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The cybernetical time

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Résumé

We consider the two mainstream cosmological models that can be derived from the two physical theories that are the best verified by experiments: general relativity and quantum mechanics, though they are incompatible and a major challenge in physics is to find how to reconcile them. The first model is the block universe, which is considered today as the best way to represent our space-time, if we accept all consequences of general relativity, which seem to imply in particular that our future is already realized and cannot change. The second is the Everett multiverse model, whose most popular interpretation is that it contains all alternative possibilities to conduct our life at our human level (with as many copies of our individual consciousness). Our purpose in this article is to show that the incompatibility between the two mainstream theories could be solved in its global principle via a cybernetical conception of time, through which the block universe would be made flexible. For this purpose, we show that the 6 extra dimensions of space-time we introduced in a previous paper (Guillemant 2018) could be used to coordinate space-time from its outside, so as to make it evolve in the cybernetical time from a 4D structure to any other one belonging to a 10D multiverse. We propose this coordination to be modeled thanks to a 3 layers neural network toy model, using two additional layers corresponding to the necessity to parametrize the choices of paths and destinations so as to restore determinism. The main interest of this approach is to maintain the possibility of a relative free will in our universe.

Key words

space-time; multiverse; determinism; time lines; future; paths; free will; neural network; consciousness; extra dimensions

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I INTRODUCTION

On the question of time, the famous philosophers Nietzsche and Bergson had at first sight incompatible intuitions, similar to the current conflict between the two big theories of modern physics that are general relativity and quantum mechanics. The first one wrote in "Human, all too human": "Our destiny exercises its influence over us even when, as yet, we have not learned its nature: it is our future that lays down the law of our today." A strange sentence, which harmonizes well with the theory of the block universe (stemming from the relativity) according to which our future would be already realized: it is then no more surprising that he can influence us. The second wrote, in *The possible and the real*: "What can be time? …

Wouldn't it be the vehicle of creation and choice? Would time's existence not prove that things are undetermined?" Yet it was demonstrated actually, from 60 years later, that a major aspect of quantum mechanics implying indeterminism and non-locality was correct (Aspect *et al.* 1982, Stefanov *et al.* 2002) and thus that it actually exists a fundamental indeterminism in the quantum scale, giving birth to the quantum model of the Everett multiverse (Everett 1957). But according to the mainstream current consensus, which considers that this is the best interpretation of the quantum mechanics (Wallace 2012, Damour 2015), this multiverse is interpreted as implying that all the alternative versions of our lives, resulting from different choices, could really exist with other self-aware copies of ourselves. We suggest in this article another perspective to reconcile both points of view that will lead us to envisage that the block universe is flexible (Figure 1), should it be only to protect the uncertainty and choices desired by Bergson. But does physics allow it? Here is the central question of this paper.

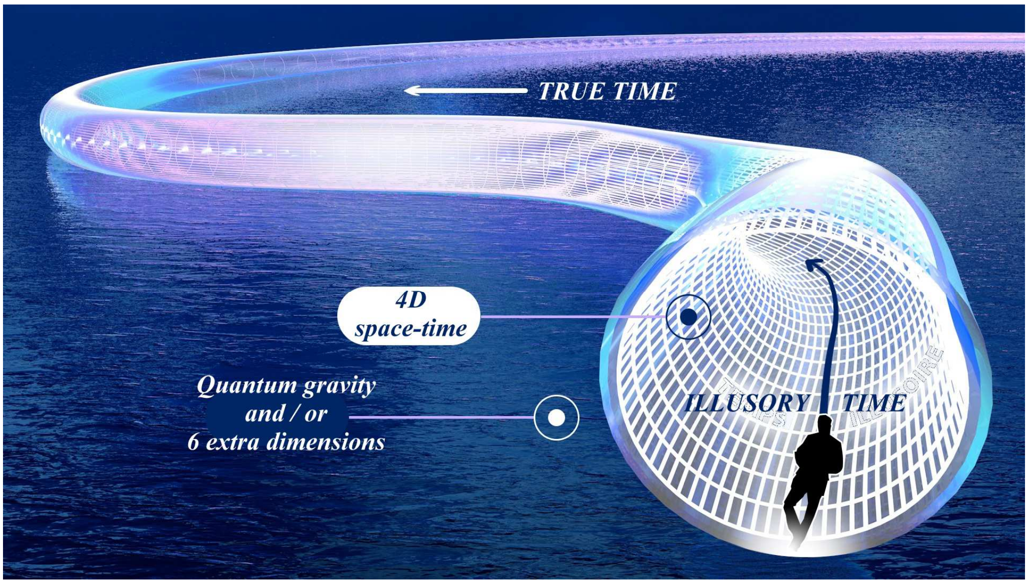

Figure 1: The metaphor of the invisible tunnel which directs our steps all the rest of our life is the consequence of the block universe in the human scale. The preservation of a free will in this context requires this tunnel to be flexible, so that is can change its position in time.

