# Controlling Degree of Polarization of Light by Interferometric Path Information

Mayukh Lahiri,[1,2,*] Armin Hochrainer,[1,2] Gabriela Lemos,[1,2] Radek Lapkiewicz,[1,2] and Anton Zeilinger[1,2]

[1] *Institute for Quantum Optics and Quantum Information, Austrian Academy of Sciences, Boltzmanngasse 3, Vienna A-1090, Austria.*
[2] *Vienna Center for Quantum Science and Technology (VCQ), Faculty of Physics, Boltzmanngasse 5, University of Vienna, Vienna A-1090, Austria.*

Polarization properties of light have been studied for centuries and have had many applications in both classical and quantum optics. Our presentation concerns partial polarization of a light beam. A quantitative measure of partial polarization is usually given by the degree of polarization. We demonstrate that the degree of polarization of a light beam can be controlled by modulating the interferometric path information in an interference experiment. We also discuss that the effect is purely quantum mechanical and cannot be described by classical theory.

Wave-particle duality of photons is one of the central features of the quantum description of light. This allows us to provide a quantum mechanical interpretation of light interference. Let us consider a single-photon interference experiment in which a photon is sent into a two-path interferometer. If the information that leads to the identification of the path traversed by the photon is completely available, interference does not occur. We call this information the "interferometric path information". The relationship between the quality of interference, i.e., the visibility of interference fringes, and the interferometric path information has attracted the attention of many researchers (see, for example, [1–6]). Not long ago, it has been theoretically predicted that a relationship may exist between the interferometric path information and the degree of polarization of a photon beam generated by superposition [7].

We perform an interference experiment in which the degree of polarization of a photon beam generated by superposition is directly controlled by modulating the interferometric path information. We discuss the relevant theoretical analysis and also present experimental data to support our claim. We explain that the phenomenon is purely quantum mechanical in nature and cannot be explained by the classical theory of light.

This project was supported by ÖAW, the European Research Council (ERC Advanced grant no. 227844 "QIT4QAD", and SIQS grant no. 600645 EU-FP7-ICT), and the Austrian Science Fund (FWF) with SFB F40 (FOQUS) and W1210-2 (CoQus).

* Electronic address: mayukh.lahiri@univie.ac.at

[1] D. M. Greenberger and A. Yasin, Phys. Lett. A **128**, 391 (1988).
[2] L. Mandel, Opt. Lett. **16**, 1882 (1991).
[3] G. Jaeger, A. Shimony and L. Vaidman, Phys. Rev. A **51**, 54 (1995).
[4] B-G. Englert, Phys. Rev. Lett. **77**, 2154 (1996).
[5] M. Arndt, O. Nairz, J. Vos-Andreae, C. Keller, G. v.d. Zouw and A. Zeilinger, Nature **401**, 680 (1999).
[6] X. Y. Zou, L. J. Wang and L. Mandel, Phys. Rev. Lett. **67**, 318 (1991).
[7] M. Lahiri, Phys. Rev. A **83**, 045803 (2011).