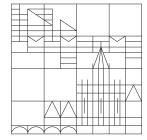
#### UNIVERSITY OF KONSTANZ

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http://tinyurl.com/qo2019



### **Quantum Optics**

Winter semester 2018/2019 - Exercise sheet 8

Distributed: 17.12.2018, Discussion: 07.01.2019

### Problem 1: Cat states of light.

a) Defining the quadratures of the electromagnetic field mode as

$$\hat{X}_1 = (\hat{a} + \hat{a}^{\dagger})/2$$
 and  $\hat{X}_2 = (\hat{a} - \hat{a}^{\dagger})/(2i)$ ,

show that their variances for the even coherent states are given by:

$$4\Delta X_1^2 = 2|\alpha|^2 \tanh|\alpha|^2 + 2|\alpha|^2 \cos(2\theta) + 1,$$

$$4\Delta X_2^2 = 2|\alpha|^2 \tanh|\alpha|^2 - 2|\alpha|^2 \cos(2\theta) + 1.$$

b) Show that the variances of the photon number operator for even and odd coherent states are given by:

$$\Delta n_+^2 = |\alpha|^4 + |\alpha|^2 \tanh|\alpha|^2 - |\alpha|^4 \tanh^2|\alpha|^2,$$

$$\Delta n_{-}^{2} = |\alpha|^{4} + |\alpha|^{2} \coth|\alpha|^{2} - |\alpha|^{4} \coth^{2}|\alpha|^{2}.$$

## Problem 2: Coherence of light.

Calculate the mean intensity at the screen in a Young's interference experiment when the state leaving the double-slit is given by  $(\hat{b}^{\dagger})^2|0\rangle/\sqrt{2}$ , where  $\hat{b}=(\hat{a}_1+\hat{a}_2)/\sqrt{2}$  and  $\hat{a}_i$  is the annihilation operator for the mode radiated by the slit i.

# Problem 3: Experimental estimation of $g^{(2)}$ .

The 546.1 nm line of a pressure-broadened mercury lamp has a line width of 0.001 nm. Sketch the second order correlation function  $g^{(2)}(\tau)$  for  $\tau$  in the range 0-1 ns.