Skyrmionic matter

Supervisors:

1) Dr Marco Mazza (Loughborough, Maths, M.G.Mazza@lboro.ac.uk)
2) Dr Ioannis Rousochatzakis (Loughborough, Physics, I.Rousochatzakis@lboro.ac.uk)

Background: The notion that "particles" can arise as stable localized solutions to classical continuum field theories has a long history and goes back to Skyrme [1-3]. A standard mechanism to realize such configurations is ubiquitous in condensed matter systems with a fixed "handedness", i.e., systems without inversion symmetry [4]. In the long-wavelength limit, the handedness manifests in the form of so-called Lifshitz invariants, linear gradient terms that favour a twisting of the underlying order parameter field(s) along more than one spatial direction, thus allowing for localized modulations. This universal mechanism underlies the condensed-matter examples of Abrikosov vortices in type-II superconductors, the formation of Z_2-vortex crystals in anisotropic hexagonal antiferromagnets [5], and the stabilization of skyrmion lattices in non-centrosymmetric helimagnets [6], which is the subject of this project, and, surprisingly, also in fluid systems like cholesteric liquid crystals.

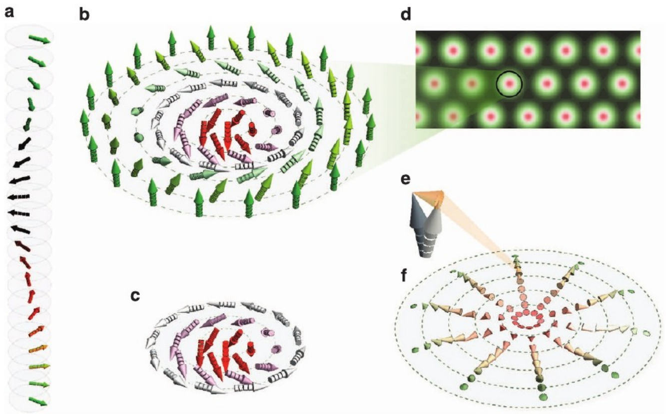

Illustration: Spin textures in chiral helimagnets [6]

Project: The aim of the project is to combine analytical field-theory methods, topology, and large-scale computational methods in order to explore the properties of skyrmionic matter in systems of current interest, such as Cu_2OSeO_3 (the first insulating chiral helimagnet that manifests skyrmions [6]) and chiral nematic liquid crystals and compare directly with ongoing experiments. More broadly, the project will bring together expertise from the field of liquid crystals and magnetism, and its ultimate goal is to explore deeper connections between the two fields and transfer relevant technology or insights from one to the other.

Student: This project is ideal for students with an interest in topological aspects of ordered matter, field theories and/or numerical algorithms. The student will be exposed to the physics of liquid crystals and magnetism, and will acquire expertise in analytical field theory methods, topology, and large-scale computational methods, such as Monte Carlo.

References:

1. T. H. R. Skyrme, Proc. R. Soc. London, Ser. A **260**, 127 (1961).
2. R. H. Hobart, Proc. Phys. Soc., London **82**, 201 (1963).
3. G. H. Derrick, J. Math. Phys. **5**, 1252 (1964).
4. A. Bogdanov, JETP Lett. **62**, 247 (1995).
5. I. Rousochatzakis, *et al.*, Phys. Rev. B **93**, 104417 (2016).
6. O. Janson, I. Rousochatzakis, *et al.*, Nature Communications **5**, 5376 (2014).