II THE EVOLUTION OF OUR IDEA OF TIME

The block universe is generally represented as a cylinder starting as a cone from the big-bang and whose main axis is time. We can represent it as well in our human scale as an invisible cylinder which directs our steps during all our life (Figure 1): any choice becomes impossible, unless this tunnel could change its position in time, which is not allowed by the standard block universe model that is perfectly static. Note that in this conception there is no more a present after which the future is not yet created: all the future is already created.

During the evolution of our conception of time, it has been often said that time does not exist. It simply means that the physicists do not understand yet today the sense of the present and that the variable "t" is even absent in the equations of physics (De Witt 1967) that are susceptible to reconcile the two big theories. In support with this, innovations such as GPS and atomic clocks show that we can travel in time a little bit and equations show that we can actually also travel in the far future (some models with wormholes even authorize travelling in the past).

On the question of time, general relativity and quantum mechanics are rather compatible. It is experimentally proven today in quantum mechanics, that the famous spatial non-locality experimented by Alain Aspect (1982) is not only a spatial one, but also a temporal one (Megidish 2013). Particles may remain entangled[1] not only through astronomical distances (without a signal that allows them to be correlated) but also over time. Indeed, many experiments have shown that there is a temporal entanglement and that quantum events can be correlated not only if separated by space, but also if they are separated by time, without any signal traveling in time.

Figure 2 is illustrating the evolution of our space-time models until a new view (to the right) where the past, the present and the future could be "now" and could even have other possible correlated versions of their states in different time lines, due to entanglement over time. Quantum gravity theories, though they have not been proved yet, are dealing with such potentials, which mean that time lines and in particular the future can fluctuate out of time. It implies that time does not exist in the sense of something that creates reality. It would rather be something that emerges, a thermodynamic emerging phenomenon (Connes and Rovelli 1994). It is until now considered that present time could be a thermodynamic illusion created by the brain itself (Buonomano 2017).

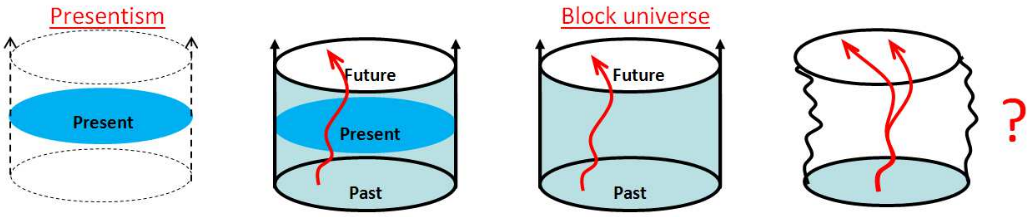

Figure 2: The evolution of our conception of space-time, from the presentism to a static block universe where the present time has disappeared or another view where entangled time lines could make space-time flexible.

III WHAT IF THE PRESENT HAD A REAL THICKNESS?

To get out of illusion, we should try to consider time as we consider space. At any point in space-time, the locality of what we perceive around corresponds to a certain space thickness. But it also corresponds to a certain time thickness because there is no perception which doesn't correspond to an event (or a non-event) and then to a minimum duration. Wouldn't it imply that only events exist? This is anyway what Carlo Rovelli wrote in (Rovelli 2018).

To try to understand better this possibility, let's integrate the idea that time might not exist in the sense that the present could be prolonged by the future and preceded by a past, which would be just as real as now is. We could say that the present could have a real thickness, in the sense that our brain is capable of making us anticipate the future and memorize the past. But we can wonder if it is not the idea itself of a sequential time between past and future that could be an illusion, leading us to speak of anticipation and memory while their information is equally here. Because if we consider space itself, what we see on our right just as what we see on our left is equally in the present and has a space thickness. And if we consider now a present event, it also has a duration and then a time thickness. The idea that time would have no thickness (or just equal to zero) would then be only a thermodynamic illusion that would generate the impression of a front of the present creating reality.

