Ultimate limits to squeezing of quantum fluctuations

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Abstract

Various limits to squeezing of quantum fluctuations below the vacuum level (still being a hot topic in such areas as detection of gravitational waves via high-precision optical interferometry, quantum non-demolition measurements, high-resolution spectroscopy, and low-noise optical communication systems) are analyzed and discussed.

Problems related to the optimum level of the above-mentioned quantum noise reduction for finite superpositions of orthonormal basis-states of quantum harmonic oscillator are thoroughly investigated. An explicit construction of states leading to maximum degree of squeezing is provided and both exact and approximate expressions for minimum variances of position and momentum operators are given. Using some analytical tools offered by computer algebra software new properties of such quantum states are discovered. Possible applications of the obtained results to quantum optics and quantum information are also elaborated.

As a by-product, new interesting properties of some classic orthogonal functions, especially an interesting behavior of zeros of properly rescaled Hermite polynomials, are obtained.

Keywords

Quantum fluctuations, squeezing, harmonic oscillators, Hermite polynomials