Abstract Submitted for the MAR16 Meeting of The American Physical Society

Bayesian mean estimation for finite two-photon experiments BRIAN WILLIAMS, PAVEL LOUGOVSKI, Oak Ridge National Lab — Estimations of quantum probabilities are commonly made utilizing frequency based methods to invert Born's rule where X is found k out of n times, $P(X) = |\langle \psi | X \rangle|^2 \approx k/n$. For an infinite measurement number the maximum likelihood estimation (MLE) represents the true probability. Unfortunately, the number of measurements in any experiment is finite. Given this, better estimates are provided by Bayesian mean estimation (BME). We present a novel method utilizing an experiment-specific probability distribution to make fully informed estimations of any quantum probability, efficiency parameter, or complete density matrix. Our method accounts for the finite measurement number, inter-basis parameter dependence, and estimate physicality. No knowledge of the pathway/detector efficiencies or the photon number generated by the source is required. Only knowledge of the raw singles and coincidence counts is needed. We present our estimation procedure for a single basis experiment, the extension to multiple bases, the application to state tomography to estimate strictly physical quantum states, simulation results comparing MLE and BME estimates, and experimental application of our method using our numerical tomography package TOMOHAK based on slice sampling.

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Date submitted: 06 Nov 2015

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