## **Contents**

Introduction Alexei Tsvelik	ix
List of Figures	xi
List of Tables	xvii
Part I Quantum Critical Points	
1	
Damping of collective modes and quasiparticles in <i>d</i> -wave superconductors Subir Sachdev and Matthias Vojta	3
1. Introduction	3
2. Impurities and the $S = 1$ resonant collective mode	7
3. Inelastic damping of the nodal quasiparticles	12
References	18
Part II Strongly Correlated One-Dimensional Systems	
2	
Dynamical Properties of one dimensional Mott Insulators	25
Davide Controzzi, Fabian H.L. Essler and Alexei M. Tsvelik	
1. 1D Mott insulators	25
2. The Sine-Gordon model	28
3. Spectral representation of the optical conductivity	31
4. Vicinity of the Luther-Emery point	36
5. Large energy behavior	37
6. Applications	41
References	43
3	
Lectures on Non Perturbative Field Theory and Quantum	
Impurity Problems: Part II	47
H. Saleur	
1. Introduction	47
2. Some generalities on form-factors	48

3. Example: The sinh-Gordon model	55
4. The sine-Gordon Model	63
5. Conductance in the fractional quantum Hall effect	67
6. Anisotropic Kondo model and dissipative quantum mechanics	72
7. Friedel oscillations: correlations involving Vertex operators	79
8. Conclusion	85
References	86
4	
Ising-model Description of Quantum Critical Points in 1D Electron and	90
Spin Systems	89
A.A. Nersesyan	00
1. Introduction	89
2. The model and its quasi-classical analysis	91
3. Relation between DSG model and deformed quantum Ashkin-Teller	00
model	92
4. Deformed quantum Ashkin-Teller model in the $(\sigma, \tau)$ representation	0.5
and the Ising transition	97
5. Correlation functions	100
6. Dimerized Heisenberg chain in a staggered magnetic field	103
7. Ising transition in the 1D Hubbard model with alternating chemical	
potential	107
8. Conclusions	114
References	115
5	
Commensurability, topology and Luttinger's theorem in quantum many-	
body systems	117
Masaki Oshikawa	
1. Introduction	117
2. Magnetization process of quantum spin system	119
3. One dimension – field theory	123
4. One dimension – Lieb-Schultz-Mattis argument	126
5. A route to Luttinger's theorem	129
6. Going up to higher dimensions	132
7. Conclusion	135
References	136
Part III Strong Correlations and Disorder	
	1.4.
Critical points two-dimensional replica sigma models	141
Paul Fendley	4.40
1. Perturbative peculiarities	148
2. WZW term	149

3. θ term
References
7
Topics in the conformal field theory of disordered systems
John Cardy  1. Logarithmic factors in correlation functions
2. Percolation cluster numbers and the spin quantum Hall transition
References
8
Disordered Dirac Fermions: Three Different Approaches
M.J. Bhaseen, JS. Caux, I.I. Kogan and A.M. Tvelik
1. Introduction
2. Massless Dirac Electrons in a Random Gauge Potential
(DRGP model)
3. The Osp (2 2) WZNW model
4. Conductivity
5. The tale of two limits
<ul><li>6. Conclusion</li><li>7. Appendixes</li></ul>
References
9 Disordered Quantum Solids
T. Giamarchi and E. Orignac
1. Introduction
2. Disordered interacting Fermions
3. Tackling the disorder
4. Other systems and RG
5. A zest of numerics
6. Variational Method
7. Commensurate systems
8. Conclusions
References
Part IV Dynamical Mean Field Theory
10
Model Hamiltonians and First Principles Electronic Structure Calculations
G. Kotliar and S.Y. Savrasov
1. Introduction
2. Cellular DMFT
3. Qualitative Insights from DMFT applied to model Hamiltonians

4. Density Functional Theory and LDA	272
5. LDA+U Method	276
6. Model Hamiltonians and First Principles Calculations	281
7. Dynamical mean-field theory	285
8. LDA+DMFT	289
9. Techniques for solving realistic DMFT equations	293
10. Successes	293
11. Connection with Landau functional	294
12. Extended DMFT, GW and GWU	295
13. Outlook	297
References	298