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Vortex photon induced nuclear reaction: mechanism, model, and application to the studies of giant resonance and astrophysical reaction rate

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The vortex photon beam induced nuclear reaction is studied. The interaction formalism of nuclei with vortex photons is developed and incorporated into the statistical reaction model to calculate reaction cross-sections. For 138 nuclei of high nuclear astrophysics and structure interest, the cross-sections of γ-ray emission and neutron production from the decay of the giant resonances (GR) populated by vortex photons are computed. It is shown that for these calculated crosssections, the GR contribution of an individual L is either enhanced or suppressed depending on the parameters of vortex γ-rays, and the contribution from the GR of a specific L can be identified and deduced. To this end, a novel method to exclusively determine the γ-strength function (γSF) for the GR of a specific L is proposed considering the measurements of the emitted γ and neutron, and the feasibility studies demonstrate that the γSF for the giant quadrupole resonance can be extracted. Furthermore, the astrophysical reaction rates of the vortex photon induced reactions in p-process are investigated. It is indicated that photo-nuclear reactions induced by vortex photons will bring new insights in nuclear physics and astrophysics research.

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