

Measuring of Entanglement Entropy in Valence Bond Quantum Monte Carlo Simulations

by

Ann Berlinsky Kallin

A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Master of Science
in
Physics

Waterloo, Ontario, Canada, 2010

© Ann Berlinsky Kallin 2010

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

In this thesis we present...

We explain VB QMC techniques:

- single projector
- double projector
- loop algorithm

Look at VB EE compared to vN

Look at Renyi EE

Area Laws

Acknowledgements

I would like to thank all the people who made this possible.

Contents

List of Tables	vii
List of Figures	viii
1 Introduction	1
1.1 Entanglement Entropy	1
1.1.1 The von Neumann Entanglement Entropy	1
1.1.2 The Area Law	1
1.2 something else to go in the introduction?	1
1.2.1 the VB QMC stuff?	1
2 Quantum Monte Carlo in the Valence Bond Basis	2
2.1 Single Projector	2
2.2 Double Projector	2
2.3 Loop Moves	2
3 Valence Bond Entanglement Entropy	3
3.1 One Dimension	3
3.2 Approaching Two Dimensions	3
3.3 The Area Law	3

4	Measuring Rényi Entanglement Entropy	4
4.1	The Swap Operator	4
4.2	1D Results	4
4.3	The Ratio Operator	4
4.4	2D Results	4
4.5	The Area Law	4
5	Conclusions	5
	APPENDICES	6
	References	7

List of Tables

List of Figures

Chapter 1

Introduction

1.1 Entanglement Entropy

1.1.1 The von Neumann Entanglement Entropy

1.1.2 The Area Law

1.2 something else to go in the introduction?

1.2.1 the VB QMC stuff?

Chapter 2

Quantum Monte Carlo in the Valence Bond Basis

2.1 Single Projector

2.2 Double Projector

2.3 Loop Moves

Chapter 3

Valence Bond Entanglement Entropy

3.1 One Dimension

3.2 Approaching Two Dimensions

3.3 The Area Law

Chapter 4

Measuring Rényi Entanglement Entropy

4.1 The Swap Operator

4.2 1D Results

4.3 The Ratio Operator

4.4 2D Results

4.5 The Area Law

Chapter 5

Conclusions

APPENDICES

Bibliography

- [1] Anders W. Sandvik. Ground state projection of quantum spin systems in the valence-bond basis. *Phys. Rev. Lett.*, 95(20):207203, Nov 2005.