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Is the Dimension Time Three-Directional?

Günter Muchow

Bangkok, Thailand

ABSTRACT

This essay does not mean to be a comprehensive treaty about Time. It neither is an attempt to explain what Time is. Instead, the intention is to give a look on Time as an independent three-directional dimension, away from the disorienting term ’space time‘, where Time is simply considered as an additional ‘dimension‘ of space. Definitions are given aiming at an unambiguous use of the term ’dimension’, as well as postulating Time as a three-directional dimension, in ranking equal to space and the other fundamental interactions. It will be reasoned why the first, perceptible time-direction does not require a ‘passing’ time. The remaining two directions of Time are presently hypothetical, although they would allow the understanding of hitherto badly understood physical phenomena. Past and Future are set in an inalterable framework containing all events happened and not-yet-happened, as promoted in the block-universe theories. Events happen only in the Present, although this is not a ‘passing’ moment in time, but merely a watershed separating Past from Future. The proposed probability scheme leads to the concept of ‘Zeitstrang’, which represents the accumulation of events – the history – of every individual. Events – world points – are recognized to make up an individual’s history contribute to an inalterable past.

KEYWORDS: *three-directional time, past-present-future, arrows of time, space and time, block universes, cosmology, probability*

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This essay is not meant to give an explanation of what time *is*. For more than 2,000 years, wise men have speculated about it, producing thousands of different, and still incomplete visions about what time *might be*. Instead of trying to explain what time is, I would like to enlarge the scope of our vision on the phenomenon Time. The idea of Time being multi-dimensional is not new [1]. Unfortunately, I forgot the source, which proposed to see Time as a “three-directional sea of time”, in which you can, metaphorically speaking, plunge and move in any direction: Past, Present, and Future. In the following, I will try to make this idea more clear.

General

We know about subjective time, we speculate about objective time, but we cannot describe what time really *is*. As of now, we still don’t know substantially more about the physical qualities of Time than we did since the writings of John M.E. McTaggart [2]. He argued that there is in fact no such thing as time, and that the appearance of a temporal order to the world is a mere appearance – “Time does not exist”, is he cited. As elucidated in the Stanford Encyclopedia of Philosophy, his argumentation suffers a tremendous flaw [3]: “An odd but seldom noticed consequence of McTaggart's characterization of the A series and the B series is that, on that characterization, the A series is identical to the B series. For the items that make up the B series (namely, moments of time) are the same items that make up the A series, and the order of the items in the B series is the same as the order of the items in the A series; but there is nothing more to a series than some specific items in a particular order.” However, Taggart is in good company with people, who consider time emergent [4].

Arthur Eddington, in the book “The Nature of the Physical World” (1928) develops the concept of a uni-directional ‘Arrow of Time’, and concludes that it is a property of entropy alone. Up till now, the passage of time is mainly defined through the increase of entropy, following the second law of thermodynamics. Under certain circumstances, and in certain cases, this arrow is bi-directional, as suggest the statistical mechanics arrow of time, and the fundamental laws of physics.

However, as Gernot Münster states, there are more possible arrows of time: beside the thermodynamic, the electrodynamic, the quantum mechanical, and the psychological, there is the arrow of time resulting from the expansion of the universe [5], and others still [6]. Adolf Grünbaum applies the contemporary (from 1974) mathematical theory of continuity to physical processes, postulating “time as a linear continuum of instants and a one-dimensional sub-space of four-dimensional space-time.” Using my definitions (*see below*), this would read: “… time as a linear continuum of events and a one-directional sub-dimension of four-directional spacetime.” [7].

Generally, timeless geometry becomes inseparable from other physical concepts, objects and phenomena. The notion of topology of the space(time) manifold also makes sense as the approximation in the limit where we study the long-distance behaviour only. At very short distances, quantum mechanics guarantees that even the topology is fluctuating (quantum foam) – one can imagine that the geometry at very short distances becomes non-commutative, although one must be ready that the word ‘non-commutative’ in the most general situation must be extended and generalized [this paragraph is a citation from ref. 4B].

"The usual picture of space and time, and particles moving around in them, is a construct. Spacetime is an emergent notion as is quantum mechanics," expound Nima Arkani-Hamed and Jaroslav Trnka [8]. Their new geometric approach to particle interactions removes locality and unitarity from starting assumptions. The amplituhedron they conceived reconceptualises colliding particles in terms of *timeless geometry*. Arkani-Hamed et al. consider time as an emergent parameter, a variable that can be perceived, and which only appears in our rather inaccurate description of nature. In consequence, the temporal version of the cosmological origin story may be an illusion. As they state: "… if we really want to understand this moment of creation, we should look at it from an atemporal perspective."

