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Probe knots and Hopf insulators with ultracold atoms[1] DONG-LING DENG, SHENG-TAO WANG, KAI SUN, LU-MING DUAN, Department of Physics, University of Michigan, Ann Arbor, Michigan 48109, USA — Knots and links are fascinating and intricate topological objects that have played a prominent role in physical and life sciences. Their influence spans from DNA and molecular chemistry to vortices in superfluid helium, defects in liquid crystals and cosmic strings in the early universe. Here, we show that knotted structures also exist in a peculiar class of three dimensional topological insulators—the Hopf insulators. In particular, we demonstrate that the spin textures of Hopf insulators in momentum space are twisted in a nontrivial way, which implies various knot and link structures. We further illustrate that the knots and nontrivial spin textures can be probed via standard time-of-flight images in cold atoms as preimage contours of spin orientations in stereographic coordinates. The extracted Hopf invariants, knots, and links are validated to be robust to typical experimental imperfections. Our work establishes the existence of knotted structures in cold atoms and may have potential applications in spintronics and quantum information processings.

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