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Changing the Past

A Philosophical Discussion of the Possibility of Time Travel

From H.G. Wells Time Machine[1], to Marty McFly's DeLorean[2], to Captain Kirk and Mr. Spock's attempts to save the humpback whales[3], to the Terminator's multiple attempts to kill John Conner[4], time travel has fuelled the imagination for over a century. Equally worth noting is the lack of understanding and logical consistency in these works of fiction, with the possible exception of the last one (only to be undone by its sequels). Nonetheless, one can see science-fiction being fuelled by science, in an era that, for the first time, may consider the realistic possibility of time travel.

Is time travel possible? Thanks in large part to the notable contribution of Albert Einstein, which suggests that the universe may allow us to make journeys into the past, we must consider this question for its scientific and logical merit. If we can travel into time, can we change the past? And if we cannot change the past, what does this tell us about the universe we inhabit?

General Relativity and Time Travel

In 1915, Albert Einstein proposed his *General Theory of Relativity*, which predicted that the universe that we live in can be described as a four dimensional space-time manifold, upon

[1] *The Time Machine*, written by Wells, originally published in 1895 by William Heinemann
[2] *Back to the Future*, Universal Pictures, 1985.
[3] *Star Trek IV: The Voyage Home* Paramount Pictures, 1986
[4] *The Terminator* Orion Pictures/Hemdale Film Corperation 1984. Currently owned by MGM.

which we many impose a metric, and that this manifold can be curved by the presence of massive bodies within it, that curvature being measured by Einstein's field equations:

$$\mathbf{G} = \frac{8\pi G}{c^4}\mathbf{T}$$

where **G** denotes the Einstein tensor, representing geometry of the manifold, and **T** denotes the energy-momentum tensor, representing the matter distribution contained. Geodesic paths along this manifold represent non-constrained inertial motion, such as the paths of photons of light, or of elevators floating through space. As such, what was previously regarded as gravitational *force*, according to the field equations, can now be regarded as the curvature of space-time itself.

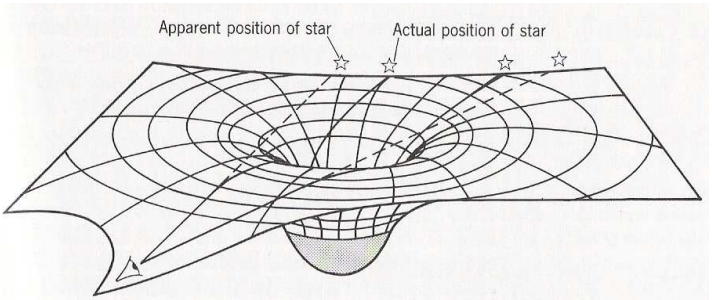

Figure 1 - Light rays bending in gravitational field of a star [5]

His theory, while initially surprising, has been successful in accurately measuring various astronomical phenomena, such as the perihelion advance of the planet Mercury, and the bending of light trajectories and red-shift of light frequencies while in gravitational fields created by stars and galaxies – in fact his theory more accurately measures these phenomena than do Newton's and Kepler's laws.

Each point on this manifold can be described as an *event* on the space-time; three coordinates indicating its three dimensional location, and one for the time it takes place. Curves that describe the motion of a particular object through the space-time, and successive events that

[5] D'Inverno 209

can be causally connected to each other, will then be called *time-like* curves, i.e. curves that locally do not exceed the speed of light[6].

Given that any one of a number of possible topologies and curvatures can be admitted as possible solutions to Einstein's equations, as a consequence, one may theorize that the topology and curvature of the universe may allow for the possibility of *closed* time-like curves; that is, curves that allow for successive events to loop around so that effects may even proceed their causes. The world lines traced by such curves would always move towards their *locally* defined future[7], thus the causality laws proscribed by the maximal signal limit set by the speed of light would not be violated.

