# Local quanta, unitary inequivalence, and vacuum entanglement

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Relativistic Quantum Field Theory, although causal, exhibits several non-local features. The well-known violations of Bell's inequalities carry over to the relativistic context, however, other startling features like the impossibility of having localized particle states or the presence of space-like vacuum correlations, are not so familiar, even if they have been extensively characterised in the framework of Algebraic Quantum Field Theory. These concepts, which challenge the very notion of particles, have deep implications in the understanding and interpretation of quantum theory.

In this work, we explore these topics through the introduction of a natural characterization for local quanta in the 1+1 free Klein Gordon field. Such a scheme, inspired by a former construction by Colosi and Rovelli, is based on modes which are completely localized at some arbitrarily chosen time to within the left or the right part of a cavity. Although it manifestly shows the problems inherent to any localization system, it is nevertheless a clean set-up, which provides a useful mathematical toolbox to analyse local state features, while enabling us to better characterize the way in which these limitations emerge. By computing the Bogoliubov coefficients relating local and global quantizations, we show that this `local perspective' yields a Fock space representation which is unitarily {\em inequivalent} to the standard (global) one. Pertinently, local creators and annihilators remain well-defined on the global Fock space. Studying the vacuum state under this light, we verify the existence of correlations between spacelike-separated regions, and find that local regions show a distribution of excitations resembling that of a Gibbs state. We discuss why this insight may open new ways for the analysis of fundamental problems.