TIFR Annual Report 2005-06
THEORETICAL PHYSICS

Foundations of Quantum Theory

Highlights

An algorithm for preservation of quantum states against decoherence which is much more efficient than the quantum Zeno effect was constructed using non-periodic inverting pulses.

Preserving Quantum States Using Inverting Pulses: A Super-Zeno Effect

Quantum state preservation against decoherence effects is one of the important ingredients of the ongoing research to use the remarkable parallel processing properties of quantum time evolution. A bang-bang control type algorithm to preserve quantum states was developed. It consists of unitary kicks in the form of inverting pulses interspersed with evolution according to the system-environment Hamiltonian. In this algorithm the number of pulses required to keep the quantum system in the same subspace upto time T with probability $\geq 1 - \epsilon$ increases only as $T \exp[\sqrt{\log(T^2/\epsilon)}]$, for large T and small ϵ, whereas it varies as T^2/ϵ for the quantum Zeno effect. [D. Dhar, L. K. Grover of Bell Laboratories, USA and S. M. Roy]

Exponentially Enhanced Quantum Metrology

A quantum mechanical state of N probes, say qubits, may be transformed by means of an unitary operator depending on a parameter to be estimated, and then measured. It was 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 $2^{-N/2}$. [Samuel L. Braunstein of York University and S. M. Roy]

Joint Probabilities for Two-Qubit EPR Systems Incorporating Quantum Correlations for Three Pairs of Detector Settings

In the EPR setting , quantum correlations between two qubits are measured by recording probabilities for dichotomic variables such as spin components along orientations a or a' for one qubit and b or b' for the other. It was shown by Fine that for certain quantum states, Bell 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 was proved that it is always possible to construct a positive joint quadruple probability for the four spin components whose marginals reproduce the quantum correlations for any three pairs of detector settings. The most general non-negative quadruple probabilities with these constraints was constructed and shown to contain 8 free parameters.

[S. M. Roy, D. Atkinson of Univ. of Groningen, G. Auberson of Univ. of Montpellier, G. Mahoux of CEN Saclay and V. Singh]