# How do we know that time exists?

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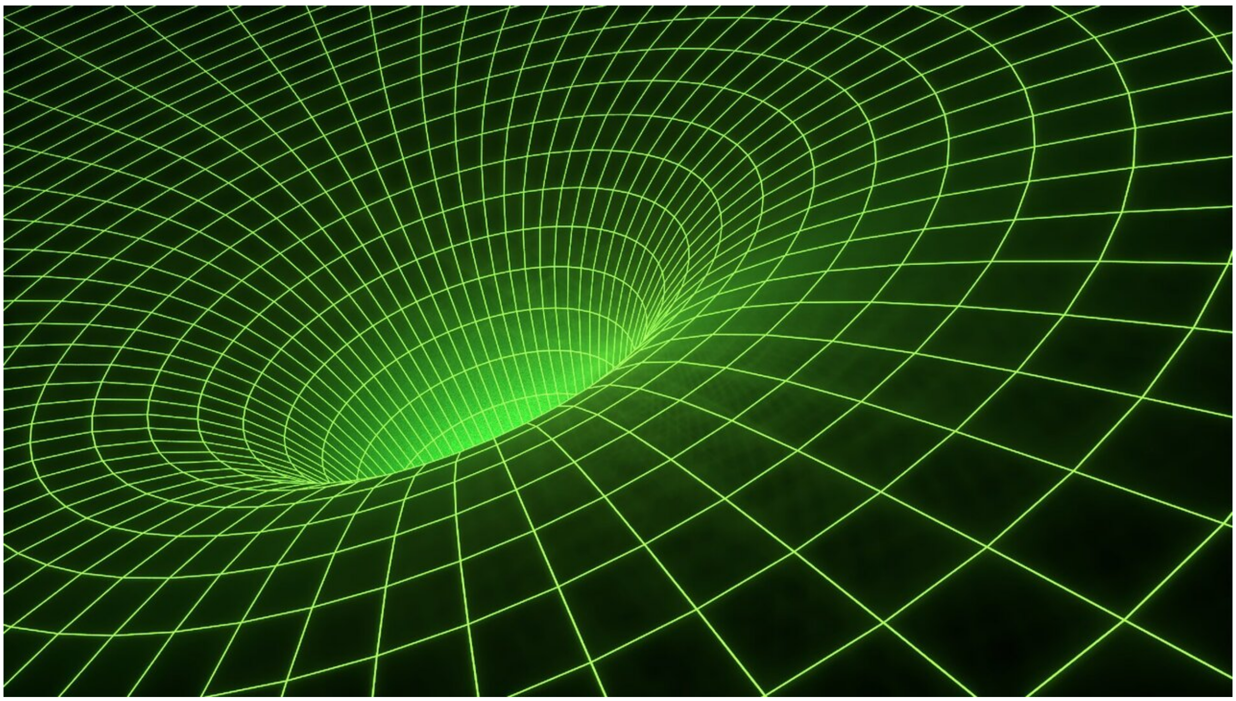

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The alarm goes off in the morning. You catch your morning train to the office. You take a lunch break. You catch your evening train back. You go for an hour's run. Eat dinner. Go to bed. Repeat. Birthdays are celebrated, deaths commemorated. New countries are born, empires rise and fall. The whole of human existence is bound to the passing of time.

But we can't see it and we can't touch it. So, how do we know that it's really there?

"In physics, we have what we call the idea of 'absolute time' and it's used to describe different changes as a sequence of events," Koyama begins. "We use Newtonian physics to describe how things move, and time is an essential element of this."

To this day, classic Newtonian thought on time—where time is constant throughout the universe—is still a good approximation of how humans experience time in their daily lives. We all experience time in the same way and we all synchronize our clocks in the same way, no matter where we are in the world, whether that be London, Tokyo or Buenos Aires.

## There's no time without space

Physicists though have realized that time can actually behave differently and is not as consistent as Newton thought. "When we speak of time, we need to think of space as well—they come in a package together," he says. "We cannot disconnect the two, and the way that an object moves through space determines how it experiences time."

In short, the time you experience depends on your velocity through space as the observer, as outlined through Einstein's special relativity, a theory on how speed impacts mass, time and space.

Additionally, according to Einstein's general theory of relativity, the gravity of a large object can impact how quickly time passes. Many experiments have been undertaken that have since proven this. Physicists have even discovered that black holes warp the immediate space-time around them due to their immense gravitational fields. Koyama continues to interrogate this theory.

"A good, solid example to get your head around all of this is to look at how we use GPS," Koyama continues. "GPS works due to a network of satellites orbiting the Earth. They're placed at a very high altitude and thus the gravity they experience is weaker. Therefore, time should actually go faster for them than it does for us on the ground, where we experience higher gravity. But because the satellites are traveling at very high speeds around the planet, this in effect helps to slow time down, compensating for the lack of gravity."

Understanding how these two effects work and influence each other is essential for ensuring that the global GPS network functions correctly. And a consistent theory of time that explains how objects move is a crucial ingredient in this. So clocks aren't telling us fibs: time exists outside of our own perception.

## Could we ever go backwards in time?

Finally, the question of whether time travel could one day be possible had to be put before Koyama, a professor of cosmology at the University of Portsmouth, and thus best placed to tell us the truth.

"I'm sorry to disappoint you but for time travel to be possible, we would need to discover a completely new type of matter that has the power to change the curvature of time and space," Koyama says. "Such matter would require properties that simply do not exist in nature. We physicists strongly believe that going back to the past is simply impossible—but it's nice to fantasize about it."

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