"Quantum optics"

WS 2016-2017 Worksheet 10

This worksheet is devoted to the study of the intensity in a Young double-slit experiment. The papers are about bunching and antibunching.

Exercise 24: Intensity in Young's double-slit experiment

Evaluate the intensity

$$I(\vec{r},t) = \mathrm{Tr}\left[\hat{\rho}\hat{E}^{-}(\vec{r},t)\hat{E}^{+}(\vec{r},t)\right]$$

in the double slit experiment for a single mode both in a

1) coherent and

2) thermal state.

Use spherical waves $\hat{E}^{+}(\vec{r},t) = f(s)\hat{a}e^{i(ks-\omega t)}$, where $s = |\vec{r}-\vec{r}_0|$ is the distance from the point $\vec{r}_0$ from which the spherical wave originates. Assume that the amplitude $f(s)$ varies slowly with the distance and that the distance between the slits and the screen is much larger than the separation of the slits.

3) Show these intensities are qualitatively indistinguishable.

Exercise 25: Paper-Work

Find the following articles online and answer the following questions for each of them:

- What is the paper about?
- Why is it interesting?
- What is done?
- How is it done?

Correlation between photons in two coherent beams of light
R. Hanbury Brown and R. Q. Twiss
Nature **177**, 27–29 (1956)

Photon antibunching in resonance fluorescence
H. J. Kimble, M. Dagenais and L. Mandel
Phys. Rev. Lett. **39**, 691–695 (1977)

Direct detection of a single photon by humans

J. N. Tinsley, M. I. Molodtsov, R. Prevedel, D. Wartmann, J. Espigule-Pons, M. Lauwers, and A. Vaziri

Nature Communications **7**, 12172 (2016).