SKYRMIONIC HOPFIONS: REALISING PARTICLE-LIKE TOPOLOGIES IN STRUCTURED LIGHT

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ABSTRACT

Three-dimensional (3D) particle-like topological excitations, such as skyrmions and hopfions, originally proposed as topological models of fundamental particles and nuclei, have received much attention in high-energy and condensed matter systems. Rather than being based on special points and lines, the field values wrap around a 2-dimensional or 3D sphere "target space" within a plane or volume, realising a topological mapping of nontrivial degree, the Skyrme number. The full state of light, including polarisation and phase, determines a point on 3-sphere we call the optical hypersphere. Decomposing via the Hopf fibration, phase varies around Hopf loops, and the base space is the Poincaré sphere parametrising polarisation. We design, experimentally generate and measure an optical beam configuration which realises all polarisations and phases together in a propagation volume, realising a 3D optical skyrmionic hopfion [1]. For sufficiently high topological degree, the 3D polarisation structures are linked and knotted [2].

Joint work with Danica Sugic, Ramon Droop, Eileen Otte, Daniel Ehrmanntraut, Christopher Parmee, Franco Nori, Janne Ruostekoski and Cornelia Denz.

[1] Sugic D., Droop R., Otte E., Ehrmanntraut D., Nori F., Ruostekoski J., Denz C., & Dennis M.R. 2021 Particle-like topologies in light, *Nature Comm*. **12** 6785

[2] Parmee C.D., Dennis M.R., & Ruostekoski J. 2022 Optical excitations of Skyrmions, knotted solitons, and defects in atoms, *Communications Phys.* **5**, 54.