# Symmetry protection of N-photon angular momentum states when interacting with cylindrical systems

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In the interaction with a cylindrical sample, the z-component of the total angular momentum of light, $m$, is a conserved quantity, whereas other quantum numbers are not (as λ, the quantum number related to helicity). Importantly, this helicity-angular momentum framework has recently allowed the study of quantum light matter interactions in nanoholes, for N = 2 and considering states with $m = 0$ [1].

In this work we show a generalization of this construction for N-photon states employing single photons with both $m = 0$ and also $m \neq 0$. Moreover, we find that N-photon symmetry protected states, that is states that are protected in the interaction with any cylindrical scatterer, can be constructed in a very general way.

Finally, we show examples of symmetry protected 2 and 3-photon states that can be found using input modes with $m \neq 0$, even when the input photons are in different modes with different angular momenta.

## References

[1] A. Büse et al. Symmetry Protection of Photonic Entanglement in the Interaction with a Single Nanoaperture. Phys. Rev. Lett. 121, 173901 (2018).