in *italics* at the end of each section. There will be a separate topic of black holes which will be used as an example of the extreme conditions that time endures and the resulting natural phenomenon.

When looking at the topic it is important to first know how time can be warped in the future direction, but it can never go backwards* (see entropy, 1.2). This is one of the ways that time travel in science fiction is wrong.

The main argument of this essay will be to show how it is very difficult to utilise the way in which time is warped and using time travel commercially in say, a spaceship. It will be shown that this is fiction after an evaluation of each topic. Time travel happens everywhere but science fiction makes it seem strange and distant.

Before you see how you are a chaotic time traveller, it is important to consider the first thing that comes to the mind when time is said. A clock. What does a clock actually measure? My Grandfather’s grandfather clock works with weights, springs and a pendulum. Clocks generally use springs because of Hooke’s law, which you may have had the pleasure of learning about for your GCSE’s. It means that the slow-release energy of the spring will be at a constant and therefore the ticks are evenly spaced apart. It is the same type of principle for the grandfather clock but with a pendulum.

However, the cup of tea*(see entropy, 1.2) that you might drink next to the grandfather clock in the living room may tell you much more about traveling through time than the clock itself. Namely a question, what is time?

'Entropy is the price of structure' – Iyla Prigogine

1.Entropy

1.1 Entropy is often described as the tendency of disorder to increase. However, a better definition for it is the tendency of energy to spread out. This is because disorder means randomness and chaos due to some kind of movement or a causal effect. However, this is not what entropy is, as described by the third law of thermodynamics: 'The entropy of a closed system at thermodynamic equilibrium approaches a constant value when its temperature approaches absolute zero.' This shows that at absolute zero where there is no energy there is no entropy. This is because entropy is the energy spreading. Does this therefore mean if we were at absolute zero, there would be no time for us? The answer is technically yes, however, we cannot get anything to reach absolute zero as we would know it has zero speed and we could then also measure its position* (see Heisenberg's uncertainty principle, 3.2). As well in 1895 Rudolf Clausius made the second law of thermodynamics, meaning that essentially all of the energy will tend to a uniform, spread out state.

1.2 Entropy is the medium by which time is measured. It is how time is measured because the spreading out of energy only occurs in one direction, Entropy only increases. For example, in metals, heat is transferred through conduction. This means that the vibration of an atom will vibrate another and so on. When a cold and a warm piece of metal are placed together heat always transfers from the hot to the cold. This is simply statistical. This is because the hot piece will vibrate the atoms in the cold piece more than the other way around until the vibration is evenly distributed. It is never statistically reasonable that a solid piece of metal suddenly gets hot on one side and cold on the other. The direction of entropy moving in only one direction is why you cannot go back in time. Going back in time would go against the very definition of entropy. It is also important to note that the higher the temperature, the more concentrated the entropy. For example, a cup of tea has concentrated entropy that gives off vapour, a gas with low entropy.

1.3 The history of the universe, from the big bang to the heat death, shows us that the direction of entropy is only one way. The universe had a relatively low entropy state right after the big bang as the entropy increased from there. The low entropy is due to gravity holding everything together in the massive density of right after the big bang.

1.4 Furthermore, in the middle of the process of the big bang to the heat death, entropy spreads out and in this time frame, life occurs. How and why? For example, we humans use energy to drive cars. By doing this we take the photons from the sun which cause natural phenomena to occur on earth such as plants undertaking photosynthesis. Dinosaurs then eat these plants. Dinosaurs then mysteriously die and form oil. Humans refine this oil into petrol and can now successfully drive to the supermarket. All of these steps spread energy out by using it, releasing low energy photons back out from the Earth. We are so good at this that some people believe it is why we exist. If there is a lot of highly concentrated energy in an area you will get better and better dissipaters of it to use this energy and increase the entropy. This happens until you get life. Jeromy England said, "You start with a random clump of atoms, and if you shine light on it for long enough, it should not be so surprising that you get a plant."