We represented in Figure 3 two representation in green and blue to illustrate that. In green we can imagine the displacement of a brain-consciousness having a clear sensation of the thickness of the

[1] Particles are *entangled* when the quantum state of each particle cannot be described independently of the state of the other(s), even when they are separated by a large distance.

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present. In blue, a brain without consciousness or with a little bit of consciousness: this brain will put illusory time at every point because its internal determinism will prevent it from detecting any possibility of bifurcation and finally make it navigate blindly, without having a choice to make in his trajectory. On the other hand, if we consider that time has a certain thickness which is the thickness of the consciousness (at this level one can even wonder about the difference between time and consciousness), we are facing a problem of choice. That is, if we find ourselves in front of a junction, the brain negates the existence of a choice whereas our consciousness will think there is a choice to make. So, the thickness of time, which could be something more real than the front of time (that is illusory sequential time), imposes us choices. But this consideration then raises the following question: does physics allow free will?

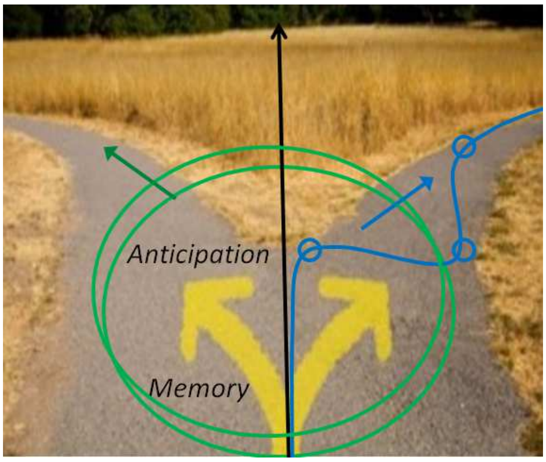

Figure 3: Illustration of the deterministic course of a sequential brain (small blue circles) with opposition to that of a consciousness to whom a thickness of time imposes choices (big green circles).

IV DOES PHYSICS ALLOW FREE WILL?

What does physics say about the possibility of choice? The indeterminism in quantum mechanics makes physicists speak about this possibility and there is even a theorem of free will (Conway and Kochen 2006). But in classical mechanics, we are not used to consider this possibility. It has even long been customary to consider that classical physics was deterministic, though it has been widely disputed by some renowned physicists. For example, Trinh Xuan Thuan wrote in a book (Xuan Thuan 2011), that chaos could liberate matter and that future could be no more exclusively determined by its present and past. Or physicists like Antoine Suarez and Nicolas Gisin, the first who have repeated in the relativistic field the famous experiments of Alain Aspect (Stefanov *et al.* 2002), are both supporters of free will (Gisin 2012, Suarez 2013). In his last paper (Suarez 2017), Suarez says that the quantum multiverse belongs to our choices and that we would have a free will thanks to that. In addition, Nicolas Gisin said in (Gisin 2016) that free will can exist because the real numbers that allow classical physics to be deterministic do not exist in reality. That is to say, we cannot inform a number describing reality with an infinity of decimals.

If we think about all the reasons for questioning the determinism of classical mechanics, we always come to a problem with information. This led us to do research from calculations of billiards and then to publish recently an article in Annals of Physics (Guillemant *et al.* 2018). In this paper we conclude that mechanics absolutely does not determine the course of events, except briefly or incompletely. We propose that to determine the course of events, we have to add 6 dimensions to the space-time: 3 to define the choices that must be made in the present in the presence of bifurcations, and 3 others to define the choices that must be made to determine the destination. According to this theory, the physical laws would not determine neither in the present nor in the future, what we are going to make, because mechanics would be incomplete. Indeterminism always remains, and our above paper concludes finally, by making the link with the quantum gravity, which ends actually in the same report, that additional extra-temporal information is required to make the choice of trajectories.

At the origin of this strange statement stands the problem of physical information.

