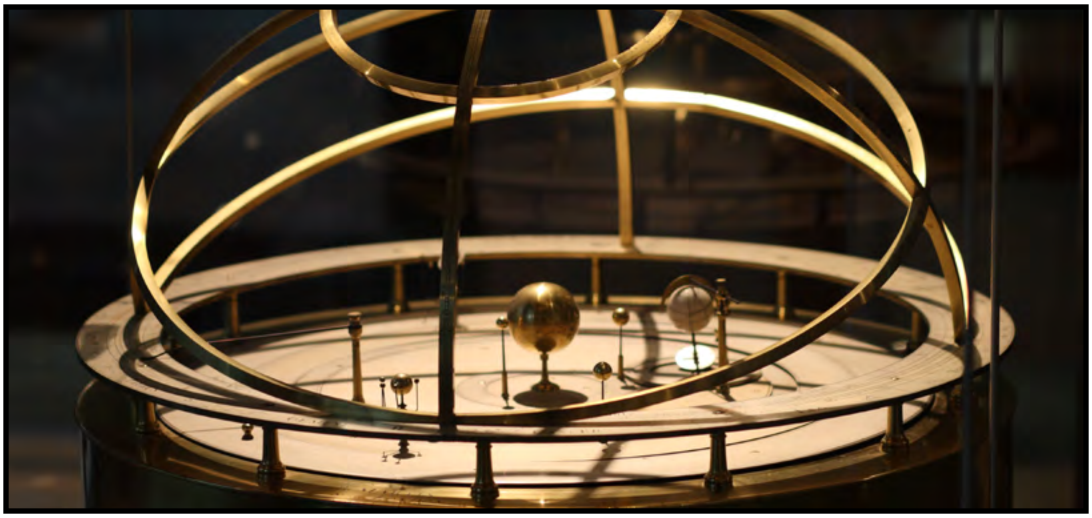
On the Feasibilityof Time Travel and its Implications

Michael A. Amaral, FRC



An orrery made by Benjamin Martin in London in 1767, currently on display at Harvard.

Time travel has been demonstrated to be feasible in theory. This raises issues dealing with our awareness of time, the problem of a frozen history versus free will and the existence of time paradoxes. A different understanding of time suggests interesting possibilities. Time periods may coexist and the past may be as indeterminate and variable as the future. Changing the past, in fact, cannot change the present and our limited perception of only the here and now may have helped our survival as a species. Even if the universe were to come to an end, there is a way for the human race to remain immortal.

One of the great theoretical findings of modern physics is that time travel appears to be feasible under certain conditions (Halper 1992; Hawkins 1998). It is Einstein's general theory of relativity that has brought time travel from the realm of pure science fiction to that of a theoretical possibility. Moreover, not one but several means of time travel have been discovered. Most involve strong gravitational fields that distort space and time. In the theory of general relativity, the three dimensions of space combine with the dimension of time to create a new entity, spacetime. Space and time are intimately related and cannot be separated from one another. Very massive objects distort the local space-time continuum, allowing time travel.

We will see that if time travel is feasible, then time periods must coexist and if this is so, then the past must be as indeterminate and variable as the future. If the past is variable rather than frozen, then why would the present follow only one history? If all those time periods do coexist, then, why is our perception of time limited only to the present? And finally, how could we use this new understanding to our advantage? Our new vantage point is obviously very different from the accepted notion that the past is frozen and that only the future is indeterminate. The various recent science fiction movies concerning time travel also attest to the firm belief that changing the past automatically changes the present. But first, we will briefly review the various means of time travel.

Traveling in Time

Forward time travel: Traveling into the future may be easier than the opposite, as relativistic equations show that time slows down as speed increases. A traveler in a rocket accelerating (and later slowing) at a rate equal to Earth's gravity would see the following results: 1 year in the rocket corresponds to 1.01 year on Earth, but 30 years would correspond to 4,478 years and 60 to 9,911,335 (Pickover 1998). If this traveler spends 60 years in a spaceship at speeds approaching the speed of light (let say while in hibernation) they will come back to Earth nearly 10 million years later.

Actually, at the speed of light, time stands still and, for a light particle (photon), there is no time and everything is instantaneous (objects having mass cannot travel at the speed of light as their mass would become infinite). This time dilation effect has already been verified experimentally using atomic clocks in accelerating rockets. The theory of general relativity has also been tested by various means to a high degree of accuracy. No matter what we want to think, this is how our world behaves.

Backward time travel is trickier and necessitates technologies that are not yet within our reach. I will mention three ways that might work in the future.

Rotating black holes (wormholes): Black holes occur when a very massive star collapses. The gravity is so large that even light cannot escape, therefore the name. Normally the whole mass of the star concentrates in a point at the center called the singularity. What happens there is unknown. Under certain circumstances of rotation, it is possible in theory that a spaceship following certain trajectories within the black hole would travel back in time. The intense gravity and rotation of the black hole distort the surrounding space-time opening some form of tunnel, commonly called a wormhole (Halper 1992). This concept has now been widely publicized in science-fiction books and movies.

