Faculty: B. Kanseri
Session: 2020-21

Major

PYL757- Statistical and Quantum Optics

Time: 02 Hours **Total Marks: 40** **Date: 17/05/2021**

Note: All questions are compulsory. All symbols have their usual meaning unless otherwise stated. Questions are self-explanatory and no queries would be entertained. All steps must be shown during derivations and calculations.

1. Answer any 2 questions. **(each 02 marks)**

1.1. Differentiate between coherent superposition and statistical mixture of quantum states.

1.2. What is central limit theorem? Explain.

1.3. Show that the annihilation operator $\hat{a}$ decreases the energy Eigen value of a photon number state by one quantum of energy.

2. Answer any 3 questions. **(each 03 marks)**

2.1. What is a displacement operator? Show that a coherent state is a displaced vacuum state.

2.2. Explain moments of a distribution. How to obtain higher order moments using generating function of a distribution?

2.3. What is meant by a wide-sense stationary, and ergodic process? Explain.

2.4. Explain Michelson Stellar interferometer and its applications.

3. Answer any 3 questions. **(each 04 marks)**

3.1. What are different kinds of non-classicality criteria for the optical states? Explain. Show that a single photon state is non-classical for any of the two such criteria.

3.2. Explain and derive orthogonality and completeness property of coherent states. What do you understand by over completeness?

3.3. Define the second order intensity correlation function $g^{(2)}$ and demonstrate that it acquires different values for coherent, thermal/chaotic and non-classical light.

3.4. Explain single photon interference using the quantum treatment of a Mach Zehnder interferometer. Explain one application of this kind of interesting effect.

4. Answer any 3 questions. **(each 05 marks)**

4.1. Quantize a single mode EM field and demonstrate that the resultant Hamiltonian resembles with the Hamiltonian of a simple harmonic oscillator. Detail the properties of annihilation, creation and number operators.

4.2. Using quantum theory of photo-detection, show the relationship between the variance of detected photons and variance of impinging photons on the photo-detector. Comment on the dependence of statistics of detected and impinging photons on the quantum efficiency of photo-detector.

4.3. Explain Bose Einstein distribution. Calculate the mean photon number and variance for this distribution. Show that the probability distribution can be written as $P(n) = \frac{\langle n \rangle^n}{\left(1 + \langle n \rangle\right)^{n+1}}$.

4.4. Two two-photon states (|2>) are entering into a beam-splitter from the two inputs as shown in the figure below. Calculate the output state? Is it entangled? Explain.