V INFORMATION: A PHYSICAL QUANTITY

For at least a century and a half, physicists fought to try to find a solution to the famous paradox of the demon of Maxwell (Figure 4). This paradox consists in just giving information to a demon having the capacity to open or close a small door between two gas chambers without consuming energy, allowing him to sort the gas molecules, resulting thereby in heating or putting pressure on one side or the other, thus creating a way to extract energy, simply from information (Szilard 1929).

This problem was the object of a lot of confusion and a vast debate (Norton 2005, Leff and Rex 2003) as it contradicts the famous second law of thermodynamics stating that the entropy can only increase. In addition, if it were realistic, it would allow extracting energy very easily, and if it were true, we would know. Today this problem is considered to be solved by considering that information has a cost in energy. This idea was initially proposed by Landauer (1991) and it was finally demonstrated in 2012 (Bérut *et al.* 2012) that manipulating bits actually costs an energy equal to k T ln(2), where T is the temperature et k the Boltzmann constant. This shows that information must be placed alongside the usual physical quantities of mass, energy, etc...

At the quantum scale, we also have the Heisenberg fundamental principle of uncertainty: one cannot know both the position and the momentum of a particle. This principle comes down to limiting the amount of information from the phase of a particle to a certain bounded value. It means that like other physical quantities, the information in the universe is always a finite quantity.

Now let us move on to quantum gravity theories. In order to unify quantum mechanics with general relativity, these theories are also obliged to use models that consider that no length less than the length of Planck (about 10^{-35} meters) has physical sense. Looped quantum gravity goes even further by postulating straight that all the information associated with any physical object is finite, including mass, energy, time (Rovelli 2012). Therefore, we would finally live in a universe of information. And it is not so surprising insofar as information is primary before physical quantities, because a mass or a temperature are information, in the sense that they are characterized by information. We can easily admit this, as soon as we understand that physics leads us to accept a reversal of perspective in which information is physical. Many different theories are already in accordance with this view, for example the holographic model of Maldacena (1998). This is finally like a coming back of the Plato's cave metaphor.

So today, physics discovers that information comes first. Now, what is information but consciousness, and what is consciousness if not information? If information is really linked to consciousness, how could we conceive infinite information? Let us remind that the great physicist John Wheeler has been given the phrase "It from bit": everything is information.

The key point is then to understand that everywhere in the universe information is finite.

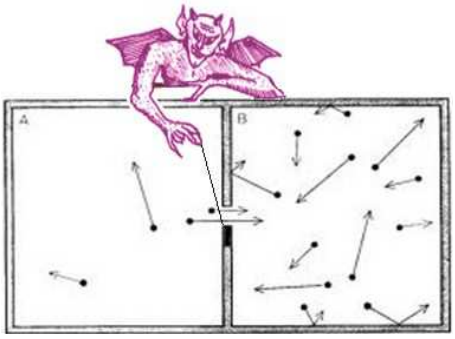

Figure 4: The paradox of Maxwell's demon bases on the thought experiment concluding that a demon who would be capable of opening or closing a small door between two surrounding gas chambers would have the capacity to create energy without consuming any (or a negligible quantity).

VI THE PARADOX OF DETERMINISM

We can now explain the extra dimensions proposed in our recent paper (Guilllemant 2018). When information becomes fundamental and finite, the problem of propagation of uncertainty (Figure 5) in dynamical complex systems, such as a billiard but also into all living systems, becomes a fundamental problem. It implies that mechanics cannot calculate beyond a certain amount of information that we found to be of the same order as information contained into initial conditions.

If we do not add more information, we calculate a multiverse and not a single reality. If we do not add extra information, information density decreases over time, due to increased uncertainty during interactions, and the system becomes a quantum system. But things around us are not quantic, so this means that there is something which adds information to our environment. This information doesn't come from decoherence[2], because this process doesn't bring information when choices are made at bifurcations. It means that there is extra-dimensional information that intervenes to help mechanics to create a single reality. This additional information would come either from additional dimensions, from outside space-time, from the quantum vacuum or from the future. We don't know yet, but in a universe of information all of them could mean the same as we are talking about extra space-time data.