Atemporal is explained in dictionaries as timeless, free from limitations of time. But this does not really cover the meaning of the word, since we generally explain time by the measurement of time. I interpret the term 'atemporal' as 'out of time', meaning there is no past, present, or future – *no* time at all. However, the imagination and the conception of 'being out of time' is extremely arduous. It would also mean, since Space and Time are intimately connected, that we have to imagine ourselves being out of space as well, immersed in complete nothingness. Since we generally define nothingness as the absence of something, in itself already a challenging concept, we certainly face an enormous difficulty here.

Approaching time from a pragmatic point of view, we are simply measuring time intervals in terms of arbitrarily defined units of time, in order to establish some kind of chronology, which we substantially attribute to the Past. However, we conceive a chronology for the Future as well. Time is conveniently and for everyday use expressed in millennia, decades, years, and so on, down to seconds and fractions of a second. Nevertheless, for human beings in general, smaller units below the tenth of a second, are not significant in our daily life. Yet, when doing relevant experiments, science is constraint to focus on even smaller time units: pico-seconds, for ex., and even smaller units of time. How could we know more about the way chemical reactions proceed, if physicists could not produce pico-second laser impulses and measure their length? [9]. Technology demands similar precision in time measurement: how to launch a mission to Mars without being capable to determine the exact moment to ignite the jets of the landing vehicle for a successful mission? But all this is time *measurement*, not time '*an sich*'.

Past, present, and future – all existence in time – are equally real. This is a standing postulate in Eternalism. Some forms of eternalism define time similar to space, namely as a discrete dimension. Future events are 'already there', and there is no objective flow of time [10]. Einstein remarked in a letter to Besso's family, on the occasion of his friend's Michele's death in 1955: "… That signifies nothing. For us believing physicists, the distinction between past, present and future is only a stubbornly persistent illusion." Space-time as propagated by Einstein is understood by Hermann Minkowski and others as an unchanging four-dimensional (in my terms 4-*directional* !) 'block', sometimes referred to as 'block universe'. Our understanding of time is conceptualised in some of the Block Universe Theories, which attribute the dimension time three regions: an immutable past, an ever-passing-by present, and future events, which are already 'there'.

On one side, I adhere to the Newtonian time model, which says that Time is a constituting part of the fundamental, yet evolving structure of the universe. On the other hand, there are important propositions suggesting that time may only be an emergent phenomenon, as illustrated above. How to reconcile these diametrical viewpoints?

Definitions

For the following, it is convenient to define – and clarify – certain terms and things used in this essay. First, I consider a dimension as a *fundamental characteristic*, necessary to describe our universe.

There are many definitions for the term dimension, mostly dependent on the context, in which it is used. In physics and mathematics, the dimension of a mathematical space (or object) is informally defined as the minimum number of coordinates needed to specify any point within it [11]. Actually, the terms dimension and direction – as for the dimension Space – are used ambiguously. As illustrated in the article of Bill Gaede [12], a dimension is represented by direction and orthogonality. Although I do not agree with this simple definition – the x-, y-, z-directions do not necessarily need to be orthogonal – it is evident that the location of an object can be defined by its spatial coordinates, and that it can move in the six possible degrees of freedom within the defined reference frame. Another objection to disagree with Gaede is, that there are many coordinate systems: the cylindrical and the spherical coordinate systems, the curvilinear coordinate system, and many more. For simplicity, based on a Euclidean reference frame, I will make a distinction between the x-, y-, and z-*directions* of space – each considered bi-directional, and extending into infiniteness within the boundaries of our universe – thus making space a fundamental dimension.

Also, a clear statement concerning the concept of time as an 'additional' dimension to the spatial directions seems necessary. Using my above definition, Time can hardly be understood as a fourth *direction*, as the term *spacetime* suggests. It is certain that, not only from the physicist's view, space and time are intimately interdependent, since they seem to emerge from the same primordial event, the Big Bang [13]. Therefore, Time cannot be regarded as a simple addendum to space. This is why I consider Space, like Time, each as a dimension *per se*. The question arises then why time is considered as one-directional only. Let me propose you to imagine time not only confined to one degree of freedom, but as two – or even three-*directional*, with a total of six degrees of freedom. If you can accept the latter, you are no longer fated to ride with this hurrying flicker in time called *'Present'* any more – or see it hustling past. You are here in the Present, but also in your Past *and* in your Future!

Further on, in the quest of elucidating how time may be defined, it appears necessary to look at the four classical, fundamental interactions or forces, namely the electromagnetic force, the weak nuclear force, and the strong nuclear force as distinct forces on their own, which are discrete quantum fields, their interactions being mediated by elementary particles. Gravity, the fourth fundamental force, is in contemporary models ascribed to the curvature of spacetime, yet there are indications that it may me ascribed a separate field character, with a corresponding particle. Like the electromagnetic force, gravity expands its field infinitely throughout space, whereas the range of the remaining fundamental interactions – ~10^{-18} m for the weak interaction, and ~10^{-15} m for the strong nuclear interaction – is very restrained.