Gödel proposed solutions describing such a universe that permit closed time-like curves in 1949 – a rather complicated universe to imagine, as described by Horwich (113f, see figure 2). A simpler but analogous example of such a universe is the "rolled-up" universe (figure 3), which shows space-like open, but time-like closed topology – thus if one follows a time-like curve long enough, she may come to her original event again.[8]

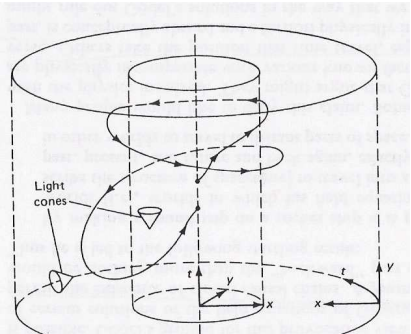

Figure 2 - Godel's Solution[9]

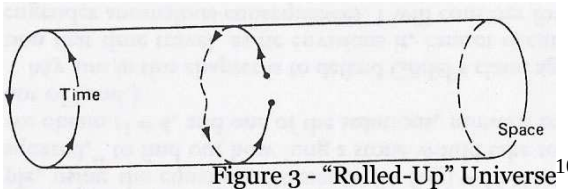

Figure 3 - "Rolled-Up" Universe[10]

[6] This is a consequence of Einstein's Special Relativity Theory (1905), and is applicable to General Relativity as well.
[7] Horwich 112.
[8] She may in fact accelerate her trip by using time dilation (theorized by Special Relativity), following a non-geodesic path.
[9] Horwich 113
[10] Ibid

A third possibility may also be proposed, that does not require such strict constraints on the global topology – it is that of the Einstein-Rosen bridge, or as it is more commonly known, a "wormhole." Such a passageway would allow for a shortcut from one event to another, again without violating causality laws. Note that these wormholes may be found in space-times that are on average globally Minkowskian – i.e. similar to flat space-times, with open time-like topology, and do not bear the physical consequences of the above examples, as described in the next section.[11]

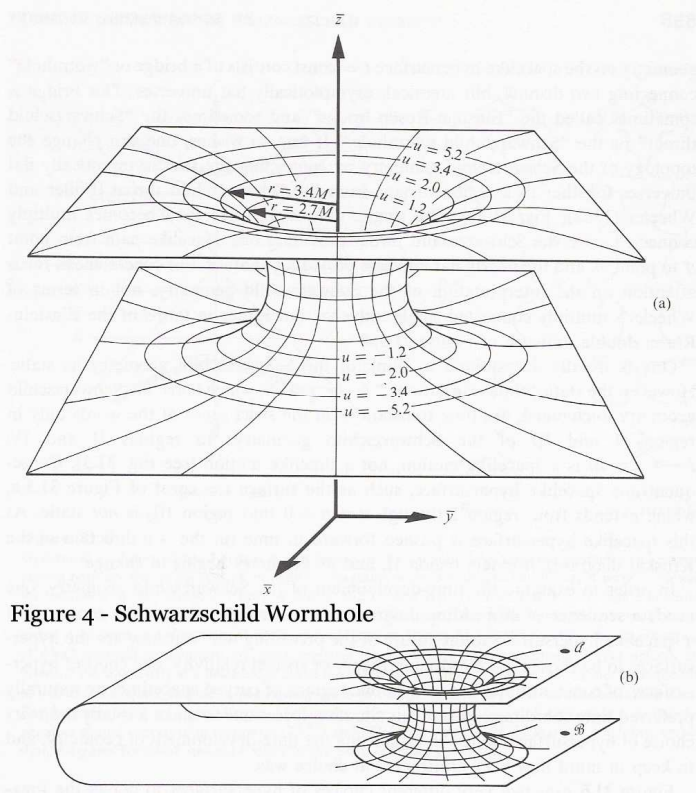

Figure 4 - Schwarzschild Wormhole

If such topologies can be *real*, then we can deal with the realistic possibility of what we would call TIME TRAVEL, the ability to follow one of these time-like paths into our own past as it has already been experienced. Before we begin talking about the philosophical ramifications of time travel, a few distinctions should be made however.[12] 1) We will make an identity requirement – the travel must follow a continuous trajectory into the past, rather than simply JUMPING from one time to another, violating Conservation of Mass, 2) It is not an alternate past one is travelling into, but her own – alternate universes are not within the confines of General Relativity Theory, and even within Quantum Mechanics, where they are proposed, how to travel from one such universe to another is unknown, 3) as we are dealing with *closed*