This implies that the basic laws of mechanics must be conceived as laws transforming an information into another, like if they were unfolding reality during a certain time, rather than as laws that create reality. It means that the laws of physics would not be creative. Mechanics laws are working only in special cases when there are very few interactions or when we consider planets, or objects that interact very little with their environment, or when this environment has a low mass compared to the mass of the body. Although it is only in special cases that the mechanics is deterministic, we have developed our vision of the world from these particular cases, while in reality mechanics cannot generally create the course of events. This result we published is in accordance with other results that mathematicians published two years ago (Bodineau *et al.* 2016), for which they were awarded in 2016 by the French popular scientific review "La recherche". These mathematicians have shown that with deterministic equations, after a certain time in a billiard table the balls have lost the information corresponding to their initial conditions and a Brownian movement is established.

[2] Decoherence is the loss of quantum coherence, meaning that the wave function of a particle with multiple simultaneous states has been destroyed so that the particle has become a classical one with a unique state. The gradual mechanism of decoherence has been experimentally highlighted for the first time in 1996 by the french physicist Serge Haroche and his team, awarded by the Nobel Prize.

This natural loss of information would then be at the origin of a macroscopic multiverse: the laws of physics would not calculate a single reality but a multiverse of potentialities. However, we still do not know if alternative potentialities are really physical universes or just virtual ones that don't exist really.

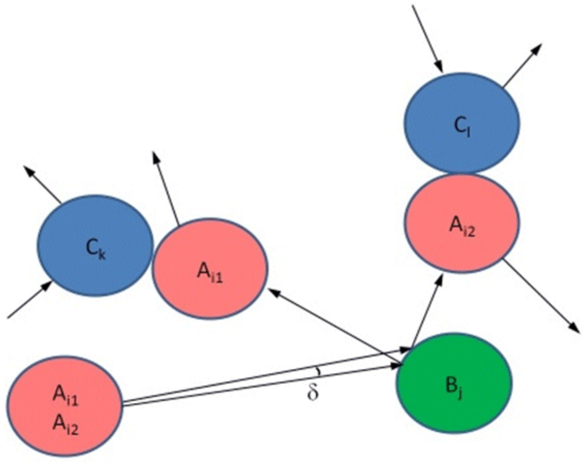

Figure 5: The increase of the uncertainty δ in the interactions leads inevitably at the end of a critical time to the occurrence of a multiverse of distinct trajectories, whose number of branches is increasing geometrically with the number of shocks.

VII SWITCHING TIME LINES OF A MULTIVERSE

We calculated the growing law of the number of multiverse branches in a billiard table, and found that it is independent of the accuracy of the calculations. We can work at a precision down to the Planck scale and even below, we never prevent the multiverse and always have exactly the same increase in the number of bifurcations after a certain delay.

This means, by making a shortcut, that classical physics is much more like quantic than we usually think. There would be enough similarities between classical and quantum mechanics to question their ontological difference, which would be at least that classical mechanics reveals multiple realities (or potentialities) only after a certain delay in the future, that we never reach. This delay from the present moment is depending on the considered system. If we consider a planet, it is going to be very large, but if we consider a living system it will last only a few seconds.

What about the process of decoherence in the absence of observers (in the future) susceptible to inform their environment? We know that for a non-isolated system, the decoherence mechanism prevents our reality to become quantic. However, even in the presence of observers, the decoherence process does not prevent the multiverse from settling down because it does not determine the necessary choices. Furthermore, it does not inform us about the future we have to live. The choices that are made remain mysterious, because even if we consider that all possible choices exist in separate universes, the problem remains namely that we always need extra-dimensional information to inform us about the universe we are living in.

Now we will examine more speculative but important consequences of our paper (Guillemant *et al.* 2018) for our daily life. Finally, in a billiard table but also in any complex system, all the possible final conditions compatible with the initial energy are systematically reached after a certain time. If in addition we wait long enough, we can even allow the luxury of finding a multitude of paths that connect initial and final conditions. As it is valid for all types of interactions, we could extend it to our human scale. Let us have an example: Tonight we are planning to go back to our home. The path that we will follow is now perfectly defined according to the theory of the block universe. However, in an hour, this trip may have changed because maybe this afternoon we have met someone who will make us follow another path. Does physics make it possible? Yes, because it is possible to keep exactly the same future tomorrow while changing the path, without changing the structure of the universe. We just have the freedom to choose the path that will allow us to go back to our home tonight. Even in the case we meet a person who will have a great influence on our life, it does not create a problem to the dynamics of space-time, because if really in our future we do something with this person, space-time will be able to send us another opportunity to meet him or her. According to this view, there is enough fluidity thanks to this multiverse that can be adjusted from the final conditions, to bring us a true free will in our daily life.

