

Hopfions in Anisotropic Heisenberg Magnets

Avadh Saxena¹, Radha Balakrishnan², and Rossen Dandoloff³

¹Los Alamos National Lab, ²The Institute of Mathematical Sciences, India, ³Sofia University,
Bulgaria

Abstract

We find exact static soliton solutions for the unit spin vector field of an inhomogeneous, anisotropic three-dimensional (3D) Heisenberg ferromagnet. Using Whitehead's integral expression, we calculate the corresponding Hopf invariant H analytically and obtain an integer, showing that these solitons are Hopfions. H is a product of two integers, the first being the usual winding number of a baby Skyrmion in two dimensions, while the second encodes the periodicity in the third dimension. We study the underlying geometry of H , by mapping the 3D unit vector field to tangent vectors of three appropriately defined space curves. Our analysis shows that a certain intrinsic twist is necessary to yield a nontrivial topological invariant. We illustrate our results using the invariant H of the exact Hopfions we have found (arXiv:2202.07195).