Problem 1

Many processes involve the absorption of single photons from quantum field state, the process of absorption being represented by the action of the annihilation operator $\hat{a}$. For an arbitrary field state $|\psi\rangle$, the absorption of a single photon yields the state $|\psi\rangle \approx \hat{a}\;|\psi\rangle$. Normalize this state. Compare the average photon numbers $\bar{n}$ of the state $|\psi\rangle$ and $\bar{n}'$ of $|\psi'\rangle$. Do you find that $\bar{n}' = \bar{n} - 1$?

Problem 2

Consider the superposition of the vacuum and 10 photon number state

$$|\psi\rangle = \frac{1}{\sqrt{2}}\Big(\;|0\rangle + |10\rangle\;\Big)$$

Calculate the average photon number for this state. Next, assume that a single photon is absorbed and recalculate the average photon number. Does your result seem sensible in comparison with your answer to the previous question ?

Problem 3

Show that the amplitude of the fluctuation ($\Delta p_n \Delta q_n$) of number (fock) state increases with increasing photons in the state.

Problem 4

Show that the uncertainity $\Delta p_x \Delta q_x$ of coherent state is independent of the number of photons and is equal to the vacuum state uncertainity.

Problem 5

Verify that the transmission of light through a beamsplitter of arbitrary loss does not change the second-order coherence.

Problem 6

Consider a single photon source that emits photons at a rate of $10^7 s^{-1}$ and has a $g^{(2)}(0) = 0.25$.

- Determine the probability of the source emitting one or more photons over a time interval of 1 ns.
- Determine the two photon probability for the same interval.