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Summary: Entanglement has long been the subject of discussion by philosophers of quantum theory, and has recently come to play an essential role for physicists in their development of quantum information theory. In this paper we show how the formalism of algebraic quantum field theory (AQFT) provides a rigorous framework within which to analyse entanglement in the context of a fully relativistic formulation of quantum theory. What emerges from the analysis are new practical and theoretical limitations on an experimenter’s ability to perform operations on a field in one spacetime region that can disentangle its state from the state of the field in other spacelike-separated regions. These limitations show just how deeply entrenched entanglement is in relativistic quantum field theory, and yield a fresh perspective on the ways in which the theory differs conceptually from both standard non-relativistic quantum theory and classical relativistic field theory.

MSC:
81P15 Quantum measurement theory, state operations, state preparations
81P68 Quantum computation
81T05 Axiomatic quantum field theory; operator algebras
46L60 Applications of selfadjoint operator algebras to physics

Keywords: entanglement; local operation; quantum field; von Neumann algebra

Full Text: DOI

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