



Contribution ID: 74

Type: **not specified**

Quantum Description of the Motion of a Single Photon and Its Stability

Thursday 25 September 2025 16:00 (30 minutes)

ABSTRACT

Until now, the theory of quantum mechanics of the photon has not been sufficiently developed; moreover, the idea of the wave function of the photon is often considered a controversial concept, see, for example [1]. Note that for the photon, there is only the quantum theory of the electromagnetic radiation, which, except for the frequency or wavelength, does not provide any other information about the space-time structure and other properties of the photon [2]. The main reason for the difficulties is that photons are never non-relativistic and can be freely emitted and absorbed, therefore there is no law of conservation of the number of photons, which makes its description within the usual paradigm of quantum mechanics, if not impossible, then very difficult. Meanwhile, theoretical attempts to determine the wave functions of the photon have a rich history and date back to the time of the formation of quantum mechanics itself [3]. It is important to note that quantum mechanics, which aims to give a complete description of various natural phenomena, must be able to describe such a fundamental physical particle as a photon, which cannot be done without formulation the concept of a particle's wave function. Recall that for the photon, there is only the quantum theory of electromagnetic radiation, which, apart from the frequency or wavelength, does not provide any other information about the space-time structure and other properties of the photon, while the cross-sections of all processes involving photons are determined by its space-time structure [2]. The problem is becoming increasingly important due to the rapid growth in the number of experiments on the generation and detection of single photons, related to such important areas as quantum computing and quantum cryptography, quantum measurements, quantum communications and other ultra-sensitive quantum technologies, see for example. The study of the structure of the photon and its evolution during large spatial transitions can be important and informative also from the point of view of astrophysics problems.

To study and solve these problems, we considered the wave function of a single photon within the framework of the $SU(2) \times U(1)$ gauge symmetry group using the Yang–Mills equations for Abelian fields [4]. The wave equation of a photon as a complex probabilistic process is investigated and, in the limit of statistical equilibrium, the mathematical expectation of its wave state is obtained taking into account relaxation on space-time fluctuations. The role of hions in the formation of the space-time structure of a photon during its “long stay in vacuum” is studied in detail.

[1] Bialynicki-Birula, I., 1995, On the photon wavefunction Coherence and Quantum Optics VII eds 495 Eberly J.H., Mandel L. and Wolf E. (New York: Plenum) p313.

[2] Akhiezer, A.I., and Berestetskii, V.B. 1965, Quantum Electrodynamics, (Interscience, New York), Ch. 497 1.

[3] Dirac, P. A. M., 1958, The Principles of Quantum Theory 4th ed. (Clarendon Press, Oxford) p. 9.

[4] Gevorkyan, A.S., Quantum Vacuum: The Structure of Empty Space–Time and Quintessence with Gauge Symmetry Group $SU(2) \times U(1)$, Particles, 2019, Vol. 2(2), pp. 281–308; doi:10.3390/particles2020019

Author: Prof. GEVORKYAN, Ashot (Institute for Informatics and Automation Problems NAS of RA)

Presenter: Prof. GEVORKYAN, Ashot (Institute for Informatics and Automation Problems NAS of RA)