Experimental Evidence of Vortex γ Photons in All-Optical Inverse Compton Scattering

M Wei[1], S Chen[1], Y Wang[2], P-L He[1,3], X Hu[1], M Zhu[1], H Xu[1], W Zhou[1], J Jia[1], X Ge[1,4], L Lu[1,3], B Li[1,3], F Liu[1,3], M Chen[1,3], L Chen[1,3], P Polynkin[5], J-X Li[2,6], W Yan[1,3], and J Zhang[1,3,4]

[1]*School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai, China*
[2]*School of Physics, Xi'an Jiaotong University, Xi'an, China*
[3]*IFSA Collaborative Innovation Center, Shanghai Jiao Tong University, Shanghai, China*
[4]*Tsung-Dao Lee Institute, Shanghai Jiao Tong University, Shanghai, China*
[5]*College of Optical Sciences, University of Arizona, Tucson AZ, USA*
[6]*Department of Nuclear Physic, China Institute of Atomic Energy, Beijing, China*
Contact Email: wenchaoyan@sjtu.edu.cn

Vortex γ photons carrying orbital angular momenta (OAM) hold great potential for various applications. However, their generation remains a great challenge. Here, we successfully generate sub-MeV vortex γ photons via all-optical inverse Compton scattering of relativistic electrons colliding with a sub-relativistic Laguerre-Gaussian laser. In principle, directly measuring the OAM of γ photons is challenging due to their incoherence and extremely short wavelength. Therein, we put forward a novel method to determine the OAM properties by revealing the quantum opening angle of vortex γ photons, since vortex particles exhibit not only a spiral phase but also transverse momentum according to the quantum electrodynamics theory. Thus, γ photons carrying OAM manifest a much larger angular distribution than those without OAM, which has been clearly observed in our experiments. This angular expansion is considered as an overall effect lying beyond classical theory.

Our method provides the first experimental evidence for detecting vortex γ photons and opens a new perspective for investigating OAM-induced quantum phenomena in broad fields.