Tipler cylinders: This idea was conceived by the physicist Frank Tipler in the 70s (Pickover 1998). According to this theory, about 100 neutron stars fused together and forming a very large spinning cylinder about 4000 km long and 40 km wide would do the job. The rotation and gravity twist space-time enough to permit traveling into the past. This is because the intense gravitational field near the cylinder slows time in its vicinity. A limitation to

An image from a NASA artist showing what a supermassive black hole might look like at the center of a galaxy. The black region in the center represents the black hole's event horizon, where no light can escape the massive object's gravitational grip. In addition to warping light, black holes are believed to warp time, slowing it down near its event horizon.

this technology is that the most backward in time one can go to is when the cylinder was created. To visit our own past, we would therefore have to hope that an advanced civilization already built such a device somewhere.

Moving space bubbles: This idea was developed by Alcubierre and Everett in the mid 90s (Parsons, 14). Relativity theory prevents solid objects like astronauts and spaceships from travelling faster or even at the speed of light where their masses become infinite. This, however, is not true for space itself, which can travel at any speed. Indeed, one of the most modern theories for the creation of the universe invokes a concept called "inflation," in which the very early universe suddenly increased in size in a fraction of a fraction of a second by a factor of 10 to the power 60, effectively moving faster than light (Penrose 1997; Gangui 2001). The authors imagined a spaceship surrounded by a bubble of space. If there were a way to contract space in front of the bubble while dilating it in the back at the same rate, then the space bubble and the ship it contains could have unlimited speed. If the ship accelerates within the bubble, it would effectively travel backward in time.

The Lagoon Nebula, some 4,000 light years from Earth.

Time Periods Do Co-Exist

If time travel were not feasible, then one could assume the prevalent view that the future does not yet exist and that the past no longer exists. However, one inevitable conclusion of the feasibility of time travel (even if it is only theoretical) is that time periods must somehow coexist. The time traveler gets to a world that has a real existence. This world just doesn't get created from scratch when the traveler arrives. It already exists. As we are the past of some future, we have to assume that the future already exists as well.

The Problems that Arise from the Feasibility of Time Travel

The feasibility of time travel brings three major problems:

First, why does our consciousness experience time as an ever-evolving present? Why aren't we aware of the time continuum?

Second is the problem of free will. We see the past as frozen. What has occurred has occurred, forever crystallized in our memories and documented in our history as well as in our archeological and geological records. As we are the past of some future time, then our own history must be frozen and free will is just an illusion. In reality, our actions follow a predetermined path. The uncertainty and chaos that we see in life and science are only the reflection of the underlying order of a history already written for us. Or is it?

Third is the problem of time paradoxes. What would occur if, for some reason, one would travel into the past and change it, for example if one would kill one's own parents or even one's younger self? Would this make that person disappear as in the Back to the Future movie? Let's try to answer those questions.

Time and Physics

The laws of physics work best when time is considered just as another dimension to be added to the three dimensions of space, creating what is known as spacetime (Hawkins 1988,1996; Rucker 1997). General relativity closely links space and time so they cannot be considered independently of one another. Yet, that is how we consider them in our common experience. We experience space on one hand and time on another. Indeed, we have separate words for them.

To our common experience, the space and time dimensions have very different properties. We can see and move in all directions of space. On the other hand, time is limited to the present moment with no easy way to peek behind or ahead. Moreover, it is ticking always in the same direction and we are inevitably getting older. Roger Penrose and Stephen Hawking have demonstrated that time does have a direction, based on cosmological properties (Hawkins & Penrose 1996;, Coveney 1990). Certainly, our experience of the dimension of time is very different than our experience of the three dimensions of space. Nevertheless, particle physicists see time as just another dimension where particles going forward in time are equivalent to their antiparticles going backward. For the purpose of pure physics, the direction of time doesn't matter (Hawkins & Penrose 1996; Penrose 1997).

The Hamzer clock mechanism in Dinan, France, from 1498.

Do you remember the two-slit experiment from your high school physics classes? You place an opaque piece of heavy paper with two vertical slits in them (about five to ten centimeters apart) between a source of light and a screen. The result is an interference pattern demonstrating the wave-like nature of light. Something interesting happens if you design an experiment to observe through which slit each individual light particle goes through: you then lose the interference pattern and get only two bars of light along the trajectory from the light source to the slit! This phenomenon is called "the collapse of the wave function." It seems that the light particles somehow know that an observation is being made and decide to follow a straight trajectory. This fact has been verified multiple times by very ingenious and subtle experiments. It always works that way.

