Homodyne measurement with a Schrödinger cat state as a local oscillator

Austin P. Lund[a,b], Joshua Combes[c]

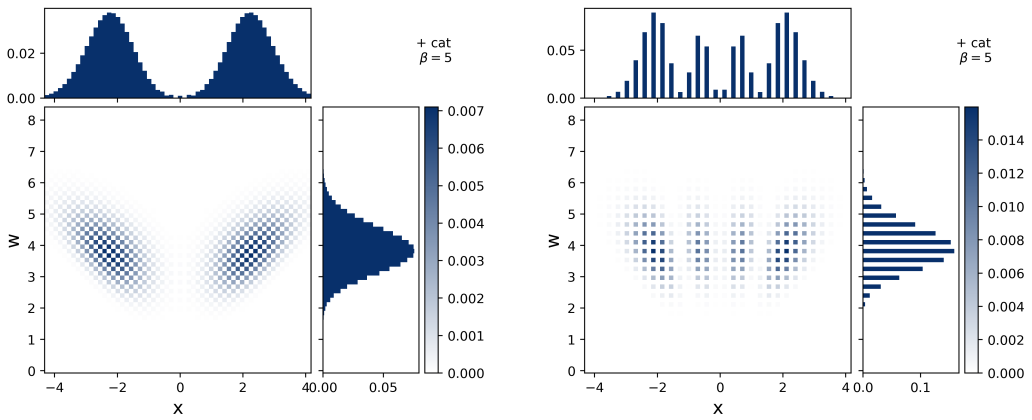
[a]*Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany*

[b]*Centre for Quantum Computation and Communications Technology, School of Mathematics and Physics, The University of Queensland, St Lucia QLD, Australia*

[c]*Department of Electrical, Computer, and Energy Engineering, University of Colorado Boulder, Colorado 80309, USA*

Homodyne measurements are a widely used quantum optical measurement. Using a large amplitude coherent state as the local oscillator (LO), it can be shown that the quantum homodyne measurement limits to a quadrature measurement. Injecting quantum states into the LO can led to non-classical measurements. Specifically we consider injecting a superposition of coherent states, a Schrödinger cat state, as a LO. We construct the Kraus operators and the positive operator-valued measure (POVM) and show the POVM is a reflection symmetric quadrature measurement when the coherent state amplitudes are large [1]. Our computation is an alternative approach to that of Tyc and Sanders [2, 3] with our approach being better suited to Fock basis computation and conditional output states.

The figure below shows the outcome probabilities for this measurement for a cat-state LO consisting of coherent states of amplitude ± 5 in a '+' superposition. The left plot shows the distribution measuring a coherent state of amplitude 1.6. The right plot shows the probability distribution for a 3 photon Fock state. The 'x' variable corresponds to the subtraction signal of the photo-detectors and can be seen to exhibit the symmetry around the origin in both cases. The sum of the photo-detections is given by the 'w' variable.



[1] J. Combes and A. P. Lund, arXiv:2207.10210 [quant-ph].

[2] T. Tyc and B. C. Sanders, Coherence and Quantum Optics VIII, Springer US, pp 453–454 (2003).

[3] T. Tyc and B. C. Sanders, J. Phys. A 29, 7341–7357 (2004).