Master de Physique Fondamentale et Appliquée
Université de Tours
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PROPOSITION DE STAGE DE MASTER 1

Coulomb charge representation of vortices in non-centrosymmetric superconductors

Vortices are at the center of the thermal and electromagnetic response of superconductors. These objects are termed topological defects, consisting of an extended core that confines quantized magnetic flux. These topological defects are solutions of nonlinear partial differential equations that cannot be solved analytically. However, in two-dimensional systems, and under specific approximations, the vortex cores in type-II superconductors can be effectively mapped to point-like charges interacting via a screened Coulomb potential

Certain class of superconducting materials break parity ; they are termed non-centrosymmetric. Within the London approximation it is possible for this class of superconductors to perform a mapping a mapping onto point-like charges. There, the interaction between point vortices becomes non-monotonic (see Fig. 1) and thus can lead to vortex aggregation [1].

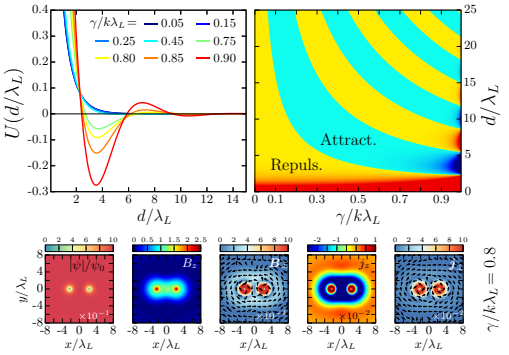

FIGURE 1 – Effective interacting potential $V_{\text{eff}}(r)$ between vortices in noncentrosymmetric superconductors.

Internship Focus

This internship is an introduction to low temperature quantum phenomena. It will explore the theoretical and computational modelling of vortices using their mapping to Coulomb charges in two-dimensional systems. Specifically, the project will involve :

- Understanding the physical origin of non-monotonic interactions in this model.
- Implementing a Molecular Dynamics (MD) simulation code to study particle systems with non-monotonic interaction potentials.
- Investigating the aggregation patterns and the emergent structure formations in the vortex system.

Candidate Expectations

- A solid understanding of theoretical physics and computational techniques, and a familiarity with programming and numerical methods.
- Regular attendance and participation to the Numerical Simulation classes.
- Interest for low temperature phenomena and motivation for research and computational modelling.

Contact

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[1] J. Garaud, M. N. Chernodub et D. E. Kharzeev, « Vortices with magnetic field inversion in noncentrosymmetric superconductors », Physical Review B **102**, 184516 (2020).