The four mentioned interactions are, actually and tentatively, combined in various Grand Unification Theories [14], since it could be shown that, at high energies – approximately at 246 GeV [15] – the electromagnetic interaction and the weak interaction unify into a single electroweak force. It is also suggested that, at even higher energies – around 10^{16} GeV, presumed occurring at the occasion of the Big Bang – all four fundamental interactions would unify. This is supposed to appear in the Theory of Everything [16], at energies just a few orders of magnitude below the Planck energy of 10^{19} GeV. In consequence, all four fundamental interactions would sum up to one single dimension, in which each of these forces would form a '*direction*', or sub-dimension. It must be borne in mind that these '*directions*' are by no means to be understood in the same way in which we understand the spatial directions, in that they posses all the characteristics of their specific forces.

Thus, we would end up with three paramount dimensions: space, time, and the TOE- unified fundamental interactions. As stated above, these latter need space to manifest their characteristics, and they are definitely quantum fields, although gravity – expressed by mass or through constant acceleration – is still missing the confirmation of its assigned particle, the graviton. However, recent proofs of the existence of gravitational waves [17] may end up in revealing the dualism of wave and particle also in this case, as was made evident for electromagnetism and light particles more than 150 years ago by J. C. Maxwell.

Whereas the typical particles of three of the above-mentioned fundamental interactions are well-defined – the graviton on the verge of discovery – we still can only speculate about the existence of a chronon as the time-particle. Whether time is continuous or discrete, only a quantum theory of gravitation could give conclusive indications. Yet, since Planck-time determines the shortest moment in time significant in physics, estimated to 5.39×10^{-44} second, this could be a compelling characteristic of this particle. As for the intrinsic characteristics of space, quantisation may be valid here as well: there is the Planck-length, the smallest possible distance, which can be used to describe lengths, areas, and volumes. A space-particle may be in this order of size, and may be found eventually. Ascribing quanta to all fundamental interactions, I consider quantised all the manifestations of the paramount dimensions.

Three-directional time

In Space, there are six degrees of freedom to move around. Yet, there are admittedly only two degrees of freedom in the time-dimension. Although Borchert [18] argues that our experience of time is *not* time-reversal invariant, in classical mechanics, under the condition that friction effects are excluded, time -reversal *is* invariant, as seemingly the laws of gravity in classical mechanics, too. Following this argumentation, Time seems to possess at least two degrees of freedom, in that the direction of the arrow of time may be reversed.

According to the commonly accepted 4D-View, each and every physical object – including any living being – has an extension in the time dimension. This temporal extension must be considered as analogous to the spatial extensions of the object, since all objects are spread out in space-time. If Time – like Space – also possesses six degrees of freedom, i.e. three directions, it is only logical to attribute to any object three temporal extensions, too.

As mentioned before, we usually consider only one time direction, generally called 'proper' time τ – meaning the time we perceive as 'passing'. This time arrow appears structured, revealing a known Past and an unknown Future, which will be unveiled *with time*. This arrow also contains a Present, which is perceived as a floating moment. The Past has a static, yes, quasi-absolute character: although people have a tendency to interpret the Past concordant to their state of mind, their individual objective(s), conforming themselves to the Zeitgeist, or any other circumstance, there is one thing that cannot be done: genuinely changing the Past from what it was. It is an inalterable series of events. This may be compared to the Block Universe concept. In discordance to a chronological perception of Past, Present, and Future, in a Block Universe featuring a three-directional time-dimension, every possible event is already there – in the Past as well as in the Future.

Thus, the Future is to be considered as an infinite pool of events not yet happened. Although we can not control future, we seem to be able – at least to a certain extent – to influence upon its realisation due to certain actions in our present. What we are not able to do – at least at our level of knowledge – is to change the laws of physics. This means that events may occur despite and without our intention.

The Present is the only moment Humans really experience: this seemingly ever-slipping-away moment. It is here, in this moment, in which we might ponder the Past, where we plan matters of our individual and/or societal future, where we *do* things *or not*. It is here where is decided, conscientiously, under the influence of an unconsidered condition, ruled by the laws of physics, or simply by chance, whether a specific event happens or not. When an event occurs in the Present, it disappears from the Future of possible events and instantly merges into the Past, and it will never happen again. Although this apparent merging of events into the Past gives us the impression of continuously advancing into the Future, that time 'flows', we have to recognise every event as a concrete happening, implying our Past increases discretely and unchangeably.

However, this seemingly 'moving' blink in time must be static. It simply is the time-shed between Past and Future, allowing us to add events from the pool of possible future events to our personal history, and in extension to our societies, to our world, to our universe. The Present – falsely called fugitive – must either be point-like with zero, or Planck-time length expansion. If the latter is the case, time passes in steps – possibly in the rhythm of chronons.

