

<https://www.mff.cuni.cz/cs/verejnost/aktuality/kvantove-tunelovani-v-komplexnim-case>

Quantum tunneling in complex time

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Physical Review Letters has published an article by authors from ÚČJF MFF UK and ÚFP AV ČR, which deals with the description of quantum tunneling in complex time. The theoretical work establishes the basis for advanced experimentation in the field of attosecond metrology.

WIKIPEDIA: Tunneling (also quantum tunneling) is a quantum phenomenon [kvantový jev](#) known from quantum mechanics, z [kvantové mechaniky](#), in which a particle [částice](#) violates the principles of classical physics [klasické fyziky](#) by passing through a potential barrier [prochází potenciálovou bariérou](#) that is higher than the energy [energie](#) of the particle.

If the energy of a particle is less than the height of the barrier, then according to classical mechanics, the particle should bounce back from such a barrier. Classical mechanics does not allow such a particle to pass through the barrier. However, quantum mechanics allows a particle to pass through a potential barrier with a certain probability [pravděpodobností](#) (hence the term tunneling).

Quantum tunneling - that is, the passage of a quantum particle through **areas of space**, → (I understand that on small size scales, spacetime is "quantized" because space and space manifest themselves as foam (which are clusters of alternating curvatures of dimensions), or crumpled space-time, Therefore, in such a "foam", a "locality" with "low curvature" may be in the way and the particle will pass through (because the potential barrier is less than the energy of the particle) or "locality-barrier" with "which is "demonstrated" by the probability that 99% of localities with a higher barrier and 1% with a lower barrier through which the particle passes will be found in the foam - that is quantum tunneling = that 1% of localities where the curvature is less than the "curvature" of particle energy) of space which, according to simple energy relations of classical physics, should remain inaccessible to it - it plays a key role both in many fundamental processes of the microworld and in many current quantum technologies. As an example, we can mention a tunneling microscope or various tunnel-based electronic structures. Tunneling is used in the radioactive decay of nuclear nuclei and may have played an important role in shaping the basic shape of our universe just after the Big Bang.

Tunneling is a direct consequence of the **quantum uncertainty that results from the wave nature of matter**, so any attempt to describe it in classical physics seems to be doomed to fatal failure. Nevertheless, it turns out - and the new article is a strong supporting argument - that a semiclassical description of tunneling is possible. However, it must be based on classical mechanics **generalized to the field of complex numbers**. (Do you make "your" Universe to the Universe in real life ... or are you here to look for physical reality in the Universe?) Specifically, the idea that **time for a tunneling particle does not run along the real axis, but is complex!** (Simply at any cost - even at the cost of devastating reality - you rape the quantity Time = the phenomenon Time without exploring it. Without devoting a little **reason to the**

possibility that the Time-Quantity-Phenomenon also has three dimensions such as Length has x, y, z, or space. Why should time run on only one axis? ...?...? http://www.hypothesis-of-universe.com/docs/c/c_012.jpg Why should the Universe expand into three dimensions? longitudinal and should not extend into three time dimensions, why not? http://www.hypothesis-of-universe.com/docs/c/c_005.jpg Why ??????????)

The idea of complex time is not new. (Sure. And why is the new idea of 3 + 3 dimensional space-time ?, an unexplored idea !!). It was introduced into physics in the form of so-called instanton solutions and various generalizations of the Feynman orbit integral, it was >> introduced <<, (... And why was it not >>introduced<< by God into the Universe? Why did the Universe not >>introduce<< a "complex time"? Or an "instanton" solution? space are you introducing something instead of searching for reality?) introduced as early as the early 1970s. However, the current article takes this idea a step further. It shows (yes, that article again shows an idea, not a reality) that the motion of a quantum particle in a classically forbidden region, ie within a potential energy barrier, can be imagined as if it took place in a potential with the opposite sign, ie in a permitted region, but with time running along the imaginary axis when real time stands still. (However, one can also imagine another idea, ie as I indicated above, in the microworld it is a "foam structure of space" - some foam that is less crooked "floats" in another foam more crooked and it in another more crooked foam, etc., etc. - čp is not homogeneous with the alternation of more or less curved localities), so in an environment with a higher curvature of space-time (you call it a "potential energy barrier"), the energy particle may run into 98% the energy particle may encounter a 98% higher energy barrier = higher curvature of dimensions and 2% of localities with lower energy barrier and you would call it "mathematically" as "potential with the opposite sign". ...). It can be imagined as if it took place in potential with the opposite sign, ie in the allowed area, but with time running along the imaginary axis, when real time stands still.