VIII DISCUSSION

8.1 How to model an unstable future?

The possibility for our space-time to be flexible, as Figure 1 is illustrating, stands on two key points:

First, we have supposed that we could switch time lines, i.e. change the program: this is a speculative proposition but it is a fundamental question, which needs serious consideration.

Second, extra-dimensional information necessarily plays a role and determines the paths, the commutations and the changes of paths that we are going to take: that is still physics.

Nevertheless, where does this information come from? Now we cross the borders of physics if we consider that free will is involved. In other words, could our brain-consciousness system be a navigation system?

From our "time thickness" concept of consciousness, we have to make a difference between brain and consciousness. Brain, like decoherence, does not seem to be able to make the choices at bifurcations. Only consciousness seems to be able to bring extra dimensional information that make us live only one reality. This is a classical point of view, but it is similar to the well-known role of observer in quantum mechanics.

Still we have to solve a problem before considering that commutations at bifurcations are possible: how can we make the different commutations compatible together? If we switch the course of the events, we will change the life of someone who will be on our new course, etc. Can physics allow it? Would there be a risk to cause a sort of space-time collapse? We can answer negatively if we consider, thanks to the principle of macroscopic entanglement, that all switches can become compatible with each other.

Today this generalization of entanglement to the macroscopic level is more and more accepted by great physicists. Thibault Damour (2015) for example, talks about it in quantum cosmology, a possible generalization of quantum mechanics on a macroscopic scale.

8.2 Neural networks and quantum entanglement

Recently, the entanglement has been simulated with the help of neural networks (Dong-Ling *et al*. 2017), which means that neural networks can allow coding various quantum states. As the reduction of entangled states needs information outside space-time (quantum fate), this allows us to better understand why the space-time could be coordinated by brains, in its future timeless evolution.
But if the possibility to change the future in a macroscopic manner takes place thanks to entangled temporal lines, it remains to understand how this process could be stabilized, because the impact

of a change of a temporal line on other changes could echo in the infinity. A solution to this problem is simply to forbid this process when it is incompatible with the future, which signifies the acceptance of retrocausality.

Today highly famous physicists like Yakir Aharonov move in this direction. The latter demonstrated that it is possible to accommodate quantum mechanics with our free will on the condition of accepting retrocausality (Aharonov *et al.* 2016). In other words, it is possible to accommodate the indeterminism of our reality with the possibility of making choice, thus to replace our temporal lines, on the condition of accepting retrocausality.

This retrocausality should not be shocking. It is only shocking if we believe it is a signal. Initially, when Costa de Beauregard proposed this concept in the 50s (Costa de Beauregard 1953), it was frowned upon because people understood that a signal was sent from the future. This is not a good interpretation because it is rather the same sense as a spatial entanglement, meaning a temporal entanglement without signal. It is not a problem in a universe where the future is already there and the past still there. Simply one must reason with events and time lines instead of reasoning with points of matter that move in time.

Today, physics teaches us to stop reasoning with matter that moves in time. Moreover, it makes us realize that matter does not exist, that there are only space-time densities of probability of presence, etc.

After understanding the pertinence to replace moving points by time lines, we think that retrocausality is the next key point to really understand time… and consciousness.

8.3 The great mystery of time

One could finally solve the great mystery of time if taking seriously, all what physics suggests to us. The biggest problem for physicists right now is to resist to dogmas: strict causality, determinism, irreversibility, brain created consciousness, etc. When we relativize dogmas and take seriously all the results of physics experiments and theoretical models, we conclude that reality is not created in time but in another way as suggested by Carlo Rovelli (2012). Time does not exist in the sense of a front already created: the past still exists and the future is already there, but we add in this paper the fact that it is simply flexible: it can change. Then the key point is that the future could influence the present.

Our cybernetic point of view, due to a long experience in computing engineering, tells us that it is possible to create a mini space-time, like a toy model. For example, if we ask to an engineer: "you shall calculate the future according to the information we give you about the present moment", he will not be able to do it, because as he would have to bring in outside information, there will be a high risk to introduce a bug to the system. On the other hand, if we ask him: "you shall consider such future and calculate the present reality while changing step by step that of the future", then he will have no problem. If you ask him to explain to you how he is doing that, he will answer you:

“I just use a switching system to introduce your information in my system. But I switch only when I can switch. It is like a GPS: you are moving in a car, you have a perfectly precise journey and at any time the GPS tells you to go there, to turn left or right, etc. Well you have the option of not following what the GPS says. You keep your free will. And what will the GPS do? It will recalculate your course. For a while, it will tell you to turn around, until it understands that in fact you wanted to do something else. As its destination is still scheduled, it has found a new route to take you to your destination.”