So, where does that take us? The universe has its own two-slit experiment. It is called a gravitational lens (Penrose 1997). The light from a far away galaxy, millions of light years away, passes near another distant heavy object (another galaxy or a black hole) before reaching us. Following the laws of relativity, the light beams are curved by the heavy mass as they pass around it (Penrose 1997). When the light reaches us, it also creates an interference pattern. When we make an observation of which path the individual light particles have followed, we also lose the interference pattern and get individual light beams. What is interesting in this situation is that the light originated millions of years ago and passed near the heavy object that split the beams also thousands or even millions of years ago. How did the light particles know that we were going to do that experiment and decide not to make an interference pattern thousands or millions of years in the past? The only answer is that something travels back in time along the light beam telling the light particles to behave differently. This is one hint that time travel might actually occur on a regular basis.

The Perception of Time

We are able to perceive only a short instant that is the present. Moreover, considering the time it takes for the nerve impulses to get from the sense organ that receives the impression (vision, hearing, touch, etc.) to the brain and be processed, we are in fact always slightly in the past (Kandel 2000; Gazzaniga 1995). Our brain adjusts for this giving us the impression that we are in the present. For most human purposes, this delay is of no consequence. However, if we were to fight electronic machines for example, the difference in reaction time might become important.

How would things be if we could perceive across time? We have something that can do just that, photographic plates. All have seen those long exposure photographs of a highway at night with cars passing back and forth. Only streaks of light are seen. This is how perception across time would look. One can immediately realize that the photographs show only blurred lines and that it is impossible to make out individual cars. Seeing across time would show the position of moving objects at every instant making the view completely blurred and the information useless or overwhelming for our brain to process.

Imagine how complicated one's movements would be across time. Just think of all the back and forth coming and going you do in your own house in a single evening and how complicated it would be to perceive the whole of it. You couldn't tell where you are.

It is much more efficient to see "frame by frame" so to speak, i.e. as a succession of instants. It would not be very useful for us to see more than a few seconds in the past. How much of a survival advantage would it be to see where that lion facing us was each second of the last five minutes? Would it give us an advantage or would we be eaten before having a possibility to run? Our reaction time is bad enough as it is. Seeing five minutes in the future wouldn't help either. We would react to things that have not yet happened and have to keep track of everything so we know where they would be when they reach the present, something that would also be too overwhelming for our brain.

The M62 motorway in Northern England, connecting Liverpool and Hull via Manchester.

Remember that all our senses are limited. We see only the amount of the electromagnetic spectrum that is relevant. Similarly, we hear only a fraction of all possible sounds. The brain has narrowed its input to what is best suited for survival. And what is best suited for survival, considering the economies we have to make is to perceive only the present. If you think hard about it, it makes a lot of sense.

But you might reply that what you would want is to see only selected frames of time in the past and future. When people speak of seeing the past and future, that's usually what they mean. Well, the brain just doesn't do that in most people. There might be instances where high mystics might be able to glimpse through time. Those things happen in the mind and would be the subject of another discussion. Our physiological senses are not designed to perceive through time. In his excellent book on higher dimensions (Pickover 1999), Clifford Pickover points out that if a two-dimensional retina is necessary to perceive the three- dimensional world, then a three-dimensional retina might be necessary to perceive beyond the three dimensions of space and across time. Of course, our brain would have to undergo the necessary adaptations. Humans would look very different with such big globular eyes, and the current definition of beauty would probably suffer.

Therefore, it might only be our senses and brain that prevent us from seeing through time for reasons of efficiency and survival. Seeing with the mind might follow different laws.

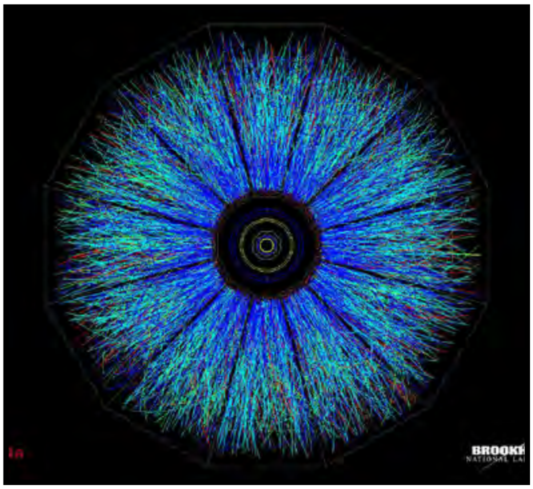
Free Will

History has been written and the past is frozen. We have proof of this through our own memories, archeology, history, and all the other sciences of the past that tell us that things have been a certain way and no other. Their traces are still present to this day. Dead friends and relatives are no longer seen in the present. Leftovers of past wars and other abominations can be found all over. As we are the past of some future, our current history must also be frozen from that future's point of view and therefore our choices follow a hidden but predetermined path. If the past no longer existed and the future was not yet created, this would not be a problem.