[11] Figure 4 – Misner, Thorne, Wheeler 837
[12] Defined in class

time-like curves, chronology violations, i.e. events taking place BEFORE themselves, will thus be permitted.

First Objection – Physical Impossibility

We have seen that, according to Einstein's Theory of Relativity, it is possible that there may be universes in which time travel is possible. The question that I would like to deal with now is whether time travel is possible in THIS universe. One may argue that discussion of the philosophical ramifications does not require that such a determination be made; one may freely discuss possible paradoxes and logical concerns in such universes without answering such a question. I would argue however, that if time travel IS possible in THIS universe, that this is a highly significant issue, which would raise such philosophical discussions from the level of fanciful conjectures up to serious concerns about our universe as we understand it. If time travel is real, what does the *second time around* fallacy (as will be discussed in the next section) imply to us about our freedom?

First, let us consider the Gödel universe, and analogously, the "rolled-up" universe. Such a universe, of course, intuitively, seems to have no beginning and no end – this is the first "nail in the coffin" for such models, as experimental data seems to indicate that at the very least, time did have a "beginning", referred to as the "big bang," as is evidenced by the recession of galaxies according to Hubble's Law, and by homogeneous, isotropic background radiation, widely regarded as the leftover imprint of that initial universal expansion. Nonetheless there are some who propose models of the universe that involve a "big crunch" at its end; that is, the universe will stop expanding at some point in the distant future and collapse in on itself to a singularity, and then possibly expand again – this would seem to be a globally repeating topology akin to our possible Gödel models. Nonetheless, the difficulty of allowing our time-traveller to somehow survive through the big crunch, followed by the big bang, would then present itself.

Adding to the weight of evidence against these models, we have the 2nd Law of Thermodynamics, that the entropy (scattered heat energy) of the universe must always increase, including in the case, as an example, of the cylindrical universe we have proposed. Horwich argues against this, suggesting cases where entropy may decrease, allowing for such a repeating time-like history.[13] However, it was definitely demonstrated to Stephen Hawking (who thought entropy would decrease in a contracting universe) that this was not the case by Don Page and Raymond Laflamme;[14] entropy will increase, even if the universe contracts, either forever, or until the "big crunch," and some scientists have even theorized that it will increase beyond that should our universe oscillate into a new one.[15]

A final problem is that demonstrated by Olber's paradox, who showed that if the age of the universe were infinite, then not only would the night's sky be white, but we would all be smashed into oblivion by a universe saturated with radiation of infinite luminosity.[16] The only way to avoid this, *per se*, on our "rolled-up" universe, would be to draw a line across our cylinder to correspond with the "big crunch/big bang" singularity; but this again would raise the question of how to get our time traveler through that singularity without herself being smashed into oblivion.

This leaves us with the wormhole possibility, which in my view is the most promising as a possible candidate for time travel. Nonetheless, such a model has problems, particularly passage through the common "Schwarzschild" variety wormhole, which essentially involves falling into a black hole and passing out of a white hole – again the problem is surviving the trip. Not only will our time traveller be crushed by the sheer stresses on her as she passes through the

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[13] Horwich 127
[14] These events are recounted in Hawking, S. *A Brief History of Time*, page 150ff.
[15] This result, that entropy would increase from one successive oscillation of the universe to the next, was originally proposed by Tolman in 1934. It is a matter of some debate, however, how entropy would survive through a big crunch/big bang singularity to the next oscillation, and it was not until work of Hawking, Ellis and Penrose in the late 60's that showed that such a mathematical singularity would necessarily occur in a universe so governed by General Relativity. See Mireau 32 – 34.
[16] D'Inverno 308

opening, she will also have to contend with infinite blue-shifted radiation raining in on her from the rest of the universe.[17]

