THEORETICAL PHYSICS

Foundations of quantum mechanics and quantum computation

Highlights

An exponential improvement in presently known quantum metrology strategies has been obtained.

Violation of classicality, in the form of lack of positivity in the Wigner function, has been shown to be detectable by measurements along only three planes, rather than the infinite number of planes usually required by quantum tomography.

TEXT

Exponentially enhanced quantum metrology

A quantum mechanical state of N qubits may be transformed by means of an unitary operator depending on a parameter to be estimated and then measured. It is shown that, by choosing a suitable entanglement generating unitary operator, a precision of order 2^{-N} in estimating the parameter can be achieved. This improves the corresponding classically obtainable precision by a factor of $2^{-N/2}$. It also improves exponentially hitherto known parallel quantum metrology strategies. [S. M. Roy with S. L. Braunstein (York, UK)]

Joint probabilities reproducing three EPR experiments on two qubits

In the EPR setting, quantum correlations between two qubits are measured by recording probabilities for dichotomic variables, such as spin components, along two different orientations for each qubit. Bell's inequalities forbid the existence of a positive joint quadruple probability for the four spin components which is positive and has marginals reproducing the quantum correlations for all four pairs of detector settings. In the present work it has been proved that it is always possible to construct a positive joint quadruple probability whose marginals reproduce the quantum correlations for any three pairs of detector settings, thereby achieving a simultaneous probability interpretation for three different complete commuting sets of operators, relating to three different experiments, which might be considered "Bohr-incompatible". [S.M. Roy and V. Singh with D. Atkinson

(Gröningen), G. Auberson (Montpellier) and G. Mahoux (CEN, Saclay)]

Quantum tomographic tests of classicality

The lack of positive definiteness of the Wigner distribution function is often considered a signature of violation of Classicality. In this work it has been shown that, for single mode laser light, measurements of quadratures along three planes suffice to reveal nonclassicality, rather than the infinite number of planes demanded for tomographic measurement of the Wigner function. [S.M. Roy with G. Auberson (Montpellier)]

Quantum Bell Inequalities as compatibility conditions for sub-system density operators

Necessary, but not sufficient, conditions for the compatibility of a set of reduced density operators, for a subset of qubits of an N-qubit system, were derived earlier by Butterley, Sudbery and Szulc for $N = 3$ in the form of quantum Bell inequalities. A new method has been developed to derive such necessary compatibility conditions for arbitrary N. [S.M. Roy]