Does Time Exist?

ABOUT THE POSSIBILITY OF A TIMELESS UNIVERSE

The nature of time and motion has been a mystery since serious philosophy and science began over 2500 years ago. In the last half century, theoretical physicists have found evidence that the quantum universe might best be thought of as static. Nothing happens in it all. A physicist from Oxford University gives an historical survey of notions of time and motion as they have developed since antiquity and explains why we are now confronted with the possibility that time does not exist and motion is an illusion created by consciousness.

From Antiquity to Newton and Einstein

The dawn of philosophy witnessed the first great debate about the nature of time and motion. Heraclitus, born in the sixth century BCE, argued that everything is in flux, but his contemporary Parmenides argued «Existence is timeless, change is impossible.» Parmenides had a big influence on Plato and, through him, on the whole of Western philosophy and science.

Plato argued that only perfect unchanging forms exist and that motion is an illusion. Thus, being is real, becoming is an illusion. One can see the strength of Plato's argument if one considers the problem of describing mathematically the motion of a galloping horse. It can only be done in terms of the changing shapes of the horse. This suggests that shapes, existing as mathematical ideals in a timeless Platonic realm, are primary and that motion is a reflection of differences between them. This is supported by the fact that a movie consists of stills. Time and motion are eternally elusive.

St Augustine had a deep answer to the question why God had not created the world sooner than he actually did. He responded «God did not create the universe in time but with time.» To the extent that time is anything, it derives from what happens in the universe.

Newton had a very different idea. He claimed «Absolute, true, and mathematical time … flows uniformly without relation to anything external.» He also conceived space as a fixed arena in which every object in the universe has a definite position at each instant of time.

Newton's ideas were criticized by Leibniz and above all Ernst Mach, who in 1883 said: «It is utterly impossible to measure the changes of things by time. Quite the contrary, time is an abstraction at which we arrive from the changes of things.» Like Leibniz, he also insisted that motion is relative, the position of any one body in the universe being defined relative to all the other bodies.

Mach's ideas had a profound influence on Einstein and became the single greatest stimulus to the creation in 1915 of his theory of gravity, the wonderful general theory of relativity. However, Einstein implemented Mach's ideas indirectly, and their full implications for the nature of time only started to become apparent over 50 years later when people attempted to create a theory that combined the insights of general relativity and quantum mechanics.

Quantum Mechanics

To understand the issues that arise when one attempts to combine quantum mechanics and general relativity as a single theory, the first thing to note is that quantum mechanics left Newton's concept of time essentially unchanged. It flows independently of everything in the universe. The radical changes that quantum mechanics introduced concerned the behaviour of matter and what we can say about it.

In Newtonian mechanics, one can always say where, at a given instant, a body is and what its momentum is (the momentum is the velocity of the body multiplied by its mass). Position and momentum are simultaneously measurable and their values can in principle be predicted with perfect accuracy. However, in the atomic domain, where quantum mechanics holds sway, things are very different. First, it is in general impossible to make definite predictions. Quantum mechanics gives only probabilities for what can be observed. It also says that one cannot measure position and momentum simultaneously.

What is very remarkable in quantum mechanics is when one considers a system of particles and wishes to measure their positions. One does not get separate probabilities for each individual particle but probabilities for complete configurations of the particles. For example, if we consider a system of three particles, they will at any instant form a triangle. Quantum mechanics gives separate probabilities, which change with time, for all possible triangle shapes and sizes and for positions and orientations of the triangle in space. This is the situation in ordinary quantum mechanics, which was created using the essentially the framework that Newton had proposed. Now we must consider what happens when we try to combine quantum mechanics with general relativity.

Quantum Gravity

There are many difficulties encountered in the attempts to create a theory that combines general relativity with quantum mechanics. It should lead to a theory of quantum gravity, but none yet exists. However, some remarkable indications of what might emerge came to light in the 1960s. Ultimately they are consequences of the fact that, in an indirect way, Mach's criticisms of Newtonian dynamics are taken into account in general relativity.

