ECE770-T14/QIC 885: Quantum Electronics & Photonics

Problem Set 5, Winter 2014, Instructor: A. Hamed Majedi

Problem 1- Consider a single-mode quantized EM field in a one-dimensional cavity resonator of length L along the z axis. If the electric field operator is x-polarized

a) Compute the uncertainty of the electric field operator.

b) Find the commutation relation between the electric field operator and the number operator in terms of creation and annihilation operators.

c) Find the uncertainty product between number and electric field operators.

Problem 2- Consider a coherent state with a complex parameter $\alpha = |\alpha|e^{i\theta}$.

a) What would be the time evolution of a coherent state for such a field. Is it still a coherent state?

b) Find the expectation value of a single-mode plane wave electric field operator that is linearly x-polarized, e.g. $\langle\alpha|\hat{E}_x(\mathbf{r},t)|\alpha\rangle$.

c) Find the uncertainty in the $\hat{E}_x(\mathbf{r},t)$.

d) What is the fractional uncertainty in photon number in coherent state, e.g $\Delta N/\langle N\rangle$.

Problem 3- Consider a typical Hanbury Brown-Twiss (HBT) experiment with a 50/50 beam splitter. Consider the case when the quantized EM radiation is introduced through just one input port (this means the second input is the vacuum state).

a) Compute the second order correlation function $g^2(0)$ in terms of the expectation value of a function of input number operator.

b) If the input is photon number state $|n\rangle$ what is $g^2(0)$?

Due: Wednesday April 2, 2014. (before starting the class)