Two-spinors, oscillator algebras, and qubits: Aspects of manifestly covariant approach to relativistic quantum information

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(Submitted on 30 Jan 2010 (v1), last revised 8 Feb 2010 (this version, v3))

The first part of the paper reviews applications of 2-spinor methods to relativistic qubits (analogies between tetrads in Minkowski space and 2-qubit states, qubits defined by means of null directions and their role for elimination of the Peres-Scudo-Terno phenomenon, advantages and disadvantages of relativistic polarization operators defined by the Pauli-Lubanski vector, manifestly covariant approach to unitary representations of inhomogeneous SL(2,C)). The second part deals with electromagnetic fields quantized by means of harmonic oscillator Lie algebra (not necessarily taken in irreducible representations). As opposed to non-relativistic singlets one has to distinguish between maximally symmetric and EPR states. The distinction is one of the sources of `strange' relativistic properties of EPR correlations. As an example, EPR averages are explicitly computed for linear polarizations in states that are antisymmetric in both helicities and momenta. The result takes the familiar form $\pm p\cos 2(\alpha-\beta)$ independently of the choice of representation of harmonic oscillator algebra. Parameter p is determined by spectral properties of detectors and the choice of EPR state, but is unrelated to detector efficiencies. Brief analysis of entanglement with vacuum and vacuum violation of Bell's inequality is given. The effects are related to inequivalent notions of vacuum states. Technical appendices discuss details of the representation I employ in field quantization. In particular, M-shaped delta-sequences are used to define Dirac deltas regular at zero.

Comments: 53 pages, version accepted in Quantum Inf. Processing (special issue on foundations), in v3 a missing 2 in (295), (297), (306) is corrected
Subjects: **Quantum Physics (quant-ph)**
Cite as: **arXiv:1002.0066v3 [quant-ph]**

Submission history

From: Marek Czachor [view email]
[v1] Sat, 30 Jan 2010 13:09:59 GMT (194kb)
[v2] Wed, 3 Feb 2010 18:06:36 GMT (183kb)
[v3] Mon, 8 Feb 2010 10:16:28 GMT (181kb)

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