Nonetheless, personally I'm not ready to dismiss the possibility of other geometric solutions to Einstein's equations, perhaps yet to be discovered, that behave like Schwarzschild wormholes, and that do not result in such an inhospitable trip. If such wormholes are possible, one then need only *find* such a naturally occurring wormhole (which may be difficult, and seriously curtail the freedom one has in deciding their destination), or artificially *create* a wormhole – but the latter proposal would require a vast amount of energy, enough to curve space-time locally in accordance with Einstein's field equations. Consider the amount of mass-energy[18] it takes to bend light even slightly around the Sun; it takes the entire mass of the Sun to do so. A bend in space-time as drastic as one involving passage to a very specific moment in time would require both extremely difficult calculation, and ability to manipulate space-time with a vast amount of mass-energy, the likes of which we have not yet seen. Horwich is also correct in stating that a trip into our distant past would be easier and require less energy than one so specifically fine tuned to lead into our own immediate past.[19] In my opinion, time travel may be possible in the distant future, but only through scientific progress which is, as yet, virtually inconceivable. Nevertheless, they likely said the same thing about flight to the Wright brothers.

Second Objection – Implausible Numbers of Banana Peels

The Second-Time-Around Fallacy and Self-Defeating Chains

If one were faced with the realistic possibility of time travel, which for the sake of argument, was even both practical to achieve, and could be done to any specific time in the past

[17] Such behaviour can be seen in analyzing Penrose conformal diagrams of Schwarschild wormholes – see D'Inverno 246. This result also verified by W. Israel in MaPh 468, as he instructed us in 1997.
[18] Mass and energy are essentially two forms of the same thing, as see by Einstein's famous equation, $E=mc^2$
[19] Horwich 123

that we desired, one would no doubt immediately consider the possibility of travelling back in time to right some of the wrongs of the past – to ask that one girl out for coffee, to study harder for that mid-term, perhaps even something as significant as to assassinate Adolf Hitler before his rise to power. In fact, in the last case, given an ability to make the trip, one might consider themselves morally obligated to do so. And of course, one might be tempted by the somewhat maniacal possibility of going back in time to assassinate one's own grandfather (the classic example), just to see what would happen, for in doing so, one would presume that they would prevent their own conception, subsequently their own time travel attempt, and thus their own assassination of their grandfather – a paradox.

This example demonstrates what is commonly referred to as the "second-time-around fallacy:" the belief that the past can be changed. Clearly, our own past cannot be changed. Why? Because it has already taken place. Some would argue that the past should be changeable; unless there is some constraint on a time traveller's freedom, they should be able to do whatever they like, including what we will henceforth call "bilking attempts," attempts to change the past, possibly even in such a way that would prevent the time travel from taking place. People who take this stance suggest that a new future will simply be created – but this stance is clearly illogical. How can a new future be created? What happens to all the people that the time traveler left behind when she stepped into her time machine, continuing to live out their timeline, which is based on their own history as they remember it? Unless a new timeline bifurcates from the bilking attempt event creating an essentially different universe, which is a very different scenario altogether, not admitted by Relativity, and not held within the confines we defined for time travel above – this is simply impossible. And besides, the past as the time traveller remembers it will still be *their* past – even if she assassinated Hitler (which she can't, but if she could, causing this bifurcation), she would still be aware of the alternate timeline, which would

still exist somewhere even though she could not return to it, a timeline which saw all the horrors of World War II.[20]

The **past is closed** to the possibility of further changes – this specifically rules out the grandfather paradox, and analogously the *auto-infanticide* paradox[21], and *any self-defeating causality chains of events*, as it rules out any attempts at bilking the past. The past has already taken place, even for the time traveller who while experiencing it as her current present and future, can still remember these same events as her past.

