

Low dimensional transport and its applications

**Thesis submitted for the degree of
Doctor of Philosophy (Science)**

in

Physics

by

Debarshee Bagchi

University of Calcutta

May 2014

Contents

Preface	i
Acknowledgement	iv
List of Publications	vi
1 Introduction	1
1.1 A brief review	5
1.2 Thermal transport in a few lattice models	6
1.2.1 Ordered Harmonic Lattice	6
1.2.2 Disordered Harmonic Lattice	7
1.2.3 Anharmonic Lattice	8
1.2.4 Momentum nonconservation	9
1.3 Thermal transport in spin systems	10
1.3.1 Ising model	10
1.3.2 XY model	12
2 The classical Heisenberg model	17
2.1 The model	17
2.2 The DTOE dynamics	19
2.3 Equilibration of a closed system	22

2.4	Energy and spin diffusion using DTOE	25
2.4.1	The diffusion phenomenology	25
2.4.2	A brief literature review	25
2.4.3	Numerical Results	26
2.5	Discussion	31
3	Thermal transport	35
3.1	Heat baths	35
3.2	Equilibration for $\beta_l = \beta_r$	36
3.3	Local Thermal Equilibrium	37
3.4	Analytical results	39
3.4.1	Limit $T \rightarrow 0$	40
3.4.2	Limit $T \rightarrow \infty$	41
3.5	Numerical Results	42
3.5.1	Current and thermal conductivity	42
3.5.2	Local energy profiles	45
3.6	Discussion	47
4	Ballistic-diffusive crossover	49
4.1	The coupled map lattice	51
4.1.1	Without scattering	52
4.1.2	In presence of scattering	53
4.1.3	With spatial correlation	56
4.2	Discussion	59
5	Thermal resonance in the classical Heisenberg model	64
5.1	Model and Numerical scheme	65
5.2	Numerical Results	67
5.2.1	Thermal resonance	67
5.2.2	Absence of thermal pumping	77
5.3	Discussion	79

6 Thermal rectification and negative differential thermal resistance	85
6.1 Model	87
6.2 Numerical Scheme	89
6.3 Numerical Results	90
6.3.1 Thermal rectification	90
6.3.2 Thermal rectification and NDTR	94
6.4 Discussion	100
A The spurious Δt dependence	106
List of Publications	108