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(First you would have to know "what it is when time is running" ..; "time is not running" !!!, but mass objects **m o v e** over time, over the time dimension (after three dimensions of Time) and thus cut intervals The cut intervals "on the dimension" of time are then perceived by us - material objects as a flow of time, so time does not flow to us, but to him. From another perspective on the same "thing" we can say that time (as we perceive this-time flow) flows because **the initial state of 3 + 3D space-time expands**, no expands bad unpackings, because after the Bang "" our "Universe" emerged "from the previous state of flat 3 + 3D as "crumpled" - extremely curved space-time .., as a foamy state of dimensions 3 + 3D, http://www.hypothesis-of-universe.com/docs/c/c_221.jpg so as a "boiling vacuum". .., as "quantum foam" 3 + 3 dimensional. And this foam = plasma of extremely curved dimensions begins **to not expand** in the genesis of development, **but unfold, unpacking**. The "unpacking" of the curvatures of the dimensions of time means - from this point of view - as if time "ran" - for objects; **m .v = m₀. c**. Time does not run on a photon... **c = 1/1**. This was just a modest abbreviated interpretation of HDV "about the passage of time" in **timeon**, - that is, a word - a novelty to the word **spaceon**, ie on three time dimensions.) As soon as the particle emerges from the barrier (which is the imaginary axis of time for you, the **mathematical** time) into the following classically allowed area, (which is ordinary **physical** time for you), the time runs again in the usual direction along the real axis. As a particle **passes through a tunnel structure**

formed by several consecutive barriers (...during the passage on paper, mathematical passage, but never in reality) and potential energy valleys (such as in some more complex molecules or in a resonant tunnel diode), both real time is gradually read (crossing the valley) and imaginary time (tunneling through barriers). The "age" of such a particle will be measured by a complex number. (The age of a particle can be measured - which you don't - even by wrapping-wrapping-tangling the time dimension into a ball in a frothy microworld...)

The main benefit of the new article is the description on paper of the singularities of the complex tunneling time, which occur (but only on paper) at the energy of the particle close to the local maxima and minima of the tunnel potential. (On paper, not in real behavior) Eg. when passing above the local maximum potential energy in the allowed area, the particle slows down (that is, because it has a low velocity ??) and the real time of its passage through the areas increases. (? increases real time = interval on "your timeline"? or what?) For energy exactly equal to the energy of the maximum, the particle is at the top of what? stops (it has $v = 0$??) and the real transit time (by what? - on paper?) becomes infinite. The same will apply to imaginary time in relation to local tunnel potential minima (reversal potential maxima) in the forbidden area. Such singularities of real and imaginary components of time were theoretically analyzed in the article for several simple tunnel potentials, while their direct connection with the so-called density of continuous energy spectrum levels (a kind of weight of quantum states contained in a unit energy interval) was demonstrated. Interestingly, analogous singularities, also related to stationary points of classical dynamics, have been studied for many years in the densities of discrete energy levels of bound quantum systems (such as molecules, nuclei or trapped atoms), in which particle motion is limited to a finite region space. The complex extension described in the article allows the generalization of these singularities into systems with unrestricted motion and continuous energy, ie the processes of quantum tunneling and particle scattering.

Because the total complex tunneling time directly affects the amplitude and phase of the quantum wave (from which it is the "quantum wave" ?? ; what is quantized?) passed through the tunnel structure, the above-mentioned effects are in principle measurable using already available "tailor-made" tunnel nanostructures. (What is it? And "what" is it?) In addition, measuring unusual time relations in quantum tunneling is becoming a hot area of current research in connection with the advent of so-called attosecond metrology. It is therefore to be hoped that the theoretical predictions contained in the new article will be the subject of advanced experimentation in the near future.

The article was published by the journal [Physical Review Letters](#).. Its authors, dr. Pavel Stránský, Ph.D. Michal Kloc and prof. Pavel Cejnar works at the Institute of Particle and Nuclear Physics, MFF UK, another author dr. Milan Šindelka works at the Institute of Plasma Physics of the Academy of Sciences of the Czech Republic.

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My opinion and comment from 27.04.2022 The translation was performed using a google translator and will definitely not be believable in the Czech style

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