

**SOME STUDIES ON
ELECTRON CORRELATION EFFECTS IN
LOW-DIMENSIONAL MODEL SYSTEMS**

**THESIS SUBMITTED FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY (SCIENCE)
OF THE
UNIVERSITY OF CALCUTTA**

**BY
BIBHAS BHATTACHARYYA
DEPARTMENT OF PHYSICS
SCOTTISH CHURCH COLLEGE
1 & 3 URQUHART SQUARE
CALCUTTA – 700006
INDIA**

1999

Contents

Preface	iv
Synopsis of the present work	vi
1 INTRODUCTION	
1.1 Interest in Electronic Correlation	1
1.2 Electronic Correlation in Low Dimensional Systems	2
1.3 Model for Electronic Correlation	6
1.4 Motivation of the Present Work	8
Bibliography	11
2 REAL SPACE RENORMALIZATION GROUP STUDY OF THE ONE DIMENSIONAL HUB- BARD MODEL	
2.1 The Real Space Renormalization Group Technique	16
2.2 RG Calculations	16
2.3 Analysis of the RG Results	19
2.4 The Hubbard Model with a Non-Half-Filled Band	22
2.5 Extension of the RG Scheme	23
2.6 Results for the Non-Half-Filled Case	26
2.7 Possible Extensions of the Present Scheme	29
Appendix 2.A	30
Appendix 2.B	34
Bibliography	37
3 THE EXTENDED HUBBARD MODEL IN ONE DIMENSION	
3.1 The Extended Hubbard Model: 1-D Chain at Half-Filling ..	39
3.2 Trouble with the Existing RG Scheme	41
3.3 Remedy for the RG Scheme: A Possible Way	44
3.4 Application of the RG: Extended Hubbard model	46
3.5 Application of the RG: Bond-Charge Interaction	48
3.6 Bond-Charge Interaction: RG Results ,	50

3.7	Electron-Phonon Interaction and the Hubbard Model	52
3.8	Scheme for Treating the e-ph Interaction	53
3.9	Results for the e-ph Interaction	56
3.10	Further Extensions	61
	Appendix 3.A	63
	Bibliography	67
4	THE ONE-DIMENSIONAL HUBBARD MODEL WITH THE PAIR-HOPPING INTERACTION	
4.1	The Pair-Hopping Interaction	69
4.2	Background of the Study of the Pair-Hopping Model	71
4.3	RG Equations for Penson-Kolb-Hubbard Model	73
4.4	Phase Diagram of the PKH Model	75
4.5	Further Possibilities	81
	Appendix 4.A	82
	Bibliography	84
5	APPLICATION OF THE REAL SPACE RENORMALIZATION GROUP IN TWO DIMENSIONS	
5.1	The BRG in Two Dimensions	86
5.2	The Hubbard Model on a 2-D Square Lattice	86
5.3	BRG on a Triangular Lattice	89
5.4	The Model and the BRG Scheme	90
5.5	Exact Results for the Model on a Triangular Lattice	95
5.6	Results Obtained in BRG	97
5.7	Conclusion	99
	Bibliography	101
6	THE REAL SPACE RENORMALIZATION GROUP REVISITED: A MODIFIED SCHEME	
6.1	Looking Back into the Troubles of BRG	103
6.2	Standard form of BRG for the Spinless Fermions	104

6.3 Scheme for Improvement: Removing the “end-effect”	107
6.4 Results in the “improved” Scheme	109
6.5 The Hubbard Model in 1D: RG Equations	114
6.6 Results for the Hubbard Model	116
6.7 Further Possibilities	118
Bibliography	120
7 COLLECTIVE EXCITATIONS IN THE PAIR-HOPPING MODEL AT ZERO TEMPERATURE	
7.1 Collective Excitations in the Pair-Hopping Model	122
7.2 Mean-Field Solution of the PK Model	124
7.3 Generalized RPA Equations of the PK Model	128
7.4 Solution of Generalized RPA Equations of Motion	130
7.5 Dispersion of the Collective Excitation	133
7.6 Conclusion	136
Appendix 7.A	138
Bibliography	142
8 CONCLUSION	
8.1 Summarizing the Present Work	144
8.2 Open Avenues for Further Investigations	148
Bibliography	150
ANNEXURE I	
List of Publications Related to the Present Work	152
List of Publications not Related to the Present Work	153
ANNEXURE II	
Reprints of Published Works Related to the Present Thesis	