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Does time really exist?

TIME seems to be the most powerful force, an irresistible river carrying us from birth to death. To most people it is an inescapable part of life, a fundamental element of the Universe.

But I think that time is an illusion. Physicists struggling to unify quantum mechanics and Einstein's general theory of relativity have found hints that the Universe is timeless. I believe that this idea should be taken seriously. Paradoxically, we might be able to explain the mysterious "arrow of time"-the difference between past and future-by abandoning time. But to understand how, we need to change radically our ideas of how the Universe works.

Let's start with Newton's picture of absolute time. He argued that objects exist in an immense immobile space, stretching like a block of glass from infinity to infinity. His time is an invisible river that "flows equably without relation to anything external". Newton's absolute space and time form a framework that exists at a deeper level than the objects in it.

To see how it works, imagine a universe containing only three particles. To describe its history in Newton's terms, you specify a succession of sets of 10 numbers: one for time and three for the spatial coordinates of each of the three particles. But this picture is suspect. As the space-time framework is invisible, how can you determine all the numbers? As far back as 1872, the Austrian physicist Ernst Mach argued that the Universe should be described solely in terms of observable things, the separations between its objects.

With that in mind, we can use a very different framework for the three-particle Universe-a strange, abstract realm called Triangle Land. Think of the three particles as the corners of a triangle. This triangle is completely defined by the lengths of its three sides-just three numbers. You can take these three numbers and use them as coordinates, to mark a point in an abstract "configuration space" (see Diagram, p 30).

Each possible arrangement of three particles corresponds to a point in this space. There are geometrical restrictions-no triangle has one side longer than the other two put together-so it turns out that all the points lie in or on a pyramid. At the apex of Triangle Land, where all three coordinates are zero, is a point that I call Alpha. It represents the triangle that has sides all of zero length (in other words, all three particles are in the same place).

In the same way, the configurations of a four-particle universe form Tetrahedron Land. It has six dimensions, corresponding to the six separations between pairs of particles-hard to conceive, but it exists as a mathematical entity. And even for the stupendous number of particles that make up our own Universe, we can envisage a vast multidimensional structure representing its configurations. In collaboration with Bruno Bertotti of Pavia University in Italy, I have shown that conventional physics still works in this strange world. As Plato taught that reality exists as perfect forms, I think of the patterns of particles as Platonic forms, and call their totality Platonia.

Platonia is an image of eternity. It is all the arrangements of matter that can be. Looking at it as a whole, there seems to be no more river of time. But could time be hiding? Perhaps there is some sort of local time that makes sense to inhabitants of Platonia.

In classical physics, something like time can indeed creep back in. If you were to lay out all the instants of an evolving Newtonian universe, it would look like a path drawn in Platonia. As a godlike being, outside Platonia, you could run your finger along the path, touching points that correspond to each different arrangement of matter, and see a universe that continuously changes from one state to another. Any point on this path still has something that looks like a definite past and future.

Now's the place

But we know that classical physics is wrong. The world is described by quantum mechanics-and in the arena of Platonia, quantum mechanics kills time.

In the quantum wave theory created by Schrsdinger, a particle has no definite position, instead it has a fuzzy probability of being at each possible position. And for three particles, say, there is a certain probability of their forming a triangle in a particular orientation with its centre of mass at some absolute position. The deepest quantum mysteries arise because of holistic statements of this kind. The probabilities are for the whole, not the parts.

What probabilities could quantum mechanics specify for the complete Universe that has Platonia as its arena? There cannot be probabilities at different times because Platonia itself is timeless. There can only be once-and-for-all probabilities for each possible configuration.

In this picture, there are no definite paths. We are not beings progressing from one instant to another. Rather, there are many "Nows" in which a version of us exists-not in any past or future, but scattered in our region of Platonia.

This may sound like the "many worlds" interpretation of quantum mechanics, published in 1957 by Hugh Everett of Princeton University. But in that scheme time still exists: history is a path that branches whenever some quantum decision has to be made. In my picture there are no paths. Each point of Platonia has a probability, and that's the end of the story.

A similar position was reached by much more sophisticated arguments more than 30 years ago. Americans Bryce DeWitt and John Wheeler combined quantum mechanics and Einstein's theory of general relativity to produce an equation that describes the whole Universe. Put into the equation a configuration of the Universe, and out comes a probability for that configuration. There is no mention of time. Admittedly, the Wheeler-DeWitt equation is controversial and fraught with mathematical difficulties, but if quantum cosmology is anything like it-if it is about probabilities-the timeless picture is plausible.

So let's take seriously the idea of a "probability mist" that covers the timeless Platonic landscape. The density of the mist is just the relative probability of the corresponding configuration being realised, or experienced, as an instantaneous state of the Universe-as a Now. If some Nows in Platonia have much higher probabilities than others, they are the ones that are actually experienced. This is like ordinary statistical physics: a glass of water could boil spontaneously, but the probability is so low that we never see it happen.

All this seems a far cry from the reality of our lives. Where is the history we read about? Where are our memories? Where is the bustling, changing world of our experience? Those configurations of the Universe for which the probability mist has a high density, and so are likely to be experienced, must have within them an appearance of history-a set of mutually consistent records that suggests we have a past. I call these configurations "time capsules".

