DAMOP05-2005-020083

Abstract for an Invited Paper
for the DAMOP05 Meeting of
the American Physical Society

The Preferred Ensemble Fact with Applications to Quantum Feedback Control

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It is well known that there are infinitely many different ensembles of pure states that are equivalent to any given mixed quantum state. The preferred ensemble *fallacy* [1] is that any particular ensemble should be used in the interpretation of an experiment involving a quantum system in a mixed state. Notwithstanding this, for open quantum systems obeying a master equation that has a mixed steady state, there is a preferred ensemble *fact*: only some ensembles are physically realizable. By this we mean that it is only some ensembles for which

1. an observer can know at all times which pure state member of the ensemble the system is in; and

2. the weight of that state in the ensemble is the proportion of time the system spends in that state.

The preferred ensemble fact has applications in quantum feedback control in LQG (linear quadratic gaussian) systems [3], which has recently been implemented experimentally in a number of systems such as spin-squeezing and nanomechanical devices. Specifically, the existence of preferred ensembles determines the quantum limit to how well certain control goals can be achieved. I will illustrate these ideas with an example from quantum optics.

[1] P. Kok and S.L. Braunstein, Phys. Rev. A **61**, 042304 (2000).
[2] H.M. Wiseman and J.A. Vaccaro, Phys. Rev. Lett. **87**, 240402 (2001).
[3] H. M. Wiseman, and A. C. Doherty, Phys. Rev. Lett. To appear (quant-ph/0408099)