With a one- or perhaps bi-directional arrow of time, one single parameter is enough to describe the order of happening events. However, the now classical double-slit experiment with single electrons shows the limitations of only one time-direction. The particle-wave dualism of a single particle can, as Chen [19] describes, effectively be explained by its motion in three time-directions: while one world line describes the classical motion of the particle in the τ direction, the other two world lines propagate the wave characteristics in the σ and φ directions. However, the introduction of two more time directions σ and φ would necessitate more than one parameter – which both can be described mathematically to correctly represent the order of events.

As illustrated in figure 1, the two additional time directions σ and φ are orthogonal to one another and meet orthogonally with the proper-time arrow τ. The intersection of these three directions is equally the point of osculation of the two cones, and thus logically the Present.

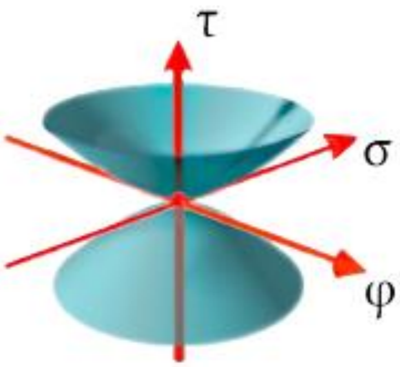

Figure 1: double paraboloid representing the three time directions

In a first approach, this double cone resembles Hawkin's Light Cone, as it shows Future and Past separated by the Present. The main difference, however, resides in the fact that the shown cone is not straight, but it consists – in a raw approximation of a double paraboloid. This is, of course, only a crude description, and only fairly correct in the vicinity of the intersection of the three directions. The Past cone must be considered as an ever-growing entity in time – and similarly the Future cone as ever-decreasing. This may best be understood visualising an hour-glass, where sand flows down from the upper part (the Future) into the lower part (the Past). As the volume of sand decreases in the upper part, the lower part increases in volume.

Events and Probability

As mentioned above, the Future is a pool containing *all* possible – I may say probable – events with non-zero probability. At any present moment, myriads of events happen and are added instantly to the Past. On one hand, there are more or less cognisant beings, who are able to reflect, to reason, to decide, and make events happen. Thinking and planning for the future uses probability in the planning process, in this way attributing a certain chance for a plan to succeed, for a specific event to occur. This planning process is certainly based on our experience, our creativity and perhaps also on our intuition. On the other hand, there are multitudes of events happening without reflection, simply following the laws of physics, and/or in the continuation of a sequence of events.

An event, in Relativity Theory, is an occurrence that is sharply localized at a single point in space and at a specific instant of time – I may add: either in 1-, 2-, or 3-directional time. Physicists also use the term 'world point' for this kind of here -now-event: it is defined as each and every set of coordinates in time or, said in classical terms, as any particular space-time event in our universe. These world points must be considered true: they have occurred, and thus, they lie in the past.

How comes then that events can happen at all? How comes that we can write *a* history? That we can prospect a Future? For an event to happen, there must be a certain probability, which is defined as a value P between the boundaries $0 < P \leq 1$. A zero-value attributed to an event would mean that it will not occur at all, so I may exclude zero-probability events from my considerations. The value $P = 1$ signifies that the event irrevocably will happen. All other values give a measure of how probable an event is: the closer to the value one, the more probable it is to occur. It is evident that, once an event has happened, all the probabilities for other events that might have happened at this moment drop to zero. The steady addition of events to timelines makes appear that there really is an evolution in time. Thus, time seems to flow, our universe seems to proceed in time.

It is extremely difficult to assign an exact value to any event. Curiously, it seems that there is only one general and rather arbitrary rule concerning probability: saying something is 'probable' usually means that it has a better than 50% chance of happening. Generally, we can allege probabilities as follows:

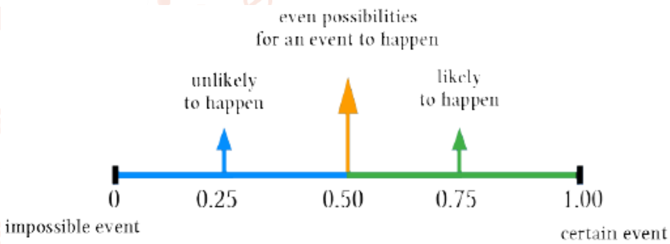

Figure 2: probability line; adapted from www.mathsisfun.com

It is evident that this probability line does not give a quantitative statement of possibilities in respect to whether an event may happen or not. The probability for an event to happen depends on multiple, mostly arbitrary and independent factors. As Aristotle says: "... nor is there any definite cause for an accident [*I would say 'event'*], but only chance, namely an indefinite cause" [20].