One is then caught into a very strange set of circumstances however. The time traveller will not enjoy the freedom to manipulate her environment that we have come to expect in our normal experience. Why is this so? Why is it that every attempt the time traveller might make, albeit foolishly, will ALWAYS fail? How is it that events seem to conspire to prevent bilking?

Banana Peels – Improbable Coincidences

Many philosophers take the stance that attempts at bilking will simply be confounded by strange series of coincidences that prevent them. For example, the time travellers attempt to assassinate Hitler will be confounded by her not making her train on time, or her gun jamming, or her slipping on a banana peel that happened to be in the way, and so on. From the perspective of the time traveller, these coincidences are bizarre frustrations to their plans that seem to limit her activity, almost inexplicably conspiring to prevent the past from changing. Such unlikely coincidences are regarded by many as being contrary to our lived experience – we don't see such limitations on our actions today. Because these coincidences are so unlikely, so completely without explanation, so physically inexplicable, perhaps even *impossible*, many conclude that on this basis that time travel itself is likely impossible.

[20] Smith discusses this distinction, 364ff.
[21] Whereby one kills their own younger self, preventing the time travel from taking place

Horwich makes an attempt to argue against this position, essentially by suggesting that while time travel is not impossible, it is improbable, constrained by the extreme difficulty of fine tuning to specific events in one's local past, and fuel that is not likely available for such a trip.[22] In doing so, he would argue, one cuts down the number of "improbably coincidences" to a number that is more in keeping with our experience. We experience coincidences in our modern world – it is only the multiplication of such coincidences that would cause us to suspect that something is amiss, that there are even limits on our freedom. So long as those coincidences are few, we can accept them. Thus, time travel may still take place – and he even agrees that on the basis of human psychology, motivation for bilking attempts make them likely[23] – its just that they are so difficult to execute that they will happen infrequently.

Smith finds Horwich's reductions to be unnecessary, arguing on other grounds for the possibility of time travel, in spite of the apparent illogical and surprising coincidences that prevent bilking. His first argument is with Horwich directly, and with others who suggest that the multiplication of improbable coincidences is suspect. Using an analogy of rolling tomatoes down a infrequently used street which results in very few tomatoes being crushed, as compared to a high frequency of crushed tomatoes should the traffic on that street increase in the future, Smith suggests that Horwich's argument, that coincidences (like banana peels) that prevent bilking are unlikely because they don't happen often now, represents a statistical fallacy.[24] A world in which time travel is common, Smith argues, may indeed experience such coincidences all the time, and these may not be regarded as unusual or miraculous – to regard them as such is to imply that the statistical realities present in our world should be those experienced in every world, even one which, UNLIKE our own, enjoys frequent time travel. The two situations, a world with time travel and one without, cannot be compared on the basis of frequency of banana

[22] 122
[23] 121
[24] Smith 369

peels and the like. The only conclusion one may draw then is that time travel to our current present is unlikely, a supposition that also enjoys the likelihood of being true on the basis of our current technological abilities. Personally, I'm not sure even this conclusion is necessary – coincidences are only judged as so with the benefit of hindsight; as such, I would wonder if we, who are unaware of any present time travelers, would even know of events happening to them that *they* regarded as coincidences until we are in the future that they came from.

His second argument[25] deals with what he regards as a mistaken perspective on counterfactuals involved in considering self-defeating causality chains, such as the auto-infanticide example. A successful attempt at killing one's younger self, rather than constituting a successful bilking attempt, will simply imply that he has killed the wrong person, as clearly the self-defeating chain is impossible. In other words, if the bilking attempt is successful, it is only because the events that were 'changed' are NOT the events that actually would change time. The error, as Smith sees it, arises from a mistaken perspective on the events themselves, particularly the miraculous coincidences, inherent in one holding to the second-time-around fallacy: the issue is not what events MUST happen to prevent the bilking, it is what DID happen. Given that these events did happen, while perhaps remarkable, they are not super-natural. If they had not happened as they did, future observers would not be able to look back to make the observation. If the events had happened differently, future observers would not think them any more or less remarkable.

