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http://tinyurl.com/qo2019

Quantum Optics
Winter semester 2018/2019 - Exercise sheet 8
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Problem 1: Cat states of light.

a) Defining the quadratures of the electromagnetic field mode as

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

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 τ in the range 0 - 1 ns.