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Multipartite Bell-type inequalities for arbitrary numbers of settings and outcomes per site

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Abstract

We introduce a single general representation incorporating in a unique manner all Bell-type inequalities for a multipartite correlation scenario with an arbitrary number of settings and any spectral type of outcomes at each site. Specifying this general representation for correlation functions, we prove that the form of any correlation Bell-type inequality does not depend on spectral types of outcomes, in particular, on their numbers at different sites, and is determined only by extremal values of outcomes at each site. We also specify the general form of bounds in Bell-type inequalities on joint probabilities. Our approach to the derivation of Bell-type inequalities is universal, concise and can be applied to a multipartite correlation experiment with outcomes of any spectral type, discrete or continuous. We, in particular, prove that, for an N-partite quantum state, possibly, infinite dimensional, admitting the $\underbrace{2 \times \cdots \times 2}_{N}$-setting LHV description, the Mermin–Klyshko inequality holds for any two bounded quantum observables per site, not necessarily dichotomic.

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1. Introduction

A Bell-type inequality represents a tight[1] linear probabilistic constraint on correlation functions or joint probabilities that holds under any multipartite correlation experiment admitting a local hidden variable (LHV) description and may be violated otherwise. Proposed first [1–3] as tests on the probabilistic description of quantum measurements, these inequalities are now

[1] In the present paper, the term *a tight* LHV constraint means that, in the LHV frame, the bounds established by this constraint cannot be improved. On the difference between the terms *a tight linear LHV constraint* and *an extreme linear LHV constraint*, see the end of section 2.1.