It is generally accepted that an event, which is attributed a high probability – according to figure 2 it should be greater than 0.75 – also has a high tendency to happen. However, that does by no means exclude low-probability events happening instead. This in turn implies, even though our influence on any given event may be big, probability can bring about events that we – or any other being – may not have conceived or provoked. In other words, an event even with an infinitesimally small value of probability may well occur. As Arthur Holly Compton formulates: "A set of known physical conditions is not adequate to specify precisely what a forthcoming event will be. These conditions, insofar as they can be known, define instead a range of possible events from among which some particular event will occur" [21]. As particular event I mainly see foreseeable – i.e. probable – events.

In an example, taken from "Factors Influencing Causation Probability" [22], a scope of possible interfering, non-ligated factors may lead to a ship-ship collision. Analysing the probabilities of these factors, the author points out four main groups, which are exemplified by actions in manoeuvring the ship, incapacitation of the personnel, onboard technical problems, and environmental causes. All these factors – whether as a single or as concurring factors – may effectively bring forth a collision. It is to assume that a similar bulk of more or less influential factors, I call them *incentive accompanying events*, may affect every forthcoming event. What is more, these incentive accompanying events must be considered to happen in a completely non-deterministic way.

The following table illustrates the dependency of individual planning, the probability an event has to occur, and the supposed importance of the possible outcome for the individual, the group, the society, or the world (I/G/S/W):

state of planning	probability of the event to happen	outcome for I/G/S/W
intense	high	important
casual / low or no contemplation	high / medium / low	less or not important
chaotic, and/or haphazard input	very low	from very high to very low importance

Table 1: dependence of planning and probability on the importance of the outcome of an event

For a highly important issue, which we plan intensely for, we expect that the event happens. However, we must not neglect all the high-probability events which must be attributed low importance, and which occur without any planning: a point on the wheel of a rolling car, for example, that spins around its axis will continue moving as long as the driver of the car does not stop, or it deflates because of a puncture. There is no reflection, only self-motion: an already initialised process will continue with high probability. When the importance of the event decreases, and there is only casual planning, the probability of the event to happen should be medium as well. Finally, there can be extremely important – and many unimportant – events that happen without any planning, although their probability is low. And there is always a possibility that a *chance event,* caused by pure haphazardness may excel.

The scope of this essay is certainly not to discuss 'importance'. However, one should be aware that this term is extremely subjective: what is important, maybe essential for one individual and can be completely obsolete for another. This is true not only for all the defined individuals in the living world – individuals, groups, the different existing societies, or the world as a whole – but also for the inanimate universe, as *we* interpret it.

Probability Timelines

I may introduce now the term probability-timeline, which will make it possible to assign any kind of event – past or future – to an individual. The Stanford Encyclopedia of Philosophy states: "It is uncontroversial that physical objects are typically extended in both space and time. According to The 4D View, temporally extended objects have temporal parts, [thus] temporal extension is perfectly analogous to spatial extension." According to this statement, each and every individual – I mean here truly every individual, every living being in the fauna as well as in the flora, every piece of matter, every atomic and subatomic particle, has its own probability-timeline. It is evident that simple objects have rather straightforward timelines, whereas more complex beings may feature interwoven timelines. This means: the higher developed the individual (as defined above) is, the more probability-timelines it possesses. Thus, in the case of a simple individual probability-timeline, it starts with the coming into existence of the particular object or being, the consecutive accumulation of occurring events, and ends with its annihilation. For more complex individuals, especially biological entities, their timeline will start with their coming into being, and will probably accumulate more timelines. Their timelines stop with their death, and their final going out of existence.

More intricate is the situation, when we consider higher conscientious beings. We know little about the cognitive capabilities of higher developed animals, but recent research indicates that in many cases we grossly underestimate their cognitive abilities. Not knowing enough about this problematic, however, I will continue to focus on human individuals. In this case, any individual timeline and Zeitstrang must be considered as much less influenced by physics than for the above cases. At any present moment, we all take decisions. At a very young age, these decisions are not or only little pondered. With increasing age of the individual, events are more and more pondered and/or anticipated. Sometimes, however, an event will happen, because it simply convenes to the individual. In addition, there are the countless events, which occur without requiring special attention of an individual. Generally an individual – for simplicity I refer here to an adult – takes her decision depending on multiple factors: starting with her education, her environment, her mental equilibrium, and much more.

We all do – or tend to do – what is pondered, and 'probably' right, or intentionally wrong. Thus, the event we want to happen has a high probability. However, it is to consider that variance is a crucial factor: if variance is high, the probability that a less important event occurs will be appreciable. For an event to effectively happen, it is stipulated that this – not-yet-happened – event is close to an individual's most recent timeline, ready to be incorporated into it.