Note that in this process, at no time the GPS has lost the thread of history. If we are able to conceive that now, thanks to technology, a system a little complicated and clever can manage the switching of time lines of a lot of people to take them safely to work and avoiding traffic jams, how can we still believe that the universe is unable to do so?

Now let us try to make a link between physics and consciousness. It is quite conceivable that the information introduced to achieve these commutations expresses itself through quantum gravity. Although we do not intend to develop the quantum gravity concept here, let us quote simply the physicist Roger Penrose who proposed to connect consciousness to quantum information in the brain, via the Orch' OR model (Penrose and Hameroff 2011) which is involving orchestrated reduction of quantum states in the microtubules of the brain.

8.4 A multistage cybernetic model

According to what precedes, it is possible to model in a very simplified way the process of space-time coordination by quantum information - stemming from quantum gravity or brain consciousness — by using the 3 layers perceptron toy model of a neural network. Considering also the billiard toy model of the space-time, the first layer is constituted by neurons that identify commutable time lines, for example the trajectory A of a given ball that can be replaced by another one. The neurons of the second layer identify all other ball trajectories that also have to commutate if A is changing, so as to manage their entanglement. The third layer is then constituted of neurons that identify given final conditions. If we consider now extra dimensions and a more realistic neural network that would manage space-time flexibility, it would be constituted of 3 layers of 3 spatial dimensions which would be scheduled with information to determine path and destination. It could then gradually change the space-time within all its possibilities of realization into the multiverse. This would involve the introduction of models susceptible to mimic the properties of consciousness such as intention and attention, but we shall not approach these questions, which rather concern psychology.

Let us recall that this modeling requires the acceptance of a double causality, *i.e.* an influence of the future on our present. To the question "is the double causality a falsifiable theory?" we answer positively by specifying that we have tried, within the framework of a research contract between the CNRS and a webmarketing company (Guillemant 2016-2018), to falsify this theory during the last four years. The way we explored this question was the introduction of random choices in the advertising or web robots, so as to highlight via a statistical analysis a possible effect of serendipity, that is the trend (of Internet users) to find accidentally a product which returns a wished service. The principle of this research was to constitute two equiprobable groups of web users receiving advertisements at randomly chosen times, by using a generator of quantum random numbers. For the first group each random draw was renewed for each individual, while for the second it was identical for all the group, but all the draws still differed by using individual offsets. The results obtained at the beginning of 2018 were positive in favor of the existence of such a serendipity effect, with a probability that it was due to chance equal to 1/56.

IX CONCLUSION

We can conclude from the above analysis that it is possible to reconcile the views of Bergson and Nietzsche about time, thanks to a cybernetic conception of a flexible space-time, although forced simultaneously by initial and final conditions. This double constraint has the merit to solve space-time paradoxes via a double causality, which takes into account its flexibility by means of a neuronal control involving outside information contained into additional dimensions… or consciousness.

This implies to relativize the ontological scope of the equations, because equations are tools and their premises (determinism and continuity) are not compatible with observed reality.

It also involves finding the appropriate cybernetic models, which could be fractal, multiscale or neuronal, to connect entanglement, indispensable for commutations, and different stages or dimensions, and then to accept the idea of an a-causal configuration in physics. Note that the need to inform about the final conditions already exists, as for example in fluid mechanics into appropriate dynamic models.

In human sciences, it means avoiding confusion between brain and consciousness, which play the role of providing additional information, and accepting the research for experimental protocols to falsify or highlight the influence of the future on the present.

Concerning the validation of this view of space-time, we think that the technologies of the internet and big data offer promising paths on this direction. Among others, the biggest brake to our understanding remains the paradigm of our mechanistic current system of thought, which prevents the researchers to break the dogmas and to venture beyond borders of their discipline.

Références

Aharonov Y., Cohen E., Shushi T. (2016) Accomodating retrocausality with free will, *Quanta* **5**, 56-60.

