UNIVERSITY NAME (IN BLOCK CAPITALS)

Thesis Title

by

Author Name

A thesis submitted in partial fulfillment for the
degree of Doctor of Philosophy

in the
Faculty Name
Department or School Name

March 2018

Declaration of Authorship

I, AUTHOR NAME, declare that this thesis titled, 'THESIS TITLE' and the work presented in it are my own. I confirm that:

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UNIVERSITY NAME (IN BLOCK CAPITALS)

Abstract

Faculty Name
Department or School Name

Doctor of Philosophy

by Author Name

The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too...

Acknowledgements

The acknowledgements and the people to thank go here, don't forget to include your project advisor...

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Abbreviations

LAH **L**ist **A**bbreviations **H**ere

Physical Constants

Speed of Light $c = 2.997\ 924\ 58 \times 10^8\ \mathrm{ms}^{-\mathrm{S}}$ (exact)

Symbols

a	distance	m
P	power	W (Js^{-1})
ω	angular frequency	$rads^{-1}$

For/Dedicated to/To my…

Chapter 1

Method

1.1 Data Generation

The evolution of the condensate phase was simulated using code written in C++. This defined the codensate as a square lattice consisting of N^2 points, where N is the linear size of the lattice, and each point restricted to be between $[0, 2\pi]$. Initially, the angle of each point was random, the system therefore being in the disordered phase. The simulation updated each lattice point according to the compactified and discretised equation:

$$\begin{aligned}
\theta_{i,j}(t + \mathrm{d}t) = \theta_{i,j}(t) &- D_x(\cos(\theta_{i,j} - \theta_{i+1,j}) + \cos(\theta_{i,j} - \theta_{i-1,j}) - 2) \\
&- D_y(\cos(\theta_{i,j} - \theta_{i,j-1}) + \cos(\theta_{i,j} - \theta_{i,j+1}) - 2) \\
&- \frac{\lambda_x}{2}(\sin(\theta_{i,j} - \theta_{i+1,j}) + \sin(\theta_{i,j} - \theta_{i-1,j})) \\
&- \frac{\lambda_y}{2}(\sin(\theta_{i,j} - \theta_{i,j-1}) + \sin(\theta_{i,j} - \theta_{i,j+1})) \\
&+ 2\pi c_L \times \sqrt{\mathrm{d}t} \times \xi
\end{aligned}$$

where $\theta_{i,j}(t)$ is the value of the condensate at points i, j of the lattice and $\mathrm{d}t$ is the timestep used. Periodic boundary conditions were used. The final term is the stochastic term where ξ is a uniformaly distributed random number (restricted to $[-0.5, 0.5]$) that was also added at each timestep.

This timestep was initilially chosen to be $\mathrm{d}t = 0.05$ but (something about plot from this data being bad) so this was swiftly altered. First the timestep was altered to $\mathrm{d}t = 0.01$ and this was the value used to generate the significant data. However, other values were experimented with: namely, $\mathrm{d}t = 0.02$ and $\mathrm{d}t = 0.001$ with system size 32. Fig XX comes the Binder cumulant for this system size for the three values of $\mathrm{d}t$. The evolution for d$t = 0.02$ did not follow that of d$t = 0.01$, implying that d$t = 0.02$ was too large of a timestep, whereas the behaviour of d$t = 0.01$ matched that of d$t = 0.001$, demonstrating that d$t = 0.01$ was an appropriate timestep for the simulation, and a smaller one was computationally unnecessary.

Next, values noise (c_L) values were chosen to determine the value at which the phase transition occurs. Figure XX shows the number of vortices at $t = 400$ for a system size of 64 at various values of c_L. A value of $c_L = 0.2$ was then chosen for the remainder of project, although other values below the transition were also tested. Naively, after determining that $c_L = 0.2$ resulted in the Binder cumulant evolving from zero to near one in the linear evolution, $c_L = 0.1$ was also tested with the expectation that the convergence would occur faster

Appendix A

An Appendix

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