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The quantum theory of time: detail modelling of the effects of T violation

Monday 1 December 2025 10:45 (30 minutes)

The violation of the discrete symmetries of charge conjugation (C), parity inversion (P), and time reversal (T) observed in high energy physics are fundamental aspects of nature. A new quantum theory [1,2] has been introduced to explore the possibility of their large-scale physical consequences. The new theory does not assume any conservation laws or equations of motion at the outset. In particular, if T violation is turned off, matter is represented in terms of virtual particles that exist momentarily only. However, with T violation turned on, what was the mathematical structure of a virtual particle now traces out an unbounded world line that satisfies conservation laws and an equation of motion. Time evolution and conservation laws are found, therefore, to be phenomenological repercussions of T violation.

The relative scale for clock time is determined by the effective strength $\lambda = i\langle[\hat{H}_F, \hat{H}_B]\rangle$ of the T violation, where $\hat{H}_F$ and $\hat{H}_B = \hat{T}\hat{H}_F\hat{T}^{-1}$ are the Hamiltonians for forward and backward time evolution, respectively, and $\hat{T}$ is the time reversal operator. It implies that the time shown by an accurate clock depends on the value of λ in its local region, and so two identical clocks will lose synchronicity if they are in spatial regions with differing values of λ . Importantly, this effect is manifested as differences in the *quantum states of the clocks* rather than differences in coordinate times.

I will present the latest results of modelling T violation in kaons, neutrinos, and spontaneously broken symmetries in scalar fields. The focus is the potential for experimental tests of the loss of clock synchronicity using neutrinos emitted by nuclear reactors.

[1] J.A.Vaccaro, Quantum asymmetry between time and space, *Proc.R.Soc. A*, **472** (2016) 20150670.

<https://dx.doi.org/10.1098/rspa.2015.0670>

[2] J.A.Vaccaro, The quantum theory of time, the block universe, and human experience, *Phil.Trans.R.Soc.Lond. A*, **376**, 20170316 (2018). <https://dx.doi.org/10.1098/rsta.2017.0316>

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