1.5 At the very end of the universe, there will be the heat death, according to Drake, 2025, where all the useful states of energy were used and everything is spread out the same distance, uniform and there will be no time. Everything will be the same backwards as forwards. I would say that this is a long time away, but time doesn't seem to be so rigid* (see relativity, 2.2).

Entropy ensures that we cannot go back in time. It would not even be a good idea to try to tamper with entropy to try to time travel. This is at least now as we are not even on level one of the Kardashev scale, meaning that we are bad at harnessing energy. This is because it is the bringer of and pursuer of life.

'Time is an illusion. Lunchtime doubly so' – Douglas Adams

2.Relativity

2.1 Before we had a proper understanding of what time was, Newton said that time was absolute. However, this changed once Einstein proposed his improved theory to describe gravity: relativity. Special relativity understood objects moving at constant speeds through space.

2.2 However, when changing speeds are introduced, this also describes gravity. In addition, Einstein proposed space-time. this is important as it shows that space and time are woven together and as one is warped, bent, stretched, squeezed or travelled through so is the other.

2.3 An example for this is Einstein's thought experiment of two observers, one on a train in the middle and another on the station. The person on the station sees two bolts of lightning, one on the front and one on the back simultaneously. However, for the person on the train they see the lightning strike on the front as they are moving into it. therefore, time is different based on the location and speed of the train. This is called time dilation.

2.4 In fact we are always moving through time differently to other people. This is further developed by an understanding of the speed of light because according to Hossenfelder, 2025 we travel through time with the speed of light. This is because Einstein figured out that the speed of light was the fastest moving thing in the universe* (or is it? see Quantum Mechanics, 3.4). Therefore, movement that is very fast bends the fabric of space time causing time to pass more slowly and so, it follows that the faster you move, the slower your life goes by. To visualise this bending of space time it is often thought of like a bowling ball on a trampoline that may pull other objects closer. If you were moving at the speed of light, there would be no time. However, anything with mass cannot move at the speed of light as its mass would become infinite due to $E = mc^2$. Additionally, another interesting property of a cosmic speed limit means that when you see a star's light, it travelled through time to get to you, so it is in the past therefore you are always looking into the past. Even when you see a tree in your garden, this is in the past; It is a past that you would never reach. The world around you is not the one you are living in; it is the past of it.

Could we use special relativity to time travel? It could be more effective if you want to age less and live longer by warping space time. We could also try to travel faster as an interstellar colony. Relativity is the everyday time travel. The use of gravity can warp space time for you so much that you could become older than your parents. Some truly amazing things can be achieved with gravity.

'Everything we call real is made of things that cannot be regarded as real' – Niels Bohr

3.Quantum mechanics

3.1 In following relativity it is impossible to go faster than the speed of light. However, introducing quantum mechanics adds a level of peculiarity. This is because very small things can appear to behave very oddly. There is a level of uncertainty. This is why there is a principle for dealing with quantum mechanics, Heisenberg's uncertainty principle.

3.2 The uncertainty principle essentially means, as influenced by Poojary, 2015, that you cannot know both the speed of a subatomic particle and its position. Only one at a time. This limits precision and is fundamental to all of quantum mechanics. The formula for this is $\Delta x \Delta p \geq \hbar/2$.

3.3 Another example of uncertainty is a superposition and Schrödinger's cat. However, people have typically misunderstood this. A superposition is when a particle is considered in multiple places at once. Schrödinger was confused about this and set out to explain it on a larger scale to show it did not seem to make any sense. He said that if you had, in a box, a particle in a superposition that will at some point do something, for example trigger poison to be released, and a cat. The cat would seem to be considered dead and alive due to this definition.

