Homodyne Detection of Optical Cat States generated by Squeezed Light Photon Subtraction*

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We have experimentally created and measured an optical Schrödinger Cat State. The method relies on single photon subtraction off a squeezed vacuum state and conditioning a homodyne measurement on the detection of that photon.

Figure 1 shows the Wigner distribution obtained by quantum state tomography performing 1000 iterations using the Lvovsky-Raymer iteration algorithm [1]. The Wigner distribution shows a clear dip at the origin with a value of +0.0038. This quantum state tomography gives a mean photon number n = 1.43. The quantum state presented in figure 1 is not corrected for the known homodyne efficiency (η_h = 0.80) and electrical background contribution (e = 0.047) to the signal. The beam splitter reflectivity (R) used for the photon subtraction was 2.5 %.

The dots in figure 2a show the quadrature probability distributions of the measured state for different phases [0 (black), π/6 (blue), π /3 (red) and π /2 (green)]. The corresponding lines represent a fit to the data. The fits were obtained from a model introduced earlier [2]. This fit allows extraction of some important experimental parameters of the impure optical Cat State. The squeezing parameter (s) was found to be 0.345 (-4.6 dB), the excess noise parameter (h) is 1.022, the modal purity (χ) of the subtracted photon was 0.815; and the purity (η_s) of the squeezed state was 0.914.

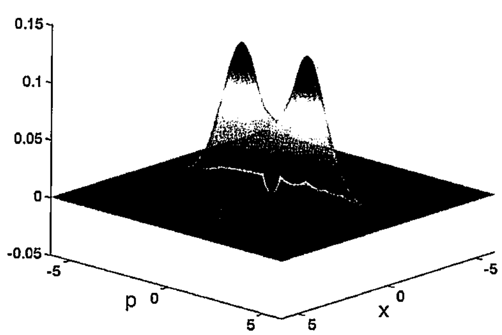
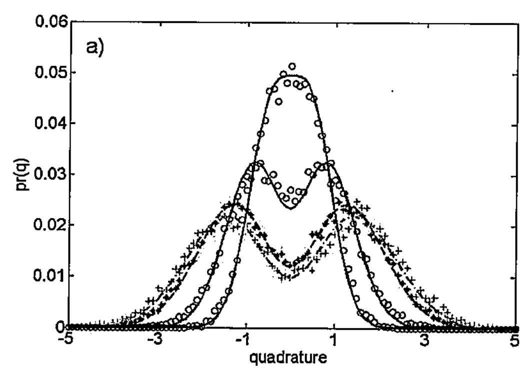


Figure 1: Wigner distribution of measured homodyne data

A pure Cat State will have h = 1, $\chi = 1$, $\eta_s = 1$, $R \to 0$, η_h = 1 and e = 0. As our homodyne efficiency and electrical background are well known, we can correct for these contributions and calculate the optical Cat State directly following the beam splitter used for photon subtraction.

Figure 2b shows the Wigner distribution calculated from the fitting parameters obtained from the data, and setting $e = 0$ and $\eta_h = 1$. The calculation shows a clear negative minimum at the origin with a value of -0.111 indicating the non-classicality of the measured state.



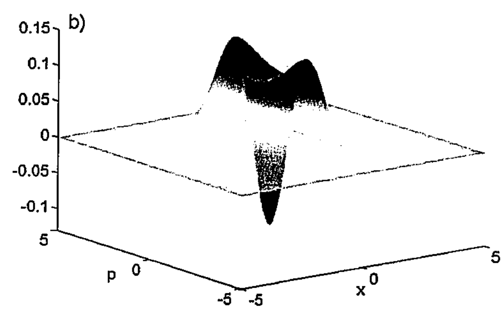


Figure 2: a) Quadrature probability distribution pr(q) of measured homodyne data (symbols) and fits to data (lines) b) Wigner distribution of homodyne data, corrected for homodyne loss and electrical background.

[1] A. I. Lvovsky J. Opt. B: Quantum Semiclass. Opt. **6**, S556 (2004)
[2] A. Ourjoumtsev, R. Tualle-Brouri, J. Laurat, P. Grangier, *Science* **312**, 83 (2006).