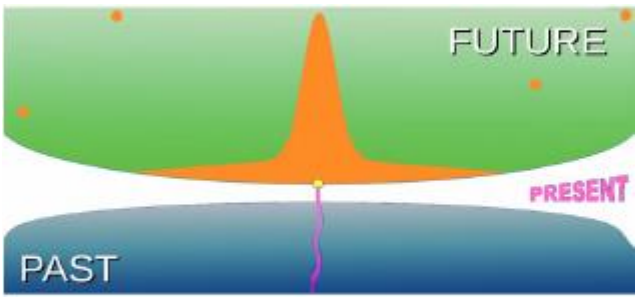

Figure 3: event probability for one timeline event

The probability distribution (orange) of one possible event (yellow point) for an individual is represented in figure 2. Orange points in the Future are depicting possible haphazard events. The gap between Past and Future must be considered in the order of a Planck-time unit. The individual's Zeitstrang (*see below*), the sum of all personal timelines, is shown in magenta colour in the Past. As the individual increases her event-history, its Past increases. Reciprocally, the total amount of possible events in the future shrinks. This also means that, when a specific event occurs to an individual, certain future events become impossible, since they were only possible until the moment when the specific event came into being.

An individual's probability-timeline represents the accumulation of events, the individual encounters: whether ruled by the laws of physics, by its own cognitive efforts (including interactions with other individuals), or by events that happen under the influence of non-planned, haphazard, i.e. random action. One important feature of every probability-timeline is that the higher the probability is for an event to happen, the closer it is to an individual's probability-timeline. In addition, every timeline of that ilk is part of the history of an individual.

From the foregoing follows that there are two types of probability-timelines to consider: one, where cognisant beings can contribute – if ever – only with tiny interventions, because this type is rigorously governed by physical laws. The second one is mainly influenced by cognisant beings – perhaps even lower animals, bacteria, etc., and certainly plants. Both probability-timelines have a common feature: they include also events, which are not reflected at all, like purely self-motioned processes, and completely haphazard occurrences.

Since individuals interact with one another – except rare exceptions – their probability-timelines are interwoven. Simple probability-timelines may be represented by quarks, assembling to subatomic particles, these form atoms, which in turn form bigger agglomerations of matter. Accordingly, the more complex the individual, the more probability-timelines it features. The birth of our universe engendered a myriad of probability-timelines, which were and are governed by the laws of physics – although we still have to find out what exactly these laws are, and whether our description of the universe with the present means is adequate and sufficient. In this context, the recent discussion about the possible consciousness of matter is quite intriguing. [23].

Zeitstränge*

The temporal extension of every individual – as defined above – means not only that each object must be characterized correctly using six coordinates: three spatial ones, and three temporal ones. It also implies that each individual must be attributed at least one timeline. I already expounded that, the more complex the individual, the more timelines it collates. The totality of timelines connected to – not only – cognisant beings I will call '*Biological Zeitstrang*'. For the totality of the interwoven, primarily physical probability-timelines I will use the term '*Universal Zeitstrang'*. Purely material accretions – I call them non-cognitive accumulations – belong to this kind of Zeitstrang. In fact, the whole history of our universe constitutes one Zeitstrang, which obeys to a very high degree physical laws, although chaos-theory keeps open the door for chance events. Both '*Zeitstränge*' are interwoven: whereas the Universal Zeitstrang is the history of the evolution of our universe, implying that we humans practically had and still have no or very little saying in this respect, the Biological Zeitstrang reflects the history of biological evolution on our world and our actual, global human society. One characteristic of the Biological Zeitstrang is that it is composed not only of the timelines, but also of the Zeitstränge of certain individuals.

Since we have a certain influence upon our – and more or less directly also on other beings' – biological Zeitstrang, we increase our and others history mainly through more or less contemplated events. However, and I consider here the less conscientious fauna and flora as well, pure physics still plays an important role, as does haphazardness: if a seed doesn't get water at all, it will not germinate. In the given surroundings of the seed, the probability of, for ex. rain, which could furnish enough water for the germination depends essentially on the reigning climatic conditions. Sure, one can argue that weather phenomena can be described physically. But it can't be excluded that rain at a certain moment, in a certain place, can simply be provoked according to the principles of chaos-theory – or not at all. There may even be a human intervention, picking up the seed and watering it. – Similarly, if a firefly turns in a given moment to the right instead of its left, the fact that it flew as it did can't be reasoned about using physics alone.

More complex is the situation, when we consider higher conscientious beings. We know little about the cognitive capabilities of higher developed animals, but recent research indicates that in many cases we grossly underestimate their cognitive abilities. Not knowing enough about this problematic, however, I will continue to express with the word Zeitstrang focus on human individuals. In this case, any individual timeline and Zeitstrang must be considered as much less influenced by physics than for the above cases. At any present moment, we all take decisions. Although at a very young age, these decisions are not or little pondered, with increasing age of the individual, events that are imminent to occur are more and more pondered or anticipated; often out of convenience, yet sometimes randomly. Yet one must not forget about the countless events that simply happen without being registered expressively. Which decision an individual – for simplicity I refer here to an adult – takes, depends on multiple factors: starting with its education, its environment, its mental equilibrium, and much more. Remember the example above, taken from "Factors Influencing Causation Probability", about the conditions leading to a ship-ship collision. Furthermore, since individuals interact, not only the timelines, but also the Zeitstränge of certain individuals are interwoven.