Here we see a tendency to anthropomorphize such coincidental events, perhaps more indicative of human psychology.[26] To suggest that events "conspire" in any way is to see things in, as Smith would view it, a "backward" perspective. The events happened, resulting in the time

[25] Ibid 371ff

[26] One could argue that "coincidences" leading to the fine tuning of cosmological constants to develop a creationist explanation for the existence of a universe that can be observed may also be the result of such anthropomorphization.

traveller's recollection of the past that has formed who he is, and led him to make the decisions he is now making. Nonetheless, I'm not sure Smith resolves the issue, for while from the perspective of the future, these events HAVE HAPPENED, and it is therefore not remarkable that they cannot change, from the perspective of the time traveller himself, they both HAVE HAPPENED and are CURRENTLY HAPPENING, a very strange state of existence, unlike anything we can relate to. It would no doubt seem odd *to them* that their freedom would be so inhibited by what they would regard as unlikely coincidence, even though they might remember this present taking place in *their own past* exactly as it does, only *again*.

I will suggest one possibility to hint at this apparent lack of freedom he seems to have. One's actions are largely determined by the conditions they find themselves in, in addition to their freedom. Given that the conditions for the second-time-around are exactly the same as they were the first-time-around, perhaps it is not as remarkable that the time traveller would make the same choices, even freely. This would, I suspect, create a context in which one's temptations to attempt bilking would be diminished, perhaps decreasing the need for large numbers of improbable coincidences to thwart them – coincidences which, again, ALREADY happened, as the event have already taken place.

Smith's final argument in justifying the apparently large number of coincidences that thwart bilking – is in noting that the improbabilities involved that motivate bilking attempts are equally high, thus accounting for the high number of coincidences that result. As he states it, "improbable outputs can be derived only on the assumption that equally improbably inputs occur."[27] For example, a bilking attempt presupposes that one smart enough to achieve time travel is also stupid enough to believe the *second-time-around* fallacy: an unlikely event. Another example: while a time traveller may attempt *once* to kill Hitler (an attempt that will and must fail), the likelihood of their continuing to make *successive* attempts after each failure will

[27] Ibid 381ff

decrease after each successive failure – so if they do continue, the baffling numbers of banana peels and so on that thwart their plan must be regarded as corresponding to their equally baffling pursuits of futility.

Self-Causing Paradoxical Chains

What then of the case of *self-causing* chains of events, particularly paradoxical chains? An example: say old William Shakespeare, age 65, finds a time machine, climbs into it, and travels back to visit his younger self at age 20, when he happens to have writers block. So old Shakespeare tells young Shakespeare what to write down, which younger Shakespeare then writes down to become the famous plays we know today. Old Shakespeare of course remembers when he was younger, and remembers when his older counterpart came back from time and gave him his plays, and so on. The question then presents itself: at what point were his plays actually created? Who created them? Who can Shakespeare ever give credit to for having made them up? Did they come from no where?[28]

This example appears to be both logically possible, and physically viable within our time-travel possible universe – but is it? An example, given in class, can be used to illustrate:

> Say Peter and Jane, both 20 years old, meet a time machine in 1999. A time traveler steps out and asks Jane to enter the machine, and travel to 2019, taking with her a diary which the time traveler hands to her. She is supposed to make a record of her trip in the diary.
>
> On arrival in 2019, Jane meets 40-year old Peter. She tells Peter to travel back 20 years to 1999, taking the diary with him and recording his trip.
>
> On arrival in 1999, Peter meets 20-year old Peter and Jane and tells Jane to step into the time machine, taking with her the diary, etc.
>
> From this example, there seems to be an indefinite number of entries.

