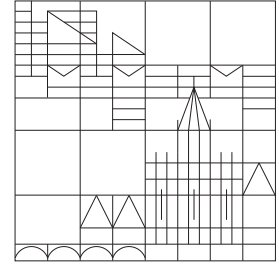


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<http://tinyurl.com/qo2018>



Quantum Optics

Winter semester 2017/2018 - Exercise sheet 08.12.2017

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Problem 1: Thermal states of light.

Starting from the expectation value of the photon number operator for thermal states, $\langle n(\omega) \rangle$, derive the expression for the energy density $\rho(\omega)$ in empty space.

Problem 2: Wigner function.

Considering a squeezed state with a real squeezing factor, calculate the corresponding Wigner function.

Problem 3: Higher-order squeezing.

Considering the Hermitian operators corresponding to the real and imaginary parts of the (single-mode) squared field amplitude, $X_1 = (\hat{a}^2 + \hat{a}^{\dagger 2})/2$ and $X_2 = (\hat{a}^2 - \hat{a}^{\dagger 2})/2i$, show that the squeezing condition is given by:

$$\langle \Delta X_i^2 \rangle < \langle \hat{a}^\dagger \hat{a} \rangle + \frac{1}{2}.$$