Contribution ID: 486

Type: Poster

The model of nuclear multipole transitions excitation by Laguerre-Gaussian beam

Thursday 3 July 2025 19:00 (20 minutes)

We theoretical calculated the probability of nuclear multipole transitions excited by Laguerre-Gaussian (LG) modes, and made a comparative analysis of its behaviors from both plane waves and Bessel mode.

Over the past few years, the interaction between matter and twisted light has been extensively studied, with particular interest in the forbidden multipole transitions induced by twisted light. Theoretical methods for generating high energy twisted photons have been proposed in [1] and [2], making the excitation of nuclear multipole transitions by twisted light experimentally feasible.

For the 8 eV nuclear transition in ²²⁹Th induced by absorption of twisted photons, theoretical calculations have been performed, using the wave functions of the Bessel mode, with the results presented as transition probabilities dependent on the impact parameter [3].

A prediction was given in [3], that for this transition, when the impact parameter is small, the excitation by idealized Bessel modes and the LG modes should give similar results in twisted light. This prediction remains to be demonstrated. Furthermore, this question is worth research due to the prevalent application of the LG mode in experiments [4].

The probability of nuclear multipole transitions excited by twisted photons with Bessel-Gaussian mode and the corresponding the selection rules have been given in the work of [5]. We applied methods similar to those in the works of [5] and [6] to calculate the probability of nuclear multipole transitions excited by twisted photons of LG modes and compared the LG01 mode with the Bessel modes under conditions of small transverse momentum.

We have reached the following conclusions:

a) Obtained the general form of probability of nuclear multipole transitions excited by twisted light, that is described by LG_{nm} mode.

b) Confirmed that the nuclear multipole transition probabilities induced by the ${\rm LG}_{00}$ mode and those induced by plane waves are formally

similar.

c) Found that under condition of small impact parameter, the LG_{01} mode predicts the same behavior as the Bessel mode twisted light in nuclear excitation of multipole transitions.



Figure 1: Figure 1

Figure 1. Intensity profiles of Bessel mode for m=2 (dashed line) and the LG_{nm} mode (solid line), where n is radial indices, m is projection of total angular momentum.

References

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Session Classification: 9. Poster Session

Track Classification: Section 1. Experimental and theoretical studies of nuclei.