

# Physicists investigate the structure of time, with implications for quantum mechanics and philosophy

February 1 2016, by Lisa Zyga

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Credit: Vera Kratochvil/public domain

(Phys.org)—Although in theory it may seem possible to divide time up into infinitely tiny intervals, the smallest physically meaningful interval of time is widely considered to be the Planck time, which is approximately  $10^{-43}$  seconds. This ultimate limit means that it is not possible for two events to be separated by a time smaller than this.

But now in a new paper, physicists have proposed that the shortest physically meaningful length of time may actually be several orders of magnitude longer than the Planck time. In addition, the physicists have demonstrated that the existence of such a minimum time alters the basic equations of quantum mechanics, and as quantum mechanics describes all physical systems at a very small scale, this would change the description of all quantum mechanical systems.

The researchers, Mir Faizal at the University of Waterloo and University of Lethbridge in Canada, Mohammed M. Khalil at Alexandria University in Egypt, and Saurya Das at the University of Lethbridge, have recently published a paper called "Time crystals from minimum time uncertainty" in *The European Physical Journal C*.

"It might be possible that, in the universe, the minimum time scale is actually much larger than the Planck time, and this can be directly tested experimentally," Faizal told *Phys.org*.

The Planck time is so short that no experiment has ever come close to examining it directly—the most precise tests can access a time interval down to about  $10^{-17}$  seconds.

Nevertheless, there is a great deal of theoretical support for the existence of the Planck time from various approaches to [quantum gravity](#), such as string theory, [loop quantum gravity](#), and perturbative quantum gravity. Almost all of these approaches suggest that it is not possible to measure a length shorter than the Planck length, and by extension not possible to measure a time shorter than the Planck time, since the Planck time is defined as the time it takes light to travel a single unit of the Planck length in a vacuum.

Motivated by several recent theoretical studies, the scientists further delved into the question of the structure of time—in particular, the long-

debated question of whether time is continuous or discrete.

"In our paper, we have proposed that time is discrete in nature, and we have also suggested ways to experimentally test this proposal," Faizal said.

One possible test involves measuring the rate of [spontaneous emission](#) of a hydrogen atom. The modified quantum mechanical equation predicts a slightly different rate of spontaneous emission than that predicted by the unmodified equation, within a range of uncertainty. The proposed effects may also be observable in the decay rates of particles and of unstable nuclei.

Based on their theoretical analysis of the spontaneous emission of hydrogen, the researchers estimate that the minimum time may be orders of magnitude larger than the Planck time, but no greater than a certain amount, which is fixed by previous experiments. Future experiments could lower this bound on the minimum time or determine its exact value.

The scientists also suggest that the proposed changes to the basic equations of [quantum mechanics](#) would modify the very definition of time. They explain that the structure of time can be thought of as a crystal structure, consisting of discrete, regularly repeating segments.

On a more philosophical level, the argument that time is discrete suggests that our perception of [time](#) as something that is continuously flowing is just an illusion.

"The physical universe is really like a movie/motion picture, in which a series of still images shown on a screen creates the illusion of moving images," Faizal said. "Thus, if this view is taken seriously, then our conscious precipitation of physical reality based on continuous motion

becomes an illusion produced by a discrete underlying mathematical structure."

"This proposal makes physical reality platonic in nature," he said, referring to Plato's argument that true reality exists independent of our senses. "However, unlike other theories of platonic idealism, our proposal can be experimentally tested and not just be argued for philosophically."

**More information:** Mir Faizal, et al. "Time crystals from minimum time uncertainty." *The European Physical Journal C*. DOI: [10.1140/epjc/s10052-016-3884-4](https://doi.org/10.1140/epjc/s10052-016-3884-4). Also at [arXiv:1501.03111](https://arxiv.org/abs/1501.03111) [physics.gen-ph]

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Citation: Physicists investigate the structure of time, with implications for quantum mechanics and philosophy (2016, February 1) retrieved 18 May 2024 from <https://phys.org/news/2016-02-physicists-implications-quantum-mechanics-philosophy.html>

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