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

Berezinskii-Kosterliz-Thouless transition of 2d superfluids : Monte-Carlo simulation of the XY-model

The Berezinskii-Kosterlitz-Thouless (BKT) transition [1], is a special kind of phase transitions that can occur in low-dimensional systems featuring a continuous symmetry. A BTK transition notoriously occurs in two-dimensional superfluids, whose thermodynamic properties can be described by the XY-model of planar spins. This *topological* phase transition driven by vortex-antivortex pair unbinding, is a hallmark of 2D systems with continuous symmetries, such as superfluid helium or thin-film superconductors.

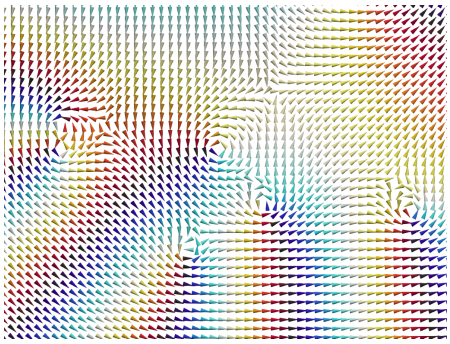

FIGURE 1 – Vortex configuration of the XY-model

This project aims to investigate the Berezinskii-Kosterlitz-Thouless (BKT) transition in two-dimensional superfluids using a Monte Carlo simulation of the XY model. The XY model, which describes a system of spins on a two-dimensional lattice with continuous rotational symmetry, provides a theoretical framework for understanding superfluidity and vortex-antivortex dynamics in low-dimensional systems (see Fig. 1). By using Monte Carlo methods to simulate the dynamics of the XY model, this study will focus on the behaviour of the system at various temperatures and examining key physical quantities such as spin correlations, helicity modulus, and vortex density.

Internship Focus

This internship is an introduction to low temperature quantum phenomena. It will explore the theoretical statistical and computational modelling of two-dimensional superfluid phase transition. Specifically, the project will involve :

- Understanding the physical origin of the XY-model and vortices.
- Implementing a Monte-Carlo-Metropolis (MC) simulation code to study 2d XY-model.
- Develop tools to measure thermodynamic quantities of this model.
- Develop tools to visualize spin configuration

Candidate Expectations

- A solid understanding of statistical 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, motivation for computational modelling.

Contact

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1. Nobel Prize in Physics 2016 : https://www.nobelprize.org/prizes/physics/2016/summary/