However, we have just seen that time periods must coexist somehow if there is such a thing as time travel. And time travel seems to be a fact we must live with.

As science progressed in the last hundred years or so, it has not discovered anything that looks like an underlying preconceived order. Indeed, what has been found is how uncertain and subject to chance the world really is. Quantum physics has shown the existence of random fluctuations determined only by the laws of probability. A physicist named Heisenberg discovered a law called "the

In Angkor Siem Reap, Cambodia, an archeologist maps a part of Pnom Bakheng Temple.



A view of one of the first full-energy collisions between gold ions at Brookhaven National Laboratory' in 2012.

uncertainty principle" where different characteristics (say, the speed and position) of the same particle cannot be known at the same time (Dirac 1958; Penrose 1989, 1994, 1997). Our experience and science of the world give us a picture of something dynamic, always changing and moving. The world appears full of chance events and random fluctuations where things cannot be absolutely measured or determined. The world we experience appears to be anything but prearranged, especially at the quantum scale. How can those views be reconciled?

The only sure thing we are somewhat certain of is our own present (as it is the only part of time that we directly experience) and our present is subject to the laws of uncertainty and probability. Our conceptions of the past and future are in fact speculations. Sure, there is our history, our geological and archeological records and our memories. But they only reflect the past that we have experienced when we were there, not the past that is coexisting with us at this very present moment.

Therefore, each episode of the past or future is subject to the same laws of physics that are experienced in the present. Indeed, time is made of a succession of present moments. This implies that the past is not frozen. It is dynamic, with its uncertainties and laws of chance. The past and future fluctuate as much as the present.

There are limitations to those fluctuations, represented by the laws of causality (Bunge 1979), the subtle web that link events through time. For example, no matter what any individual dinosaur decided to do, they would still all be extinct today because their choices didn't and couldn't influence the events that brought their end about. It is difficult to visualize a dynamic time dimension where everything continuously changes but it is the best explanation. To complete the picture, we have to discuss time paradoxes.

There Are No Time Paradoxes

Our histories in the time dimension are like the waves on the ocean. They remain connected throughout time; otherwise we would not have the experience of continuity that we have. However, they fluctuate to accommodate for the indeterminacy of the laws of nature at each given moment.

Let us look more closely at what would happen if you go back in time and kill your younger self. Would you immediately start to disappear as in the movies? The answer is no. The flow of time is one second per second. The change that was initiated in the past would have to move along the time dimension at that very same rate, in fact never catching up with the present. For you to disappear, the change you made would have to move faster than the time flow itself in order to catch up with your present self. This is why altering the past cannot alter the present.

It is reassuring that our existence doesn't depends on a freak event occurring in the past due to the negligence of a time traveler. The history that gave rise to us is stable, even if it is fluctuating and even if time is an uncertain place.

One conclusion of this model is that the past that has physical reality (not just our own history) is as undetermined as our future. Not only do we have to muster incredible technology to travel backward in time, but, in the event that we might be successful, we would probably not be able to find there the events that are directly significant to us, i.e. we would only find a variation of our own history.

One other possibility is that each variation of each present moment along the time dimension would give rise to a new history of the world, starting to travel at the rate of the local time flow. Trillions of trillions of different histories would then be traveling along the time axis, parallel to one another and maybe only a fraction of a fraction of a second apart. Finding our own real past in this crowd might prove difficult. Physical time travel, although possible, would not be practical and maybe this is why we have not yet seen time travelers come our way.

Jean-Baptiste Mauzaisse, Time showing the ruins it brings, and the masterpieces it then leaves to be discovered, *1822.*

Can the Human Race Become Immortal?

Recent astronomical research has concluded that our universe is flat, i.e. it has no curvature (Glanz 1997). This means that the gravity of the cosmos is not sufficient to have the universe collapse back on itself in a "big crunch" to restart again. The galaxies will therefore forever fly apart, always more distant from one another. The stars will spend their nuclear fuel and die out. In millions of years, our world will be a cold empty space unsuitable to life.

There is worse. The latest discoveries show that the expansion of the universe is actually accelerating. This is felt to be due to a repulsive force, which exists within the fabric of spacetime. It has been called "dark energy" and its exact nature is not yet known (Rowan et.al. 2003; Watson 2002). This dark energy will eventually stretch the basic unit of space-time (called the space-time metric). Every object and being will be torn apart. Do we have any chance of surviving this?

In fact, we do. We have billions of years along the time dimension to live in. If we can travel in time and if altering the past doesn't alter the present or future, there is then the possibility that, at some point, the human race (and possibly other intelligent beings) would migrate into the distant past to colonize it. Those incredible migrations could be done over and over again, effectively making us immortal within the lifespan of the Universe—The "Boat of Millions of Years" of the ancient Egyptians.

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