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[*]The translation of this German term into English would give the – to my feeling – rather awkward word: time-strands. Strang [Ge, plural Stränge] may be translated to rope, or strand [Br]. I may cite the most appropriate definitions for the latter, given by the Merriam-Webster online dictionary: 1) one of the elements in a complex whole, 2) an element (such as a molecular chain) resembling a strand. There are more translations and definitions given, but they are even less appropriate to describe what I want to

Space and time

The question of whether there could be time without change has traditionally been thought to be closely tied to the question of whether time exists independently of the events that occur in time. For, the thinking goes, if there could be a period of time without change, then it follows that time could exist without any events to fill it ("Absolutism with Respect to Time"); but if, on the other hand, there could not be a period of time without change, then it must be that time exists only if there are some events to fill it ("Reductionism with Respect to Time") [24]. – To my conviction, the first statement must be true: in a thermodynamic equilibrium, for ex. considering a chemical reaction, there is no detectable macroscopic change although, on the microscopic level, forward and reverse reactions may occur. However, as we consider this equilibrium, time passes. There is seemingly a parallel to Space: if matter is essential for Space to exist, then it must be that space exists only if there is matter, However, if there is space without matter, then it follows that empty space must exist.

As outlined before, time is intricately related to space, as is mass. With the Big Bang, the result of a singularity with infinite mass, space came into being, and with it time. One important effect of the observed inflation after the Big Bang is that the matter density diminishes along the time-direction τ with progressing inflation of the universe. Thus, I may postulate that time in our universe slows down, for two reasons:

1. Inflation is an accelerated process. Einstein showed us that time measured in an accelerated reference frame – compared to the reference frame of a non-moving observer – slows down,
2. Mass causes acceleration – i.e. gravity. The farther away we are from an important mass, the slower ticks our clock.

Following the above argument, I postulate an inverse proportional dependency between matter density and time in our universe: when matter is infinite – as in the singularity of the Big Bang, time is Zero. It must be borne in mind, that the following graph is purely qualitative.

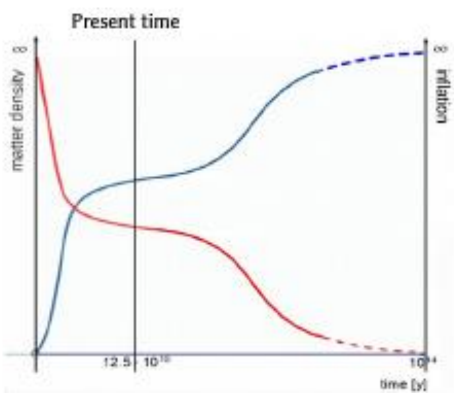

Figure 4: inflation vs. matter density

In accordance to my postulate, as matter density decreases, time slows down. Nevertheless – estimated in around 10^{14} years matter density will have approached a value close to zero. Inflation still may go on, but the universe is very close to an equilibrium state, and time has practically come to a halt. It may be speculated that this situation may engender another singularity, but this is not the scope of my essay.

How can we say the total age of our universe will reach 10^{14} years? The discovery of the Hubble constant H_0 is based on a set of equations published in 1922 by Alexander Friedmann, which showed that the universe might expand. Later calculations by Hubble yielded a value of H_0 to be ~500 km/s/Mpc, which was substantially lowered by later calculations. Since ~1965, the most appreciated values oscillate roughly between 100 and 50 km/s/Mpc, with a convergence to values near 65 ∓ 10 km/sec/ Mpc since 1985 [25]. This gives an estimated age of our universe between 8 and 13.8 billion years. Recent findings of Adam G. Riess et al. [26] yield the value $H_0 = 74.03 \pm 1.42$ km/s/Mpc, indicating that our universe may be about one billion years younger than anticipated until now, namely between 12.5 billion to 13 billion years.

The "Big Freeze" is one of the possible scenarios our universe may face. Under the assumption of continued adiabatic expansion, the universe asymptotically approaches absolute zero temperature [27]. This scenario, in combination with the "Big Rip" scheme [28] is currently gaining ground as the most important hypothesis [29] about our universe's far-future development. However, there are several constraints and conditions: in the absence of dark energy, it could only occur under a flat or hyperbolic geometry. Furthermore, with a positive cosmological constant, it could as well occur in a closed universe. In this scenario, stars are expected to form normally for 10^{12} to 10^{14} years. Yet, still other scenarios have been developed [30] and certainly must be considered as well.