The apparent indeterminate age of the diary, and in fact of the time machine itself, demonstrates logical errors in the formulation of the scenario in the first place. Consider the diary; at what point does it enter the time machine? If 40-year old Peter put it in before his first trip in 2019, he

[28] Smith cites two similar examples in his footnote (371). Regarding these examples as "puzzling", neither does he attempt to account for them, nor does he regard them as obstacles to the possibility of time travel itself.

would have been prevented by 20-year old Jane, who had the diary already. If 20-year old Jane had put it in in 1999, she would have been prevented by 40-year old Peter who already had it, and so on. This is logically impossible, not to mention a violation of the Law of Conservation of Mass. There had to be a FIRST TRIP for this chain to occur – this first trip would involve the building of the time machine, say in 2019, the insertion of the diary at that time, and Peter's getting into it and travelling back. This would be followed by his taking places with Jane, as described in the example, her travelling forward to 2019, BUT on arriving there will NOT be able to trade places with 40 year old Peter, as he will have to get into his newly constructed time machine and travel back with his new diary. The diary will thus only have two entries, one for the backward journey, and the other for the forward one. This is the only logical way for this scenario to take place.[29]

Thus, our Shakespeare example, while seeming logical and physically possible, is in fact NOT so – but it does not show that time travel itself is impossible, rather it shows an erroneous formulation of the example in the first place. While self causing chains may be possible, causing things that *have happened* in the past, ones that involve unaccounted for ideas or material are *not* possible. Every creative idea, such as *Hamlet, Macbeth,* or *King Lear* originates with some*one*, just as every diary has mass that comes from some*where*. Simply put, this example *can not happen*.

One Last Possibility

What makes the case of time travel so unusual is the juxtaposition of two different perspectives on the same person: the time traveller, who knows that the past has already happened, and therefore cannot change, but also who now regards that past as HER OWN future at the same time. She knows what's going to happen next, and yet any and every action she takes to try to make something different happen will be greeted with some kind of coincidence to prevent it from happening – a coincidence THAT HAS ALSO ALREADY HAPPENED.

We know that the past is determined, and have little difficulty accepting this fact. However, it is more difficult to accept that our time traveller's future seems also to be determined; she may even have already experienced it and remember it. I would wonder if, in a universe where time travel is possible, it might suggest something about the determinacy of the

[29] If someone argues that the example does not indicate that the original time traveller was Peter, only subsequent time travellers, then this would be a case of the *second-time-around* fallacy – only if Peter was the time traveller the first time around could he be subsequent times around.

future in general. We have seen[30] a rather surprising result arise from the case of Special Relativity (that may be carried over to General Relativity), that as all events that take place in our own plane of simultaneity can be regarded as REAL, and as ANY event in the future can be regarded as simultaneous to an event on our plane of simultaneity according to *some* inertial reference frame, even events within our own time-like future, that the future can be regarded as *determined*. This conclusion is surprising, and even suspect – and has been countered on various rather sophisticated grounds[31] – still, I find myself startled that in both case we are left with the surprising determinacy of one's future; only in the time traveler's case, they *know* that future already. While Prof. Rueger has stated his doubts about connections between these two cases, I think this connection may warrant further investigation.

Conclusion

A number of objections are often raised when considering the possibility of time travel, those named above perhaps carrying the greatest weight. It is from General Relativity that the possibility of time travel presents itself; it is also from General Relativity that the *physical* difficulties are manifest. These difficulties must be overcome before time travel can be seriously considered as a possibility for people inhabiting *our* universe. The logical difficulties, arising from the occurrence of apparent miraculous coincidences that prevent the past from changing; to me, these, while still present, are less troublesome, as Smith and others have demonstrated. If we follow his line or reasoning, they may present no difficulty whatsoever. Still, whether they clear up the matter or not remains to be seen, perhaps into the distant future, *if ever*, when time travel might be seriously attempted and experimented with. In the meantime, the subject of time travel will no doubt continue to be the subject of philosophical discussion, both good and bad, and of science fiction, both good and bad, to our enjoyment, and at times frustration.

[30] demonstrated in class
[31] at least, so we have been told in class

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