Squeezed Cooling and Squeezed Lasing via Cavity-Assisted Raman Transitions

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Squeezed lasers [1] are sources of non-classical light that retain both the spectral purity of a conventional laser and the quadrature-squeezing characteristics of correlated photons. In this work, we present a theoretical implementation of such systems in the optical regime by leveraging cavity-assisted Raman transitions [2] in ensembles of Rubidium atoms. However, in the proposed setup, losses of the cavity will tend to degrade squeezing in the long-time limit [3]. Thus, we show how the same Raman scheme can be used to engineer cavity-atom interactions that lead to cooling into a squeezed cavity mode. This constitutes on itself a squeezed cooling mechanism without any fundamental limit on the achievable intracavity squeezing in the steady state. Furthermore, we see that thanks to the presence of this additional dissipative channel, reduced quadrature fluctuations are obtained in the lasing setup. Essentially, the system exhibits a driven-dissipative phase transition into a lasing regime in which quantum states evolve into phase-diffused superpositions of displaced squeezed vacuum states (Figure 1). Overall, our results establish this model as a compelling platform for generating squeezed states in cavity QED systems with potential applications in quantum metrology.

References

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Figures

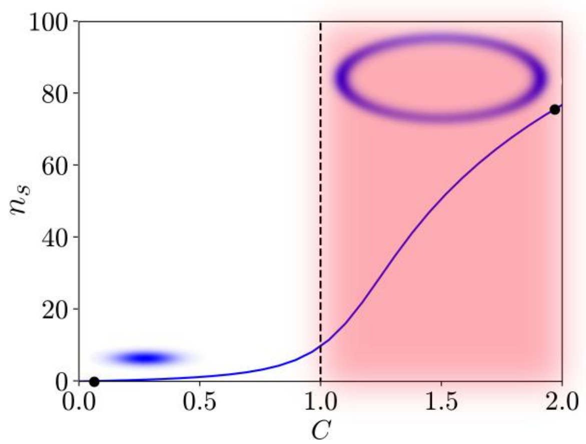

Figure 1: Driven-dissipative phase transition of a squeezed laser. The photonic population in the squeezed cavity mode is represented in terms of the cooperativity, which acts as control parameter. The red shadowed area marks the mean-field lasing region. The Wigner functions represent the steady state of the system for the points marked with black circles.