
Contribution ID: **104** Type: **Oral presentation**

# Probing Nuclear Structure and Reactions with Vortex Photons

*Thursday, October 9, 2025 1:45 PM (30 minutes)*

Over the past decade the use of twisted photons to probe the properties of atomic and nuclear systems was considered both theoretically and experimentally [1-3]. Since the angular momentum is conserved in the transitions involving the electromagnetic radiation, it is convenient to consider the states of photons with well-defined total angular momentum. Therefore in the first part we discuss the structure of twisted photons in terms of the spherical ones and show how this distribution is controlled by the opening (pitch) angle. We determine the transition amplitude for the absorption of a twisted photon as well as the cross sections for the population of various final states having the same energy but different angular momenta, including the nuclear rotational bands and isomeric states. Our previous studies include calculation of reaction rates in astrophysical plasmas accounting for twisted gamma photons [4] and multipole selection rules in the absorption of superimposed Bessel beams [5]. By means of angular momentum algebra, we extend the calculations to vortex particles and factorize the scattering cross sections into reduced, spherically averaged nuclear quantities, multiplied by geometrical factors that depend on the initial beam parameters—total angular momentum, pitch angle, spin helicity—and on the distance from the nucleus to the beam singularity. The impact parameter is shown to play a major role together with the transition energy in the enhancement of multipolarities.

Emphasis is also placed on the initial spin-polarization of the vortex beams and its effects on the scattering process. Our results will include analytical expressions for both the vortex-beam absorption cross section and the angular distribution and polarization of the emitted particles, accounting for different nuclear multipolarities and their interference via partial-wave analysis. The present work is useful for proposing experiments aiming to probe more elusive nuclear states. An example is provided for the electromagnetic multipolarity ratios in the absorption cross section of superimposed Bessel beams by Th-229 isotope. Based on these formalisms we will also speculate about the possibility to detect experimentally such twisted photons and on the angular momentum transfer mechanism at various beam intensities.

[1] A. Afanasev, C.E Carlson, M. Solyanik, Phys. Rev. A 97 023422 (2018)
[2] B.A. Knyazev, V.G. Serbo, Physics-Uspekhi 61 449-479 (2018)
[3] Y.Taira, T. Hayakawa, M. Katoh, Scientific Reports, 7:5018 (2017)
[4] Y. Xu et al., Phys.Lett. B, 852, 138622 (2024)
[5] C. Iorga et al., Phy. Scr. 100, 065306 (2025)

**Primary author:** Prof. BARAN, Virgil (University of Bucharest)

**Presenter:** Prof. BARAN, Virgil (University of Bucharest)

**Session Classification:** Session III