University of Crete
Department of Physics

Physics Colloquium

Thursday, 28 September 2023 | 17:00 – 18:00, Seminar Room 3rd Floor

Hopfions in Condensed Matter: Anisotropic Heisenberg Magnets

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ABSTRACT

Nontrivial topological defects such as knotted solitons called hopfions have been observed in a variety of materials including chiral magnets, nematic liquid crystals and even in ferroelectrics as well as studied in other physical contexts such as Bose-Einstein condensates. These topological entities can be modeled using the relevant physical variable, e.g., magnetization, polarization or the director field. Specifically, we find exact static soliton solutions for the unit spin vector field of an inhomogeneous, anisotropic three-dimensional (3D) Heisenberg ferromagnet and calculate the corresponding Hopf invariant H analytically and obtain an integer, demonstrating that these solitons are indeed hopfions [1]. H is a product of two integers, the first being the usual winding number of a skyrmion in two dimensions, while the second encodes the periodicity in the third dimension. We also 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 (linking number). Finally, we focus on the formation energy of hopfions to study their properties for potential applications.

*[1] R. Balakrishnan, R. Dandoloff, and A. Saxena, Phys. Lett. A **480** 128975 (2023); arXiv:2304.06240.*