IOP Publishing Journal of Physics A: Mathematical and Theoretical

J. Phys. A: Math. Theor. **44** (2011) 035305 (16pp) doi:10.1088/1751-8113/44/3/035305

Local hidden variable modelling, classicality, quantum separability and the original Bell inequality

Elena R Loubenets

Applied Mathematics Department, Moscow State Institute of Electronics and Mathematics, Moscow 109028, Russia

E-mail: erl@erl.msk.ru

Received 23 March 2010, in final form 26 August 2010
Published 16 December 2010
Online at stacks.iop.org/JPhysA/44/035305

Abstract

We introduce a general condition sufficient for the validity of the original Bell inequality (1964) in a local hidden variable (LHV) frame. This condition can be checked experimentally and incorporates only as a particular case the assumption on perfect correlations or anticorrelations usually argued for this inequality in the literature. Specifying this general condition for a quantum bipartite case, we introduce the whole class of bipartite quantum states, separable and nonseparable, that (i) admit an LHV description under any bipartite measurements with two settings per site; (ii) do not necessarily exhibit perfect correlations and may even have a negative correlation function if the same quantum observable is measured at both sites, but (iii) satisfy the 'perfect correlation' version of the original Bell inequality for any three bounded quantum observables A_1, $A_2 = B_1$, B_2 at sites 'A' and 'B', respectively. Analysing the validity of this general LHV condition under classical and quantum correlation scenarios with the same physical context, we stress that, unlike the Clauser–Horne–Shimony–Holt inequality, the original Bell inequality distinguishes between classicality and quantum separability.

PACS numbers: 03.65.Ta, 03.65.Ud, 03.67.−a

1. Introduction

Analysing in 1964 a possibility of a local hidden variable (LHV) description of bipartite[1] quantum measurements on two-qubits, Bell introduced [1] the LHV constraint on correlations, usually now referred to as *the original Bell inequality*. Both of Bell's proofs [1, 2] of this LHV inequality are essentially built up on two additional assumptions—a dichotomic character of Alice's and Bob's measurements plus the perfect correlation or anticorrelation of Alice's and Bob's outcomes for a definite pair of their local settings. Specifically, the latter assumption is usually abbreviated as the assumption on perfect correlations or anticorrelations.

[1] In quantum information, two parties (observers) are usually named as Alice and Bob.