Present past

An arbitrary matter distribution, like dots distributed at random, will not have any meaning. It will not tell a story. Almost all imaginable matter distributions are of this kind; only the tiniest fraction seem to carry meaningful information.

One of the most remarkable facts about our Universe is that it does have a meaningful structure. All the matter we can observe in any way is found to contain records of a past.

The first scientists to realise this were geologists. Examining the structure of rocks and fossils, they constructed a long history of the Earth. Modern cosmology has extended this to a history of the Universe right back to the big bang.

What is more, we are somehow directly aware of the passing of time, and we see motion-a change of position over time. You may feel these are such powerful sensations that any attempt to deny them is ridiculous. But imagine yourself frozen in time. You are simply a static arrangement of matter, yet all your memories and experience are still there, represented by physical patterns within your brain-probably as the strengths of the synapse connections between neurons. Just as the structure of geological strata and fossils seem to be evidence of a past, our brains contain physical structures consistent with the appearance of recent and distant events. These structures could surely lead to the impression of time passing. Even the direct perception of motion could arise through the presence in the brain of information about several different positions of the objects we see in motion.

And that is the essence of my proposal. There is no history laid out along a path, there are only records contained within Nows. This timeless vision may seem perverse. But it turns out to have one great potential strength: it could explain the arrow of time.

We are so accustomed to history that we forget how peculiar it is. According to conventional cosmology, our Universe must have started out in an extraordinarily special state to give rise to the highly ordered Universe we find around us, with its arrow of time and records of a past. All matter and energy must have originated at a single point, and had an almost perfectly uniform distribution immediately after the big bang.

Hitherto, the only explanation that science has provided is the anthropic argument: we experience configurations of the Universe that seem to have a history because only these configurations have the characteristics to produce beings who can experience anything. I believe that timeless quantum cosmology provides a far more satisfying explanation.

In Platonia, there are no initial conditions. Only two factors determine where the probability mist is dense: the form of some equation (like the Wheeler-DeWitt equation) and the shape of Platonia. And by sheer logical necessity, Platonia is profoundly asymmetric. Like Triangle Land, it is a lopsided continent with a special point Alpha corresponding to the configuration in which every particle is at the same place.

From this singular point, the timeless landscape opens out, flower-like, to points that represent configurations of the Universe of arbitrary size and complexity. My conjecture is that the shape of Platonia cannot fail to influence the distribution of the quantum probability mist. It could funnel the mist onto time capsules, those meaningful arrangements that seem to contain records of a past that began at Alpha.

This is, of course, only speculation, but quantum mechanics supports it. In 1929, the British physicist Nevill Mott and Werner Heisenberg from Germany explained how alpha particles, emitted by radioactive nuclei, form straight tracks in cloud chambers. Mott pointed out that, quantum mechanically, the emitted alpha particle is a spherical wave which slowly leaks out of the nucleus. It is difficult to picture how it is that an outgoing spherical wave can produce a straight line," he argued. We think intuitively that it should ionise atoms at random throughout space.

Mott noted that we think this way because we imagine that quantum processes take place in ordinary three-dimensional space. In fact, the possible configurations of the alpha particle and the particles in the detecting chamber must be regarded as the points of a hugely multidimensional configuration space, a miniature Platonia, with the position of the radioactive nucleus playing the role of Alpha.

Ageless creation

When Mott viewed the chamber from this perspective, his equations predicted the existence of the tracks. The basic fact that quantum mechanics treats configurations as whole entities leads to track formation. And a track is just a point in configuration space-but one that creates the appearance of a past, just like our own memories.

There is one more reason to embrace the timeless view. Many theoretical physicists now recognise that the usual notions of time and space must break down near the big bang. They find themselves forced to seek a timeless description of the "beginning" of the Universe, even though they use time elsewhere. It seems more consistent and economical to use an entirely timeless description. But for these ideas to be more than speculation, they should have concrete, measurable results. Fortunately, Stephen Hawking and other theorists have shown that the Wheeler-DeWitt equation can lead to verifiable predictions. For example, established physical theories cannot predict a value for the cosmological constant, which measures the gravitational repulsion of empty space. But calculations based on the Wheeler-DeWitt equation suggest that it should have a very small value. It should soon be possible to measure the cosmological constant, either by taking the brightness of far-off supernovae and using that to track the expansion of the Universe, or by analysing the shape of humps and bumps in the cosmic microwave background. And a definitive equation of quantum cosmology should give us a precise prediction for the value of the constant. It is a distant prospect, but the nonexistence of time could be confirmed by experiment.

The notion of time as an invisible framework that contains and constrains the Universe is not unlike the crystal spheres invented centuries ago to carry the planets. After the spheres had been shattered by Tycho Brahe's observations, Kepler said: "We must philosophise about these things differently." Much of modern physics stems from this insight. We need a new notion of time.

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The author of this article, Julian Barbour is an independent theoretical physicist who lives near Oxford, UK.

Further reading: Julian Barbour's The End of Time is published by Weidenfeld & Nicolson, £20