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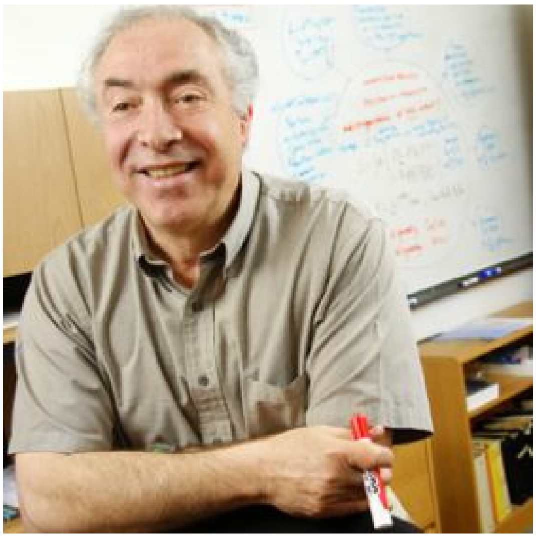
A Two-Time Universe? Physicist Explores How Second Dimension of Time Could Unify Physics Laws



USC College theoretical physicist Itzhak Bars has pioneered efforts to discern how a second dimension of time could help physicists better explain the laws of nature. Photo credit: Don Milici

For a long time, Itzhak Bars has been studying time. More than a decade ago, the USC College physicist began pondering the role time plays in the basic laws of physics — the equations describing matter, gravity and the other forces of nature.

Those laws are exquisitely accurate. Einstein mastered gravity with his theory of general relativity, and the equations of quantum theory capture every nuance of matter and other forces, from the attractive power of magnets to the subatomic glue that holds an atom’s nucleus together.

But the laws can’t be complete. Einstein’s theory of gravity and quantum theory don’t fit together. Some piece is missing in the picture puzzle of physical reality.

Bars thinks one of the missing pieces is a hidden dimension of time.

Bizarre is not a powerful enough word to describe this idea, but it is a powerful idea nevertheless. With two times, Bars believes, many of the mysteries of today’s laws of physics may disappear.

Of course, it’s not as simple as that. An extra dimension of time is not enough. You also need an additional dimension of space.

It sounds like a new episode of “The Twilight Zone,” but it’s a familiar idea to most physicists. In fact, extra dimensions of space have become a popular way of making gravity and quantum theory more compatible.

Extra space dimensions aren’t easy to imagine — in everyday life, nobody ever notices more than three. Any move you make can be described as the sum of movements in three directions — up-down, back and forth, or sideways. Similarly, any location can be described by three numbers (on Earth, latitude, longitude and altitude), corresponding to space’s three dimensions.

Other dimensions could exist, however, if they were curled up in little balls, too tiny to notice. If you moved through one of those dimensions, you’d get back to where you started so fast you’d never realize that you had moved.

“An extra dimension of space could really be there, it’s just so small that we don’t see it,” said Bars, a professor of physics and astronomy.

Something as tiny as a subatomic particle, though, might detect the presence of extra dimensions. In fact, Bars said, certain properties of matter’s basic particles, such as electric charge, may have something to do with how those particles interact with tiny invisible dimensions of space.

In this view, the Big Bang that started the baby universe growing 14 billion years ago blew up only three of space’s dimensions, leaving the rest tiny. Many theorists today believe that 6 or 7 such unseen dimensions await discovery.

Only a few, though, believe that more than one dimension of time exists. Bars pioneered efforts to discern how a second dimension of time could help physicists better explain nature.

“Itzhak Bars has a long history of finding new mathematical symmetries that might be useful in physics,” said Joe Polchinski, a physicist at the Kavli Institute for Theoretical Physics at UC Santa Barbara. “This two-time idea seems to have some interesting mathematical properties.”

If Bars is on the right track, some of the most basic processes in physics will need re-examination. Something as simple as how particles move, for example, could be viewed in a new way. In classical physics (before the days of quantum theory), a moving particle was completely described by its momentum (its mass times its velocity) and its position. But quantum physics says you can never know those two properties precisely at the same time.

Bars alters the laws describing motion even more, postulating that position and momentum are not distinguishable at a given instant of time. Technically, they can be related by a mathematical symmetry, meaning that swapping position for momentum leaves the underlying physics unchanged (just as a mirror switching left and right doesn’t change the appearance of a symmetrical face).

In ordinary physics, position and momentum differ because the equation for momentum involves velocity. Since velocity is distance divided by time, it requires the notion of a time dimension. If swapping the equations for position and momentum really doesn’t change anything, then position needs a time dimension too.

“If I make position and momentum indistinguishable from one another, then something is changing about the notion of time,” said Bars. “If I demand a symmetry like that, I must have an extra time dimension.”

Simply adding an extra dimension of time doesn’t solve everything, however. To produce equations that describe the world accurately, an additional dimension of space is needed as well, giving a total of four space dimensions. Then, the math with four space and two time dimensions reproduces the standard equations describing the basic particles and forces, a finding Bars described partially last year in the journal *Physical Review D* and has expanded upon in his more recent work.

Bars’ math suggests that the familiar world of four dimensions — three of space, one of time — is merely a shadow of a richer six-dimensional reality. In this view the ordinary world is like a two-dimensional wall displaying shadows of the objects in a three-dimensional room.

In a similar way, the observable universe of ordinary space and time may reflect the physics of a bigger space with an extra dimension of time. In ordinary life nobody notices the second time dimension, just as nobody sees the third dimension of an object’s two-dimensional shadow on a wall.

This viewpoint has implications for understanding many problems in physics. For one thing, current theory suggests the existence of a lightweight particle called the axion, needed to explain an anomaly in the equations of the standard model of particles and forces. If it exists, the axion could make up the mysterious “dark matter” that astronomers say affects the motions of galaxies. But two decades of searching has failed to find proof that axions exist. Two-time physics removes the original anomaly without the need for an axion, Bars has shown, possibly explaining why it has not been found.

On a grander level, two-time physics may assist in the quest to merge quantum theory with Einstein’s relativity in a single unified theory. The most popular approach to that problem today, superstring theory, also invokes extra dimensions of space, but only a single dimension of time. Many believe that a variant on string theory, known as M theory, will be the ultimate winner in the quantum-relativity unification game, and M theory requires 10 dimensions of space and one of time.

Efforts to formulate a clear and complete version of M theory have so far failed. “Nobody has yet told us what the fundamental form of M theory is,” Bars said. “We just have clues — we don’t know what it is.”

Adopting the more symmetric two-time approach may help. Describing the 11 dimensions of M theory in the language of two-time physics would require adding one time dimension plus one space dimension, giving nature 11 space and two time dimensions. “The two-time version of M theory would have a total of 13 dimensions,” Bars said.

For some people, that might be considered unlucky. But for Bars, it’s a reason for optimism.

“My hope,” he says, “is that this path that I am following will actually bring me to the right place.”

Source: USC College