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Fisher-Information and entanglement of non-Gaussian spin states

One major area of quantum technologies is metrology, where entangled input states are employed to enhance the performance of interferometers. For the particularly attractive system of Bose-Einstein condensed clouds, squeezed states have been produced, which improve measurement sensitivity by reducing the fluctuations of the observable. Metrological sensitivity beyond spin squeezing can be obtained with non-Gaussian states, which require scalable methods for creation and verification in mesoscopic ensembles. We report on the generation of non-Gaussian spin states via unstable fixed point dynamics and a general method to extract the Fisher information, which reveals quantum states that are not spin squeezed but nevertheless entangled. Fisher information is at the same time the key parameter that quantifies achievable phase sensitivity, which we confirm by the implementation of a Bayesian estimation protocol surpassing the standard quantum limit in accordance with the extracted Fisher information. We also present recent experimental results demonstrating that atomic squeezing generated via nonlinear dynamics can be scaled to large ensembles by employing suitable spatial traps. We show the applicability for quantum enhanced magnetometry by swapping the squeezed state to magnetically sensitive hyperfine levels featuring negligible nonlinearity and find a quantum-enhanced single-shot sensitivity of 310(47) pT for DC magnetic fields in a volume as small as 90 μm^3.