A nonlocal topological switch: skyrmions and multi-skyrmion dynamics

B. Sephton[1], F. Nothlawala[2], P. Ornelas[2], M. Koni[2], B. Piccirillo[1], L. Feng[3], I. Nape[2], V. D'Ambrosio[1] and A. Forbes[2]

[1]*University of Naples 'Federico II', Department of Physics, Via Cintia, 80126, Napoli, Italy*

[2]*University of the Witwatersrand, Department of Physics, 1 Jan Smuts, 2017, Johannesburg, South Africa*

[3]*University of Pennsylvania, Department of Electrical and Systems Engineering, Philadelphia, 19104, USA*

Skyrmions are particle-like topologies associated with the wrapping of a spin or pseudospin field and characterized by an integer-valued topological charge (n, skyrmion number). These topological excitations are an emerging resource, promising stable quantum information encoding in optics [1]. Only recently have they been realised in quantum photonics, with single photons [2], across entangled photons [3] and both [4]. Their topologies, however, have remained a well-defined feature of their underlying states. We introduce spin-skyrmion entangled states [5], where the topology of one photon is remotely controlled by its entangled twin. Using dual-wavelength entangled photons we demonstrate this, transitioning between two different skyrmion numbers (Fig. 1). With a topological Bloch sphere, the full controllable landscape of skyrmion and multi-skyrmion topologies are visually captured (Fig 1 (b)) with no well-defined spin texture or skyrmion number existing prior to measurement of the entangled partner. This platform opens new avenues for harnessing quantum skyrmions and multiskyrmions in remote configurations and quantum-information protocols.

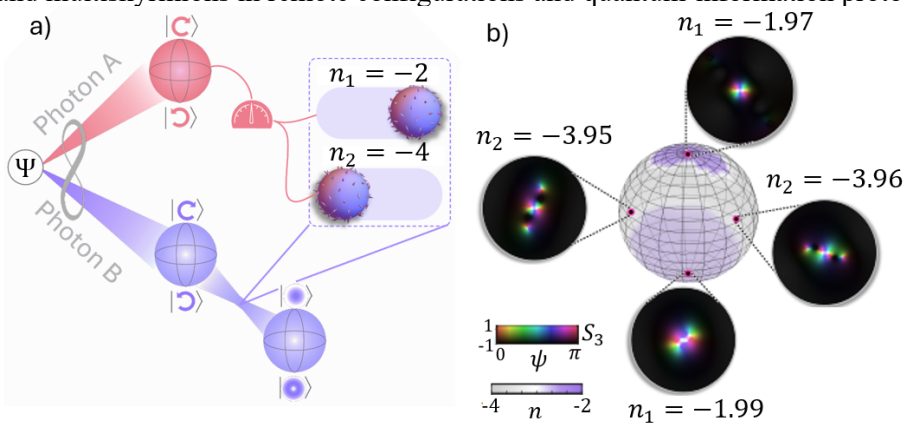

Fig. 1: *a) Concept: Photons A and B can be engineered to form a spin-skyrmion entangled state where a polarization measurement on A will collapse B onto a defined topology, switching between two skyrmion numbers (n_1 and n_2). b) Topological Bloch sphere visualisation of photon B's topologies, heralded experimentally from Photon A's polarisation state. A quantum multiskyrmion having quasiparticle-like distributions is revealed at the equator, having one skyrmion number (n_1), while a higher order skyrmion is realised at the poles with another number (n_2).*

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References

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