3.4 However, one of the strangest topics in quantum mechanics is quantum entanglement. In this area the spin of fundamental particles, which means its angular momentum and orientation, can be determined seemingly faster than light. The orientation of a particle can be in line or opposite to the measuring device, meaning when measuring it, the probability of getting it correct is a fifty-fifty chance. If it is wrong the spin will change. For entanglement, if the particles were prepared correctly, spontaneously out of energy, then if one is measured correctly with one spin, the other will have the opposite. The spin could not be set before as if both were the same this would violate the law of angular momentum, meaning the spins have to cancel. This then means that faster than light communication seems to occur between one correctly measured particle and the other corresponding particle. This is because by measuring one you instantly seem to know the other, no matter the distance. How can this be, would this not violate the laws of relativity? What do you think? This seems to be one of the strange properties of quantum mechanics. This is why Einstein called it 'spooky action at a distance' in 1935.

Very strange things happen on small scales. Humans are not very small and therefore do not experience these things. We cannot even harness them on a large scale as once it becomes large enough it is not quantum. Even if we were to utilise quantum effects, we would have to accept a level of uncertainty. Pertaining to entanglement, could we communicate faster than light? The answer is, no. This is because the result at a detector will be random, a fifty-fifty. Regardless you would not know what you would get for one reading before you send a signal to the other.

"The past is a foreign country; they do things differently there." - LP Hartley

4.Black holes

4.1 Black holes are an example of the laws of the universe that bind time to sensibility driven to the limit of possibility. So appropriately this section will have an example of a person having an unfortunate encounter with a black hole. As such this section will be slightly different. There will still be an evaluation of its use in time travel in a future, science fiction sense at the end in *italics*. It will, however, be an example explaining what will happen in a fictional scenario and not an explanation tested by time. It is more modern theoretical work that could be fact or science fiction just as the utility of time travel for humans could be.

4.2 The example will be of a lost astronaut called Fatuous. He is part of a mission to further study black holes and is not very cut out for this Job. As such he knows nothing about black holes. So, when he drops his sandwich into one, he goes diving in after it. Fortunately for the researchers he happens to be immortal and can tell them what he sees. He does not become 'spaghetti' What happens to him?

4.3 Before delving into this example scenario, what is a black hole. The first photo of a black hole was of M87 in 2017. You may have seen it. A black hole is formed by gravity overcoming pressure created by nuclear fusion due to size or less fusion taking place. Fusion is the process by which stars emit heat and light. The form the compressed star takes depends on its size. When the star is relatively small it may become a white dwarf. A white dwarf has the vibration of particles that have been pushed closer creating a pressure to equalise with gravity. Next is a neutron star which is formed when the star was so big that the pressure created by the particles is not enough. This is because the fastest that they can move is the speed of light. And so, protons and electrons have to join to form neutrons and neutrinos. Neutrinos are just fundamental particles meaning they are not able to be broken down. This mass limit for white dwarfs that mean neutron stars are formed was proposed by Subrahmanyan Chandrasekhar in 1930. Beyond even this mass, black holes are formed.

4.4 The anatomy of a black hole can vary. The basic anatomy is a singularity, a point where all mas has been squashed into infinite density. Then the event horizon, the point of no return where not even light can escape. These will be looked at further in our scenario. Depending on type and size there may be an accretion disc where matter and hot gas spin around the black hole in an orange-red ring. They have coronas which are arcs above the black hole. It may have particle jets that have matter streaming away from the black hole. Black holes emit Hawking Radiation, where the mass becomes energy which can be radiated away. The scenario in this example is a spinning black hole.

4.5 Fatuous pushes off the space station after his sandwich very fast. As he approaches the black hole, the other astronauts see him slowing down until he reaches the event horizon. At the event horizon they see him stop. He slowly gets redder and redder until he disappears. Alternatively, Fatuous sees himself going straight through. He passes through the horizon extremely fast. Just as he is doing this he sees light and tries to run towards it. He fails and takes a bite of the sandwich he was reunited with through his futuristic, one way helmet. Then he is pulled into the inner horizon. In here he sees the singularity. It is in the shape of a ring. He is able to move freely. He decides to move through the singularity. After this he is pushed out of it into a different universe. Gravity pushes here. He finds this very odd and loses his appetite.