Let us first deal with the relativity of position. In Newtonian theory and in quantum mechanics, the positions of objects are defined relative to space (strictly an inertial frame of reference, but that is an inessential difference). However, it is meaningless to say that the universe itself has a position in space. As already Leibniz pointed out, if you imagine the whole universe moved by a certain amount in invisible space, nothing in anything you could actually observe would be changed.

When Einstein's theory is represented in the appropriate way, this is indeed what it says. The implication for a quantum theory of the universe can be expressed in terms of the triangles considered earlier. Let us suppose a toy model of the universe consisting of just three particles. Ordinary quantum mechanics says that the particles can form a triangle of any shape and size that has any position and orientation in space. It gives probabilities for all these possibilities. However, position and orientation in space of the complete universe have no meaning in general relativity. Accordingly, quantum gravity can only give probabilities for the shape and size of the universe, not ‹where it is›.

In fact, the overall size of the universe is almost certainly a meaningless concept, and this suggests that quantum gravity should only give probabilities for possible shapes of the universe, not sizes as well. This does not affect the issue of time, to which we now turn.

What Is an Instant of Time?

Let us shed all ideas that the Newtonian way of thinking induced in us. Why do we say time passes? Without distorting anything, we can consider only what we see; what comes to us through the other senses adds richness to life but nothing to the scientific aspect. We see a succession of views of the world. We could imagine taking snapshots of them like stills of a movie. We do not see them embedded in a river of time. As Leibniz said, time is merely the succession of coexisting things, which we can identify with the different objects that we see simultaneously: trees, rocks, flowers, etc.

This suggests that an instant of time is nothing to do with something outside the universe, say a line on which each point represents an instant (this is the most common scientific way of representing an

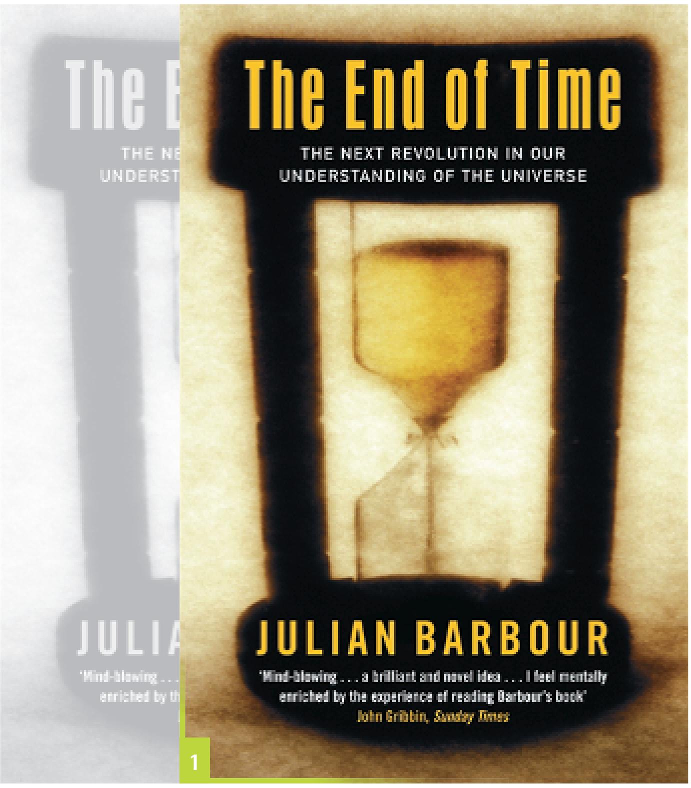
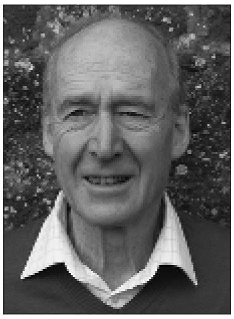


Figure 1
Cover of «The End of Time», Phoenix Paperbacks



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born in 1937, is a British physicist with research interests in quantum gravity and the history of science. After receiving his Ph.D. degree on the foundations of Einstein's general theory of relativity at the University of Cologne in 1968, Barbour has supported himself and his family without an academic position, working part-time as a translator. Since 2008 he has been a Visiting Professor in Physics at the University of Oxford. In his book «The End of Time» (1999) he argues that time, as we perceive it, does not exist as anything other than an illusion. Barbour lives in Oxford, Great Britain. Contact: barbourJ@physics.ox.ac.uk

instant of time) but is just a possible arrangement of things within the universe that occur together. It is like a movie still.

