3D quaternionic condensation and spin textures with Hopf invariants from synthetic spin-orbit coupling

CONJUN WU, YI LI, Department of Physics, University of California, San Diego, XIANGFA ZHOU, Key Laboratory of Quantum Information, University of Science and Technology of China, CAS, Hefei, Anhui 230026, China — We study unconventional condensations of two-component bosons in a harmonic trap subject to the 3D $\vec{\sigma} \cdot \vec{p}$-type spin-orbit (SO) coupling. The topology of condensate wavefunctions manifests in the quaternionic representation. The spatial distributions of the $S^3$ quaternionic phase exhibit 3D skyrmion configurations, while those of the $S^2$ spin orientation possess non-zero Hopf invariants. As increasing SO coupling strength, spin textures evolve from concentric distributions to lattice structures at weak interactions. Strong interactions change condensates into spin-polarized plane-wave states, or, superpositions of two plane-waves exhibiting helical spin spirals.

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