

Block time: Why many physicists still don't accept it?

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Abstract

The concept of time as defined in physics is the most naturally interpreted as a block time. According to this interpretation, time is like any other parameter in physics, without any intrinsic flow and without any fundamental difference between past and future. Yet, such a view of time is in a sharp contrast with our intuitive subjective experience of time. Where this discrepancy comes from? I argue that this discrepancy is an artefact of the linguistic inconvenience that we use a single word “time” to describe two very different things, one described by physics, the other being related to consciousness. To clearly distinguish between them, I refer the former to as *pime*, abbreviating the expression “physical time” or “parameter time”. As the phenomenon of consciousness is not truly understood by our current understanding of physics, current physics has little to say about time. Physics is only about *pime*, which is a block *pime* without a flow and without a fundamental difference between past and future. The relation between *pime* and time remains a challenge for the future research as a part of the hard problem of the relation between matter and mind.

1 Introduction - a very brief history of “time”

The concept of time is one of the basic abstract concepts in human language. Everyone knows what time is. Or at least, everyone thinks he/she knows, until one starts to think seriously about it. But when one starts to think seriously about time, or when one is asked to say explicitly what time is, then one usually gets into a trouble. Even if he/she is a well-educated physicist who immediately says something like “time is what clocks measure” or “time is the fourth dimension”, he/she will probably feel that such a statement, even if perfectly correct, is not really a completely satisfying answer.

The concept of time was developed by humans before they developed science or philosophy. This is because some sense of the flow of time is inherent to all humans, so they need a word to denote this common but hardly explainable subjective experience. But at some point in the history, someone attempted to turn this subjective notion of time into something more objective. Someone invented a (primitive version of a) *clock*.

Even if you are not interested in finding a deeper answer to the question what time is, a clock may be a very useful device in practice. Indeed, a first clock was probably invented with only a practical motivation in mind. Nevertheless, it is quite clear that a clock does have something to do with the abstract flow of time. In a sense, the state of a clock can be taken as a *measure* of the otherwise subjective elapsed time. But is a measure of time the same thing as time itself? I believe this is one of the crucial questions that needs to be answered in any attempt to understand the nature of time in scientific terms.

In modern science, a positivistic philosophy dominates. According to positivism, it does not make sense to discuss about something unless it can be empirically experienced. But observation involves a subjective observer, while science insists on evidence that is objective, rather than subjective. So, how to make positivism compatible with the requirement of objectivity? The answer is - by measurement. To measure something, means to perform a procedure that associates a number with it, in a manner that provides that all subjective observers agree on the value of that number. In particular, a clock is a device that associates a number t with an elapsed time. Hence we say that a clock measures time. Since, according to scientific positivism, only a measured time is a meaningful concept, for scientists (or more precisely, for physicists) it is natural to *identify* the number t with time. In physics, it is common to say that t is time.

Of course, physics is not only experimental physics. Physicists also like to make predictions before doing the actual experiments, because successful predictions obtained in a systematic way allows them to say that they *understand* nature. This is what theoretical physics is about. Since theoretical physics must be about numbers such as t , the natural language of theoretical physics is mathematics.

In theoretical physics, one deals with various equations that involve the time variable t , as well as many other quantitative variables, such as length, energy, temperature, etc. In the language of theoretical physics, time is like any other physical parameter. In particular, nothing in physical equations that deal with time says that the past is more certain than the future, just like nothing in physical equations that deal with space says that the left is more certain than the right, or just like that nothing in physical equations that deal with temperature says that a lower temperature is more certain than a higher temperature. In other words, nothing in these equations says that time, unlike other variables, has a property of “lapsing” or “flowing”.

Or does it? Certain macroscopic equations of theoretical physics do involve a “time arrow”, i.e., a property that time possesses some kind of a direction. There is a consensus among physicists (see, e.g., [1, 2, 3, 4, 5, 6, 7]) that all these time arrows can be reduced to the thermodynamic time arrow. The latter is also known as the second law of thermodynamics, which says that the total entropy cannot decrease with time. Nevertheless, mathematically speaking, the claim that entropy increases with time is not different from the claim that, e.g., temperature increases with energy. As the latter certainly does not imply that energy lapses, in the same sense the former does not imply that time lapses.

Even though equations of physics do not imply that time lapses, they also do not imply that time does not lapse. In fact, it is difficult even to imagine how one could express the lapse of time in a mathematical language. Something that cannot be expressed in terms of numbers does not belong to physics, or at least not to what most physicists mean by “physics”. Nevertheless, it may still seem reasonable to believe that time does lapse in agreement with our subjective experience, even though we do not understand it very well from the physical point of view.

