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Quantumness by linear mixing

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The classical or quantum nature of a two-mode state of a bosonic field may be recognized either by the presence of nonlocal correlations or in terms of the analytical features of its phase-space distributions. The former are quantified by quantum discord, an entropic measure which accounts for quantum correlations also in separable mixed states. On the other hand, the state of a bosonic field can be represented in the phase-space as a mixture of classical fields, weighted by a certain phase-space distribution. Whenever this distribution develops highly singular behaviors, there is no statistical ensemble of classical fields corresponding to the state being represented.
These two notions of nonclassicality, termed C-nonclassicality and P-nonclassicality respectively, are almost mutually exclusive, i.e. only a zero measure set of states is classical according to both criteria, and represent two different kinds of resource for quantum technology. In this work we analyze the generation of two-mode P- and C-nonclassical states by linear mixing of two single-mode Gaussian states, first considering a Gaussian state being mixed with the vacuum, and then recovering the realistic case of thermal photons entering the second port of the beam splitter.