Metrological Gain of Non-Gaussian States Generated by One-Axis Twisting in the Presence of Decoherence

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Non-Gaussian spin states can produce larger quantum enhancements for interferometric precision measurements than Gaussian spin-squeezed states, but extracting their sensitivity requires the measurement of nonlinear spin observables.

We analytically determine higher-order moments of the spin observables of over-squeezed spin states generated by one-axis twisting $H = \hbar\chi S_z^2$ in the presence of relevant decoherence processes of atomic experiments and use these results to identify the maximally reachable quantum sensitivity enhancement as a function of the noise parameters and atom number.

We further develop optimized strategies that attain these enhancements and show that measurement-after-interaction techniques, known for amplifying output signals in quantum parameter estimation protocols, give an optimal scaling of the quantum enhancement with the atom number N at any time $N^{-1} < \chi t < N^{-1/2}$ and allow for the effective measurement of nonlinear spin observables.

References

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