Quantum Nonlocality and Gaussian Smoothing of the Wigner Distribution Function

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Using the phase-space approach[1-3] based on the Gaussian-smoothed Wigner distribution function, we study the problem of simultaneous measurement of two conjugate variables such as two quadrature amplitudes of the radiation field. The mathematical process of Gaussian smoothing describes the physical process of measurement-induced decoherence with the widths of the smoothing function identified as measurement errors. Gaussian-smoothed distributions can thus be identified as distributions that are actually measured or tomographically reconstructed in experimental schemes designed to measure such variables[4]. In particular, The Q function or the Husimi distribution function represents the distribution observed in ideal simultaneous measurements with the maximal accuracy allowed by the Heisenberg uncertainty principle[5]. Comparison of the smoothed phase-space distributions we computed for simple dynamical systems with the corresponding classical distributions indicates that nonlocality persists even after decoherence caused by relatively large measurement errors[6]. We stress that the smoothing process is an invertible point-to-point integral transform, and thus no loss of information occurs. The Wigner distribution function can in principle be reconstructed from the Gaussian-smoothed distribution functions obtained experimentally.

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