Consistency Requirements
for Quantum Measurement in Minkowski Space-Time

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Abstract

In order to exclude causal paradoxes arising from the tension between the space-time structure of (special) relativity and the fundamentally nonlocal correlations in the joint outcome statistics of remote measurements inherent in quantum theory, one usually requires that the latter cannot be used to send signals faster than light (no signalling). This is mathematically implemented by postulating commutativity of operators associated with spacelike separated quantum measurements (local commutativity).

In this talk, I will propose as another requirement, that displays of measurement results (e.g. represented by pointer orientations) must be consistent under Lorentz transformations (relativistic consistency). I will show that requiring relativistic consistency for spacelike separated quantum measurements has no signalling as a consequence, but in general not vice versa, such that relativistic consistency can be considered to be more fundamental. Moreover, in contrast to no signalling, the notion of relativistic consistency does not rely on anthropocentric concepts like the decision of an experimenter to perform a given measurement or not. The relativistic consistency- and no signalling conditions will be finally used to analyse the physical meaning of local commutativity for general quantum measurements.

For the mathematical formulation and analysis, a general setting of the quantum theory of measurement is introduced, which goes beyond the common textbooks formulation (covering mostly only the special case of ideal measurements).