

Invitation to IQST Seminar

on Wednesday, November 23rd, 2022 at 1 pm
Universität Ulm
Albert-Einstein-Allee 11
N24/101

Prof. Sándor Varró

Wigner Research Centre for Physics, Hungarian Academy of Sciences, Budapest
ELI-ALPS Research Institute, Szeged, Hungary

The excitation statistics of squeezed number states and squeezed thermal states of a harmonic oscillator

Abstract:

The coherent and squeezed states of a quantum-mechanical harmonic oscillator have already been constructed by Schrödinger [1] and Kennard [2], respectively, immediately after the invention of wave mechanics. From the sixties of the last century these states have played an important role in quantum optics and quantum information, for instance in the theory and practice of lasers and parametric processes [3], [4]. The squeezed (coherent) states also naturally appear in the nonperturbative description of the minimal coupling interaction of radiation fields with charges (e.g. in the high-order harmonic generations process [5]), so they have a role in attosecond physics, too.

The photon number distribution of (generalized) squeezed coherent states is well known, it has become a textbook material. The probability amplitudes are determined by the matrix elements of the product SD , where S is the squeezing operator and D is a displacement operator. It has long been known that the matrix elements of SD , and D can be expressed by the classical Hermite and Laguerre polynomials, respectively. However, for the matrix elements of S alone, referring to the squeezed number states, no compact expression of a similar structure have been published in the enormous literature on squeezed states, which appeared in the last ninety-five years.

Recently we have shown [6] that the probability amplitudes of S for the squeezed number states can be expressed in a simple closed form, in terms of the classical Gegenbauer polynomials. After showing some examples for the photon number distribution, we shall also apply this result for describing transitions in parametric processes, taking place e.g. in black-body radiation. The explicit form of the density matrix of a squeezed thermal state will also be given. Besides, we plan to briefly discuss the connection with the oscillator representations of the 2+1 parameter Lorentz group.

References:

- [1] Schrödinger E, Der stetige Übergang von der Mikro- zur Makromechanik. Die Naturwissenschaften 14, 664-666 (1926).
- [2] Kennard E H, Zur Quantenmechanik einfacher Bewegungstypen. Z. Physik 44, 326-352 (1927).
- [3] Dodonov V V, Nonclassical states in quantum optics: a squeezed review of the first 75 years. J. Opt. B: Quantum Semiclass. Opt. 4, R1–R33 (2002).
- [4] Andersen U L, Gehring T, Marquardt C and Leuchs G 2016, 30 years of squeezed light generation. Phys. Scr. 91, 053001 (2016).
- [5] Varró S, Quantum optical aspects of high-harmonic generation. Photonics 2021, 8, 269 (2021). [<https://doi.org/10.3390/photonics8070269>].
- [6] Varró S, Coherent and incoherent superposition of transition matrix elements of the squeezing operator. New Journal of Physics 24, 053035 (2022). [<https://doi.org/10.1088/1367-2630/ac6b4d>]