Aspect A., Grangier P., Roger, G. (1982) Experimental Realization of Einstein-Podolsky-Rosen-Bohm Gedankenexperiment: A New Violation of Bell's Inequalities, *Physical Review Letters*, Volume 49(2), pp. 91-94.

Bérut A. *et al*. (2012) Experimental verification of Landauer's principle linking information and thermodynamics, *Nature* 483, 187-190.

Bodineau T., Gallagher T., Saint-Raymond I. (2016) The Brownian motion as the limit of a deterministic system of hard-spheres., *Invent. Math* 203, 493-553.

Buonomano B. (2017) Your brain is a time machine: The neuroscience and physics of time, W.W. Norton & Co.

Connes A., Rovelli C. (1994) Von Neumann Algebra Automorphisms and Time-Thermodynamics Relation in General Covariant Quantum Theories, *Class. Quantum Grav.* 11, 2899–2918.

Conway J., Kochen K. (2006) The free will theorem, *Found. Phys*., 36, 1441-1473.

Costa de Beauregard O. (1953) Mécanique Quantique, *Comptes Rendus Académie des Sciences* 236, 1632.

Damour T. (2015) Quantum cosmology: from Einstein to Everett, Dewitt...and back, A lecture at I.H.E.S. https://indico.math.cnrs.fr/event/781/

DeWitt B. S. (1967) Quantum Theory of Gravity. I. The Canonical Theory, *Phys. Rev.*, Vol 160 (5), pp. 1113–1148.

Dong-Ling D., Xiaopeng L., Das Sarma S. (2017) Quantum Entanglement in Neural Network States, *Phys. Rev.* X 7, 021021.

Everett H. (1957) 'Relative state' formulation of quantum mechanics, *Reviews of modern physics*, 29, 454.

Gisin N. (2012) L'impensable hasard, Odile Jacob.

Gisin N (2016) Physics killed free will and time's flow. We need them back, New Scientist.

Guillemant P. (2016-2018) Etude de faisabilité d'un traitement de l'information favorisant la sérendipité des moteurs de recherche et du big-data, Contrat de collaboration de recherc*he CNRS RICARG ORG, SPV 121 011*.

Guillemant P., Medale M., Abid C. (2018) A discrete classical space-time could require 6 extra-dimensions, Annals of Physics 388, 428-442.

Landauer R. (1991) Information Is Physical, Physics Today 44(5), 23–29.

Leff H. S., Rex A. F. (2003) Maxwell's Demon 2: Entropy, Classical and Quantum Information, Computing, Philadelphia, Pennsylvania Institute of Physics Publishing.

Maldacena J. (1998) The Large N limit of Superconformal Field Theories and Supergravity, *Advances in Theoretical and Mathematical Physics* 2, 231–52.

Megidish E., Halevy A., Shacham T., Dvir T., Dovrat L., Eisenberg H.S. (2013) Entanglement Swapping between Photons that have Never Coexisted, *Phys. Rev. Lett.* 110, 210403.

Norton J. D. (2005) Eaters of the lotus: Landauer's principle and the return of Maxwell's demon, Studies in the History and Philosophy of Modern Physics 36, 375–411.

Penrose R., Hameroff S. (20111) Consciousness in the Universe: Neuroscience, Quantum Space-Time Geometry and Orch OR Theory, *Journal of Cosmology* 14.

Rovelli C. (2012) Et si le temps n'existait pas : un peu de science subversive, Dunod.

Rovelli C. (2018) L'ordre du temps, Flammarion.

Stefanov A., Zbinden H., Gisin N., Suarez A. (2002) Quantum correlations with spacelike separated beam splitters in motion: Experimental test of multisimultaneity, *Phys. Rev. Lett.* 88, 120404.

Suarez A. (2013) Is science compatible with free will? Springer.

Suarez A. (2017) All-Possible-Worlds: Unifying Many-Worlds and Copenhagen, in the Light of Quantum Contextuality, arXiv: 1702.06448 [quant-ph].

Szilard L (1929) On the Reduction of Entropy in a Thermodynamic System by the Intervention of Intelligent Beings, *Zeit. Phys.* 53, 840-856.

Wallace D. (2012) The emergent multiverse. Quantum theory according to the Everett interpretation, Oxford University Press.

Xuan Thuan T. (2011) Le cosmos et le lotus, Albin Michel.