At least this is so in nonrelativistic physics. Namely, in nonrelativistic physics, time enters equations in a way different than other quantities do, so one is allowed to speculate that it might something to do with the fact that only time manifests as something that lapses. Even though nonrelativistic physics does not explain or even express the lapse of time, at least it does not contradict our subjective experience that it does. However, the situation in *relativistic* physics is entirely different. There, time enters equations in a manner completely identical to that of space (up to an opposite sign in the metric tensor). Historically, this relativistic symmetry between space and time completely revolutionized the concepts of space and time, by merging them into a single entity called “spacetime”. As we certainly do not have a good reason to say that space lapses, relativity suggests us that time does not lapse either. Instead, relativity suggests a picture of the *block time*¹, where time is nothing but one of the coordinates on the static 4-dimensional manifold. All we know about relativity² is perfectly consistent with such a picture. According to this picture, the universe does *not evolve* with time. Instead, the universe simply *is*, extended in 4 dimensions, one of them being called “time”. Both the “future” and the “past”, as well as the “presence”, are there, without any of them being less certain or less real than the other. Moreover, any attempt to define “future”, “past”, and “presence” in an observer independent way destroys the mathematical structure of the theory in an artificial and arbitrary manner.

So, from the point of view of current knowledge in physics, it seems reasonable that every physicist should adopt this block-time picture of the universe. Nevertheless, most physicists, even many relativists, do not find such a picture of time acceptable. Why is that? Clearly, the reason must be the fact that such a picture clashes with our subjective experience of time. But where this clash between the two pictures comes from? Why our physical theories of time, which are in excellent agreement with all existing experiments, do not incorporate the most basic property of time, the property of lapsing? In this

¹This picture of time is also frequently referred to as *block universe*. See, e.g., [8] and references therein.

²Here I have in mind classical (i.e., non-quantum) relativity, both special and general. Some attempts to formulate a quantum variant of general relativity (see, e.g., [9]) seem to destroy such a perfect symmetry between space and time, but it does not much help to understand the origin of time lapsing.

essay we attempt to answer this question on a deeper level. In fact, the reason is already implicitly explained in the very brief history of “time” above. What we need to do is to make this explanation a bit more explicit.

2 Two “times”

Before saying anything about time, one must first define “time”, to specify what one is actually talking about. For example, Carlo Rovelli in his book [9] distinguishes 10 different notions of time. Nevertheless, it is clear that not all these different notions of time can be equally fundamental.

Ideally, one would like to have only one universal fundamental notion of time, so that all other notions of time can be reduced to this fundamental one. Yet, as I argue below, such a universal notion of time *does not exist*. Or at least, it does not exist within our current understanding of nature. Instead, there are (at least) two fundamentally different notions of “time”, the relation between which, if any, is not well understood by the present achievements in physics (or science in general). These two “times” are:

1. *Subjective time*. It is a pre-scientific time, the notion of time that (presumably) every person experiences. The basic property of this time is the property of lapsing.
2. *Physical time*. This is the time as defined in science, especially physics. It is represented by a real number t . It may correspond to a reading of a clock, or to a parameter in a physical theory that, at least in principle, is able to make predictions on readings of clocks. For example, in the theory of relativity t is identified with one of the coordinates x^μ .

To make further discussions easier, from now on I shall refer to subjective time as *time*. To distinguish time from the notion of physical time, I shall introduce a new word *pime*, which can be thought of as an abbreviation for the expression “physical time” or “parameter time”.

What do we gain with such a new terminology? At first sight, not much. Nevertheless, I believe we gain a lot. I believe that a lot of confusion among physicists about the nature of “time” stems from the fact that they use a single word for these two very different concepts, suggesting them that these two concepts are actually the same, which, in turn, leads to various apparent paradoxes. Now, by using different words (time and pime) for different concepts, the possibilities for a confusion are significantly reduced.

For example, the concept of pime may be very useful as a pedagogic tool in teaching special relativity. The equations of special relativity are not difficult, but students may have deep conceptual problems to accept and understand *intuitively* that time may depend on the observer’s velocity. This is because students are also humans, with their intuition on time developed much before any exposition to science called physics. Now if you tell them that relativity (and physics in general) says nothing about time, but only about a formal (but measurable) physical quantity called pime, then a (large part of) clash with intuition is avoided in a very simple way. Of course, students may remain disappointed that physics says nothing about such an important concept such as time, but they will not be too disappointed because they are already used to the fact that physics also says

nothing about other important concepts, such as emotions, consciousness, good and evil, free will, etc.

Such a terminology is even more useful in dealing with the so-called *time-travel* paradoxes. Even professional theoretical physicists specialized in general relativity often have problems with this type of paradoxes. Now there can be no time-travel paradox in physics simply because there is no time in physics. At best, there can be only a pime-travel paradox in physics. But there is no any pime-travel paradox either. As discussed in more detail in [11], all time-travel paradoxes stem from the fact that time lapses, that there is a flow of time. On the other hand, unlike time, pime does not lapse or flow. Pime simply is, just like space. In this block-pime picture of the universe, there is simply no room for a pime-travel paradox [11], just as there is no room for a space-travel paradox. Of course, one can still wonder what happens with time and free will in a universe that allows a pime-travel, but there is no any paradox with it, at least not within physics as we currently understand it, simply because physics says nothing about time or free will. (Nevertheless, I will express some personal speculations on that issue in the next section.)

