The XXVII International Scientific Conference of Young Scientists and Specialists (AYSS-2023)

Contribution ID: **1369** Type: **Oral**

HOM effect for monochromatic and non-monochromatic photons

Wednesday 1 November 2023 17:25 (15 minutes)

The Hong-Ou-Mendel effect (HOM effect) was discovered and experimentally demonstrated by Hong et al. in 1987 [1] and theoretically described in [2]. In this paper, we will consider its implementation on a linear beam splitter consisting of a substrate and two waveguides on it, closely converging in the center, with two input and output ports, and with detectors at each output port. The essence of the effect under consideration is that two identical single-photon waves fall on the beam splitter in a ratio of 1:1 (with reflection coefficients R and transmittance T close to 1/2), one for each input port. When photons are identical, they cancel each other out. The HOM effect often takes place both in fundamental works on quantum mechanics and in practical implementations of quantum technologies [3]. A simple theoretical explanation of the HOM effect has been found based on the constant coefficients R and T and the statistical distribution of bosonic photons [4, 5]. In this interpretation, we are not interested in what happens to the incident photons in the beam splitter. To do this, we consider lossless with constant coefficients R and T (i.e., "ordinary" beam splitters), and the beam splitter is the source of two other photons, subject to bosonic statistics. Choosing the values of the coefficients R = T = 1/2 and substituting them into the expression for the wave function of photons at the output ports of the beam splitter from [4], it turns out that in this case the photons come out in pairs, i.e. the probability will be P = 1/2 for each of the detectors, which contradicts the classical idea of the separation of two beams of light with coefficients R = T = 1/2. In the classical representation, at R = T = 1/2, there can be 4 options: 1. the first and second photons hit detectors 1 and 2, respectively; 2. the first and second photons hit detectors 2 and 1, respectively; 3. the first and second photons hit detector 1; 4. The first and second photons hit detector 2.

As a result, there are 4 equally probable events, which obviously gives the probability P = 1/4 for each of them. This phenomenon is called the HOM effect and is a good way to test the quantum properties of not only photons but other particles as well. In other words, in the HOM effect, the probability of photons hitting the first detector, and for the second detector P1,2 = (R − T)2, with equal R and T will be equal to zero. If we consider non-monochromatic photons [6,7], but identical (frequency-dependent beam splitters), then choosing R = T = 1/2, we take into account frequency-dependent fluctuations of the beam splitter coefficients, which were not previously taken into account. Here we consider cases for different practical applications of the proposed theory in the case of different frequency-dependent functions. These issues will be discussed in detail in this work.

The work was supported by Russian Science Foundation grant № 20-72-10151.

[1] Hong, C. K., Ou, Z. Y. & Mandel, L. Measurement of subpicosecond time intervals between two photons by interference. Phys. Rev. Lett. 59, 2044–2046 (1987).
[2] F. Salvat, J. D. Martinez, R. Mayol, and J. Parellada Phys. Rev. A 36 (2), 467-474 (1987)
[3] C. K. Hong, , Z. Y. Ou, and , L. Mandel Phys. Rev. Lett. 59, 2044–2046 (1987).
[4] Z.-Y. Ou 2007 Multi-Photon Quantum Interference (New York: Springer).
[5] A. Politi, M. J. Cryan, J. G. Rarity, S. Yu, and J. L. O'Brien Sience 320, 646–649 (2008).
[6] D. N. Makarov Optics Letters 45, 6322–6325 (2020).
[7] D. N. Makarov Scientific Reports 10, 20124 (2020).

Primary author: TSYKAREVA, Yuliana (Northern Arctic Federal University named after M.V. Lomonosov)

Presenter: TSYKAREVA, Yuliana (Northern Arctic Federal University named after M.V. Lomonosov)

Session Classification: Condensed Matter Physics

Track Classification: Condensed Matter Physics