Mesoscopic EPR Steerable States

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Einstein, Podolsky and Rosen (EPR) presented their famous “EPR paradox” in 1935, establishing inconsistency between the completeness of quantum mechanics and local realism [1]. States that show an EPR paradox are called EPR-steerable [2,3]. While there have been many realisations of this form of nonlocality, there has been only limited evidence of EPR-steering between massive objects. Here, we present experimental evidence for genuinely steerable states involving thousands of atoms in a Bose-Einstein condensate. Using theory based on superselection rules [4], we show that EPR steering exists between two atomic modes created in a BEC atom interferometer [5]. To do this, we construct a full, three-dimensional finite temperature quantum model of the experiment. We thus extract the dynamics of a two-mode correlation moment that we show is a signature of a two-mode EPR-steerable state. The value of the moment places a lower bound on the number of atoms genuinely comprising the steerable state. Further, by analysing the higher-order structure of the two-mode correlations, we discuss evidence for entangled superpositions of states with different masses.

References