MOUNT ALLISON UNIVERSITY

Improving the Contrast of Neutron Interferometry Phase Measurements Using Online Bayesian Markov Chain Monte Carlo Methods (Super Tentative Crappy Title)

by

Thomas Alexander

A thesis submitted in partial fulfillment for the
degree of Bachelor of Science with Honours

in the
Faculty of Science
Department of Physics

January 2014

Declaration of Authorship

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

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed: _____

Date: _____

"Such is the vastness of his genius that he can outwit even himself."

Steven Erikson

MOUNT ALLISON UNIVERSITY

Abstract

Faculty of Science
Department of Physics

Bachelors of Science with Honours

by Thomas Alexander

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...

Contents

List of Figures

List of Tables

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

Introduction

1.1 Neutron Interferometry

1.1.1 History

1.1.2 Application to Quantum Information

1.1.3 Application to Quantum Fundamentals

1.1.4 National Institute of Standards and Technology

1.2 Bayesian Markov Chain Monte Carlo Methods

Chapter 2

Theory

2.1 Neutron Interferometry

2.1.1 History

2.1.2 Application to Quantum Information

2.1.3 Application to Quantum Fundamentals

2.2 Bayesian Markov Chain Monte Carlo Methods

Chapter 3

Experimental Setup

3.1 The Neutron Interferometer

3.1.1 NIST

3.1.2 Reactor and Lab

3.1.3 Motors and Actuators

3.1.4 Sensors

3.2 NI-Engine

3.2.1 Design Requirements

3.2.2 Language and Library Choices

3.2.3 System Architecture

3.2.4 Documentation

3.3 Q-Infer

3.3.1 Interaction with NI-Engine

3.3.2 GPU Implementations of Likelihood functions

Chapter 4

Discussion

4.1 Application to Quantum Information

4.2 Application to Quantum Fundamentals

4.3 Application to Materials Science

4.4 Outside of Neutron Interferometry

Chapter 5

Conclusion

5.1 Contrast Improvement with MCMC Methods

5.2 The Experimental Setup

5.3 Application of Findings

Bibliography

[1] A. S. Arnold, J. S. Wilson, and M. G. Boshier. A simple extended-cavity diode laser. *Review of Scientific Instruments*, 69(3):1236–1239, March 1998. URL http://link.aip.org/link/?RSI/69/1236/1.

[2] Carl E. Wieman and Leo Hollberg. Using diode lasers for atomic physics. *Review of Scientific Instruments*, 62(1):1–20, January 1991. URL http://link.aip.org/link/?RSI/62/1/1.

[3] C. J. Hawthorn, K. P. Weber, and R. E. Scholten. Littrow configuration tunable external cavity diode laser with fixed direction output beam. *Review of Scientific Instruments*, 72(12):4477–4479, December 2001. URL http://link.aip.org/link/?RSI/72/4477/1.