This way of thinking leads to a much richer notion of instants of time. They are not mere featureless points on a mathematical line. They are complete configurations of the universe. In the simplest case of the toy universe consisting of three particles, the configurations are just the possible triangles that three points can form.

This is a valid way of interpreting Einstein's general theory of relativity, even though it is not the way he thought about it. The fact is that although Einstein made no direct attempt to put Mach's ideas into his theory they were incorporated indirectly. As a result, time in general relativity is, except in special circumstances we can ignore, «an abstraction at which we arrive from the changes of things.»

The Timeless Quantum Universe

Once we see that a configuration of the universe defines an instant of time, we can understand why something drastic is likely to happen in quantum gravity, which we expect to be the quantum theory of the universe. Ordinary quantum mechanics predicts probabilities for configurations of systems at different instants of time. But if the configurations of the universe are the instants of time themselves and we want to keep the idea that quantum mechanics defines probabilities, then we arrive at the conclusion that the quantum mechanics of the universe simply gives probabilities for configurations of the universe. That's all there is to say. The probabilities cannot change with time because time has been eliminated from the picture.

Anticipations of this remarkable picture of a timeless universe, in which there are simply different probabilities for different possible configurations, can be found in the convictions of Plato, St Augustine, Leibniz and Mach. They have become acute with the advent of general relativity and quantum mechanics. They force us to ask insistently: What is time? In what sense does it exist? I have already given my definition of an instant of time. Let me end with an attempt at an answer to the second question.

Time without Time

Given a system of particles, quantum mechanics tells us that we can in principle determine exactly where they are. If we do that, we can say nothing about their speeds. We can also determine their speeds exactly, but then we know nothing about their positions. I take (relative) position to be fundamental. If that is the case, then the quantum mechanics of the universe is a theory that gives probabilities for static configurations of the universe. By what miracle can our undoubted experience of motion and the passage of time arise?

Until we have an understanding of consciousness, we cannot hope to have an explanation for that. We still have no idea why we see colours when physics tells us that all that exists in the external world is light of different wavelengths. We cannot expect what is in the external world to match what we experience, but we do want there to be a correspondence; what we call green is always associated with a shorter wavelength than red.

Now consider 100 black dots on a white sheet of paper. There is neither motion nor life in them. But with those 100 dots a skilled cartoonist can conjure up an evocative story, say of a girl making eyes at a young man. More directly relevant, a photograph of a speedboat creating waves on the smooth surface of a lake tells us that it represents the boat in motion. Shown the photo, a physicist, knowing the properties of water, could even determine the speed of the boat.

The point is this. Completely static configurations can still encode information about motion. In the case of the speedboat photo, we take the motion to be real, but perhaps consciousness does not need to be correlated with actual motion in the universe. It may be enough for it to be correlated with configurations that have the appearance of motion. I call such configurations time capsules. The complete set of possible configurations of the universe certainly includes time capsules, though they are a great rarity among the remainder.

The final step in my argument, for which there is some support from known results in ordinary quantum mechanics, is the conjecture that the quantum mechanics of the universe gives a high probability to configurations that are time capsules. If that is the case, and I give arguments for it in my book The End of Time, then the external world described by timeless quantum gravity will have a potential counterpart for the motion we experience in our inner life. Our bustling life, so full of sights and sounds, can still be there even if only as the mysterious elusive reflection in becoming of the utter stillness of being.