With the Big Bang, our universe came into being, and with it space, time, and matter as an expression of energy. In fact, there is no need for time to 'flow', and thus it is completely irrelevant, whether it 'flows' in an expanding, decelerated or in a steady state universe, see figure 5:

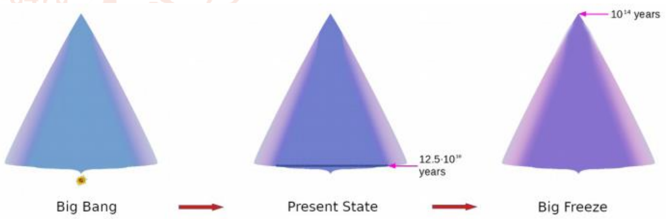

Figure 5: Possible development since the Big Bang

The Big Bang created our universe, and immediately opened up a future, represented by the left cone in figure 5. This Future contains all events possible in and for this universe. With events happening, a past is generated, which evidently takes away events originally contained in the Future, since these become Past events, the time-shed – the Present – separating one from the other. Thus, the Past – the history of our universe – increases. As more and more events happen, gradually less probable events remain in the future cone, until there are no events left, which will probably happen in about happen 10^{14} years, when *everything* will be Past.

The actual time – $12.5 \cdot 10^{10}$ years universal time – falls in a period of accelerating expansion. However, the further progression of expansion and diminution of matter density, as well as their asymptotic behaviour approaching 10^{14} years illustrated in figure 4 (*inflation vs. matter density*), is speculation. When our universe reaches the age of 10^{14} years, according to the above cited estimates, our universe will have infinite size, and any existing clock will come to a stop. In this scenario, at 0 K exactly (if this temperature can be attained), an equilibrium is reached. Finally, a timeless thermal equilibrium will rule, which could last for aeons, or end in another singularity. This appears possible, although this equilibrium state has not any *useful* energy left, – but energy will still be present.

As there is decidedly an initial state, and there is more and more energy converted into – useless – thermal energy, there must be, according to physicists, a final state, as illustrated above. Also, our experience, which is expressed in the aphorism: “Whatever has a beginning must have an end” [31] points into this direction.

CONCLUSION

The universe undoubtedly started at one point in the Past, which we may consider Zero-Time and Zero-Space. The Big Bang, the initial state of our universe, engendered simultaneously Space and Future, and with the latter Time. Directing our regard from this zero-point in the Past to the other end of this vector, we look into the future of our universe. Hawking stated in one of his lectures in 1996: " …the universe has not existed forever. Rather, the universe, and time itself, had a beginning in the Big Bang, about 15 billion years ago" [32]. However, whether there was something before our universe, as Hawking implies, is merely a metaphysical problem, since we are unable to elucidate this question.

As outlined above, it is important to make a differentiation between dimension and direction. In Space, directions are simply the x-, y-, and z-axes of the reference frame. For the Time dimension, we can also attribute three ‘directions’: the main direction τ, the generally perceived ‘arrow of time’, and the directions σ and φ, allowing the separation of Past and Future, assigning a three -directional temporal characteristic to every object. The Present thus becomes an immovable point, which simply separates Future from Past.

Everything that will happen is contained in the Future, in a pool of probable events. This pool diminishes when events occur. What actually happens is exclusively in the Present, this apparently ‘moving’ blink, occurring in a Planck-time interval, which may be a main characteristic of the suspected chronon. The Present is simply the time-shed between Past and Future. In the Past are assembled all events that did happen. An event is to be considered a world-point, *ipso facto* revealing that time is discrete.

As Future is containing all – unalterable – *possible* events, the Past accumulates all *executed* events, which can’t be changed anymore. As a consequence, an observer may be able to visit the Past, but she will have no means to change anything there, since everything happened already. Similarly, she may visit the Future, but with no chance to change anything there that might inflict the Present or the Past, simply because things did not happen yet.

In a universe with the three fundamental dimensions Space, Time, and the TOE-unified dimensions, each of them three-directional, there is no need for a ‘passing’ time. It appears to me that merely the fact that each and every event makes a contribution to our past that a time-arrow seemed necessary for our understanding the universe.

We measure time, we measure space. However, we still do not understand what these two dimensions really represent. We simply have to accept that the dimension Time *is*, as Space *is*, three-directional each one of them. And that they undoubtedly are interdependent. The future will show, whether the configurations of Space and Time, as described above, combined with the TOE unified fundamental dimensions, will make it possible to review our universe according to a different than the classical reference frame based on a four-dimensional ‘spacetime'. The new developments in geometric approaches to this problematic is encouraging.

What we must realise is that we are only humble spectators in, and observers of our universe, which develops according to the known laws of physics, which we still have to elucidate completely.

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