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On the existence of a local quasi hidden variable (LqHV) model for each *N*-qudit state and the maximal quantum violation of Bell inequalities

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We specify the local quasi hidden variable (LqHV) model reproducing the probabilistic description of *all* N-partite joint von Neumann measurements on an N-qudit state. Via this local probability model, we derive a new upper bound on the maximal violation by an N-qudit state of Bell inequalities of any type (either on correlation functions or on joint probabilities) for S observables per site. This new upper bound not only improves for all N, S and d the corresponding results available for general Bell inequalities in the literature but also, for the N-qubit case with two observables per site, reduces exactly to the attainable upper bound known for quantum violations of correlation $2 \times \cdots \times 2$ setting Bell inequalities in a dichotomic case.

Keywords: Local quasi hidden variable (LqHV) modelling; Bell inequalities; the maximal quantum violation.

1. Introduction

In 1935, Einstein, Podolsky and Rosen (EPR) argued[1] that *locality* of measurements performed by two parties on perfectly correlated quantum events implies the "simultaneous reality — and thus definite values"[a] of physical quantities described by non-commuting quantum observables. This EPR argument, contradicting the quantum formalism and known as the EPR paradox, seemed to imply a possibility of a *hidden variable* account of quantum measurements.

Analyzing this possibility in 1964–1966, Bell explicitly constructed[2] the hidden variable (HV) model reproducing the statistical properties of all qubit observables. Considering, however, spin measurements of two parties on the two-qubit singlet state, Bell proved[3] that any local hidden variable (LHV) description of these bipartite joint spin measurements on perfectly correlated quantum events disagrees

[a] See Ref. 1, on p. 778.