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On coherence and non-classicality

Although quantum coherence is a basic trait of quantum mechanics, the presence of coherences in the quantum description of a certain phenomenon does not rule out the possibility to give an alternative description in purely classical terms. We provide definite criteria to determine when and to what extent quantum coherence is equivalent to non-classicality. We prove that a Markovian multi-time statistics obtained from repeated measurements of a non-degenerate observable cannot be traced back to a classical statistics if and only if the dynamics is able to generate coherences and to subsequently turn them into populations. Furthermore, we show with simple examples that such connection between quantum coherence and non-classicality is generally absent if the statistics is non-Markovian.