In my opinion, the solution of pime-travel paradoxes is one of the strongest arguments for adopting the block-pime picture of the universe. Nevertheless, as a possibility for a pime-travel is still only a speculation rather than a fact, an even stronger argument is a standard argument based on special relativity in flat spacepime (for simple presentations of that argument see, e.g., [6, 7, 8, 10]). The argument goes as follows: Assume that pime “flows”, or more precisely that for any point in spacepime called “now” one can determine what is its past (that has already happened) and what is its future (that has not yet happened). However, it cannot be done for the whole universe (but only for the interiors of light cones that do not cover the whole universe), because a hypersurface of equal pime that crosses a given point is not unique. In other words, *since the coordinate pime is not uniquely defined in the theory of relativity, the assumption that there is a global flow of pime in the universe is not compatible with relativity*. Therefore, if we want to retain relativity, the block pime seems to be the only viable option.

Now we are finally ready to answer the question posed in the title of this paper. Why many physicists still don’t accept the block-time picture of the universe? This is because they use the same word “time” for two different entities. One of them, that we still call time, is indeed incompatible with the block-time picture. The block picture refers only to the other, now called pime. All the confusion stems from a tacit assumption that these two “times” are the same, while they are not.

3 On the relation between pime and time

In the preceding section we have been considering pime and time as if they were completely independent entities, which apparently solved many (if not all) deep fundamental problems about the nature of pime. However, the problem with such a solution is the fact that pime and time are *not* really completely independent. For if they were, humans would never use the same word for them and think of them as different manifestations of the same entity. Can we say anything more about their relation, without ruining their difference needed for compatibility between block pime and flowing time?

As we have discussed in the Introduction, time is a kind of a subjective experience.

In other words, time cannot be completely understood without understanding consciousness.³ On the other hand, I think it is safe to say that so far science has not been able to understand the origin of consciousness. Hence, as time is one of the manifestations of consciousness, I believe that at the moment science cannot provide understanding of time either.

Or can it? In physics literature that deals with pime arrow,⁴ it is often pointed out [5, 6, 11, 12] that the thermodynamic pime arrow can explain the *psychological* pime arrow. The word “psychological” may seduce someone to think that the subjective experience of time can be derived from the physical properties of pime. Nevertheless, it cannot. Namely, what is meant by the “psychological” pime arrow in that context, is the fact that humans remember the past and not the future. It turns out that the thermodynamic pime arrow can explain why *physical objects* such as brains or computers “remember” the past and not the future, where “to remember” means “to reproduce” from the state at some given pime. As it certainly does not prove that computers have a subjective experience of the flow of time, the explanation of the “psychological” pime arrow is not really an explanation of the origin of the flow of time.

Then what is the origin of the subjective flow of time? We don’t know. All we can say is that it is probably a part of the hard problem of understanding the relation between mind (e.g., consciousness) and matter (e.g., brain). While science understands the latter pretty well, the former still seems to be a complete mystery. Nevertheless, as a pure speculation and philosophy, I cannot resist to present my own personal view. This seems to me to be the simplest way to unify mind and matter without modifying the side that we already understand pretty well - the matter side. The reader does not need to agree with me or may feel that it needs further refinements, but here it is: Matter (which includes space and pime) satisfies the laws of physics as we know them. But there is also something more, something not described by the known physical laws. Perhaps one day we shall also understand this in physical terms and think of it as a kind of matter too. Nevertheless, for now let me call it “unmatter”. To provide consistency with the known physical laws, I postulate that unmatter cannot influence matter (one can refine it by proposing that this influence is very small), but that matter can influence unmatter. One of the manifestations of unmatter is consciousness. (In a minimal “model”, consciousness is the only form of unmatter.) Consciousness may be thought of as a helpless observer of matter. Consciousness does not observe the whole block universe at once, but scans along a world-line of a brain; this scanning is perceived by consciousness as *the flow of time*. Consciousness is not able to observe all the details of the states of brain, but perceives only some of them. Consequently, some causal connections between the states of the brain are not perceived. This apparent lack of causal connections consciousness perceives as *free will*. Clearly, in such a minimal “model” of the world, free will is only an illusion. In this way, one avoids the conflict between physical laws as we know them and the appearance of consciousness and free will.

³To reduce vagueness in the further discussion, I specify what I mean by “consciousness” by saying that consciousness *is* subjective experience.

⁴The term used in this literature is, of course, the “time arrow”, but the appropriate translation consistent with terminology used in this paper is “pime arrow”.

4 Conclusion

The physical *measure of time*, represented by a numerical parameter t and referred to as *pime*, is not the same thing as time itself. While time is a subjectively experienced flow, pime, as a numerical parameter, does not have a flow. Instead, pime simply is, just like space, which corresponds to the block-pime picture of the universe. The origin of time is not well understood in physical terms, but the separation of the intuitive concept of time from the physical concept of pime avoids discrepancies between intuition and formal knowledge in physics.

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