On the interpretation of time

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Summary: Time in physics is always viewed from the point of view of duration, but this interpretation causes many problems and paradoxes. I would like to explore a change of interpretation of time. By thinking time as a cut, many problems could be easily solved. Particularly, with such interpretation, quantum gravity theories based on 3+1 spacetime (e.g. Kuchar or Ellis' evolving block universe) may open unexpected and fruitful views.

Time in **classical physics** has always been neglected. A few examples:

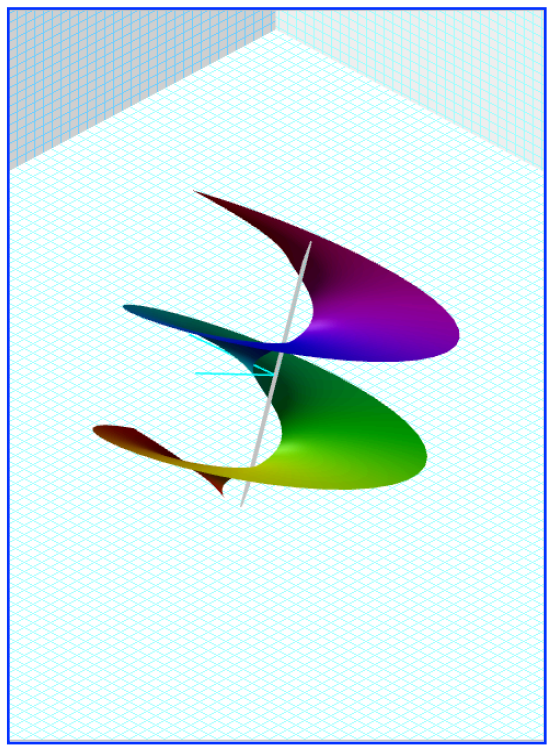
- **Measurements:** to define the state of a physical object, position and velocity are considered simultaneous, although it is clearly an abstraction;
- **Reversibility:** it is the simple substitution of the parameter t with $-t$, without taking into account dissipative effects; however, as a space translation is linked to the impulse, a time translation is linked to the energy. Therefore, time reversal implies the inversion of energy: if friction dissipates energy as time goes forward, then it should increase energy as time goes backward;
- **Entropy** still implies reversibility, although with an extremely low probability; however, if the energy inversion is taken into account, then time reversal is no more possible at all, as energy inversion would imply creation of energy from nothing.

Time problem clearly emerge already in quantum mechanics and relativity:

- **Quantum Measurements:** it is mandatory to divide between *before* and *after* the measurement;
- **Bohr's Complementarity:** time is mandatory to divide two complementary, but mutually exclusive, patterns (wave/particle);
- **Rhythm:** relativity has drawn the attention of the rhythm of time, which could be different depending on mass-energy and velocity; time is no more uniform.
- **Time is not the fourth dimension** like the three space dimensions: Gödel involuntarily proved it (1949, 1952). Cosmological expansion sets a preferential time, thus removing closed timelike curves.

Reinterpreting 3+1 Quantum Gravity (e.g. Kuchař 1971; Ellis 2013, 2014):

- **Three dimensional hypersurfaces divided by time (cut).** Lapse function does not set the duration of time between two hypersurfaces, but it is a cut (→ cut function);
- Thinking at a cut, then it has no meaning to ask about its thickness; there is still the interval (flux of cuts), but as any interval between two real numbers, it opens on the infinity; there is still an order, as for real numbers, but there is no minimum quantity;
- **The order of time is not relational, is not spatial, there is no here, there is no there, because what is happened and what will happen do not exist as the now.**
- What will happen does not exist yet: it has to be generated; there is nothing beyond now. Now is a hypersurface of transition, of infinite open possibilities as offered by the laws of physics. In the now, what is possible according to physical laws become in place. A clear example is the theory of β-decay by Enrico Fermi (1934): a proton, an electron, and an antineutrino do not exist inside the neutron before the decay, but are generated when the neutron disappears.



The exponential complex function offers a visualization of the cut of time.

For more details: L. Foschini, *Fisica del Tempo* (Bonomo, Bologna, 2018)
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