Abstract Submitted
for the MAR17 Meeting of
The American Physical Society

Quantum smoothing for classical mixtures[1] DIAN TAN, MAHDI NAGHILOO, Washington University, St. Louis, KLAUS MÖLMER, Aarhus University, KATER MURCH, Washington University, St. Louis — We employ a superconducting qubit embedded in a 3D cavity to study quantum smoothing using projective measurements. Whereas the density matrix $\rho(t)$, which depends on the evolution dynamics and measurements performed prior to time t makes predictions about the outcomes of measurements performed at time t, further probing of the qubit allows us to refine our prediction in hindsight. We introduce an auxiliary matrix $E(t)$, which is conditioned on the measurement record from t to a final time T. The pair of matrices ($\rho(t)$, $E(t)$) exhaust our ability to make a smoothed prediction for the measurement outcome at an earlier time t. If the combined dynamics and measurements on a system lead to $\rho(t)$ with only diagonal elements in a given basis $\{|n\rangle\}$, it may be treated as a classical mixture. If continued probing and dynamics of the system lead to $E(t)$ that is also diagonal in the basis $\{|n\rangle\}$, we examine whether the classical mixture description is still valid in determining the smoothed probabilities for the measurement outcome at time t. We show experimentally that the smoothed probabilities do not, in the same way as the diagonal elements of $\rho(t)$, permit a classical mixture interpretation of the state of the system at the time t.

[1]Supported by John Templeton Foundation and the Sloan Foundation

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Date submitted: 10 Nov 2016 Electronic form version 1.4