4.6 What is going on here? To explain this, it is important to first understand light cones and Penrose diagrams, named after Roger Penrose. A light cone is a graph of space and time that has the speed of light at a forty five degree angle. This then shows all of the possible places you could go in the future. This is like how the observable universe is all we can see as the light has to travels back to us. There is also a light cone opposite to show all that could have happened in the past. A Penrose diagram shows space time when it is curved and when it is so curved that there is a black hole. When Fatuous reaches the event horizon, the photons that display the image of him are stuck on the horizon as this is the exact point where the force flowing inwards ins the same as the speed of light. The reason why he becomes more red is due to redshift, according to Howard and Dobrijevik, 2023. This is when the waves of light are extended due to them fighting against the force of gravity to escape. However, for Fatuous, he can pass normally through. Inside the horizon nothing escapes as the force is greater than the speed of light. This can be visualised as a circular waterfall where the effort to escape is too much beyond a point and the same at a point. Now when considering the singularity, Penrose diagrams become very helpful. This is because they show that the singularity is not a point in space but a moment in time. For some black holes, the singularity can be forever in your future just out of reach. In Penrose diagrams, the universe and a black hole are depicted together in a helpful map. Scientists morph light cones and Penrose diagrams. By doing this they see that in the past of the black hole there is the opposite, a white hole. It pushes everything out of it like how a black whole attracts things. This is what Fatuous feels as he is pushed out. It is important to note that if this were not a spinning black hole he would have gone into a parallel universe where two people from different universes could meet in a black hole. However, he goes into an opposite universe where this type of universe and the opposite, alternate infinitely. At the centre of the alternate universe, black hole, white hole and our own universe is a wormhole. It is unstable. This is why when Fatuous tries to run across it he cannot. He can only run a finite amount. He is limited by the speed of light whereas the wormhole is not. The wormhole will 'pinch off.' Kip Throne and Micheal Morris found some wormhole structures that could work mathematically but are physically difficult. This is why wormholes are described as 'not naturally occurring.' This is where the boundary between science and science fiction are blurred and it may be the science fiction that forms the new science. Only the future will tell.

Could black holes be harnessed by humans, to master gravity and travel through universes. Maybe, in a lot of time. There are some problems such as 'spaghettification' before even arriving to the singularity that may always lie in your future. The only way to test whether there are other universes is to jump in. We could certainly not use wormholes. However, one thing is certain, there is more to come, we don't know what we could do with them as we do not fully understand them yet.

‘All we have to decide is what to do with the time that is given us.’ - J.R.R. Tolkien

Conclusion

In the essay the unlikelihood of time travel in a science fiction sense has been explained through the exploration of four topics and each of these topics highlights a fundamental reason why time travel in a science fiction sense is unlikely. The key reasons are summarised as:

> Entropy can only increase, limiting the arrow of time.
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> Relativity limits the speed anything can go at.
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> Quantum mechanics allows uncertainty to arise when dealing with the nature of particles and their interactions with time. However, this does not apply to large scale interactions.
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> Black holes are hostile to humans and therefore difficult to utilise.

To conclude, it may seem as though our traveling through time is very limited but this is not the case. We have many possibilities working with these rules. I believe that time travel would be so difficult to harness that as a species, we should have nothing to do with it, as much as we can. Moreover, the universe seems to have laws prohibiting anything that contradicts itself, meaning most of science fiction to do with time travel. This is exemplified by relativity and entropy. Although the human imagination and yearning for what is not already understood and controlled by us is formidable. It would not be surprising that we manage to do something more impressive in the endless search for what is unattainable. For now, we have time travel in an everyday, interesting sense which people do not seem to appreciate for its bizarre nature. We should enjoy that and marvel at the curious nature of everything around us but still keep looking for what comes next; however, we get there.

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N.B. all websites and papers are cited in the text

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