Coherent and incoherent superposition of the transition matrix elements of the squeezing operator

S Varro[1]

[1] *Theoretical Solid State Physics, Wigner Research Centre for Physics, ELI-ALPS, ELI-HU Ltd, Budapest, Szeged, Hungary*
Contact Email: varro.sandor@wigner.mta.hu

We discuss the general matrix elements of the squeezing operator between (photon) number eigenstates of a harmonic oscillator. These matrix elements have first been determined by Popov and Perelomov [1] long ago in their classic analysis of the parametric excitation of a harmonic oscillator. Their formula expresses the matrix elements in terms of transcendental functions, namely, in terms of associated Legendre functions (see also [2]). In the present contribution, we will show that there exists an equivalent polynomial formula, which is suitable for determining the coherent and incoherent superposition of these matrix elements in closed forms. Our results can be applied in the description of multiphoton transitions in coherent and thermal fields, as well. We will also explicitely show that in the case of a charged particle [3, 4] interacting with a quantized thermal field, the semi-classical transition probabilities (using classical stochastic field amplitudes) can only be reproduced in the Rayleigh-Jeans limit, so, in the Wien limit, the semi-classical description fails.

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