

Contents

1	Introduction	1
1.1	Introductory Remarks	1
1.1.1	General Consideration: Strong Versus Weak Correlations	1
1.1.2	Theoretical Approaches to Strongly Correlated Systems	3
1.1.3	Quantum Phase Transitions and NFL behavior of HF compounds	12
1.1.4	Limits and Goals of the Book	16
	References	18
2	Landau Fermi Liquid Theory and Beyond	21
2.1	Quasiparticle Paradigm	21
2.2	Pomeranchuk Stability Conditions	23
2.3	Thermodynamic and Transport Properties	24
2.3.1	Equation for the Effective Mass and the Scaling Behavior	25
	References	29
3	Fermi Liquid with Fermion Condensate	31
3.1	The Fermion-Condensation Quantum Phase Transition	31
3.1.1	The FCQPT Order Parameter	33
3.1.2	Quantum Protectorate Related to FCQPT	35
3.1.3	The Influence of FCQPT at Finite Temperatures	36
3.1.4	Phase Diagram of Fermi System with FCQPT	38
3.2	Two Scenarios of the Quantum Critical Point	40
	References	49

4	The Topological Phase Transitions Related to Fermion Condensate	51
4.1	Topological Phase Transitions Related to FCQPT	51
	References.	59
5	Appearance of Fermion-Condensation Quantum Phase Transition in Fermi Systems	61
5.1	The Superconducting State with FC at $T = 0$	61
5.1.1	Green's Function of the Superconducting State with FC at $T = 0$	63
5.1.2	The Superconducting State at Finite Temperatures	64
5.1.3	Bogolyubov Quasiparticles.	66
5.1.4	The Dependence of Superconducting Phase Transition Temperature T_c on Doping.	68
5.1.5	The Gap and Heat Capacity Near T_c	69
5.2	The Dispersion Law and Lineshape of Single-Particle Excitations.	70
5.3	Electron Liquid with FC in Magnetic Fields.	73
5.3.1	Phase Diagram of Electron Liquid in Magnetic Field	73
5.3.2	Magnetic Field Dependence of the Effective Mass in HF Metals and High- T_c Superconductors	78
5.4	Appearance of FCQPT in Fermi systems	81
	References.	84
6	Highly Correlated Fermi Liquid in Heavy-Fermion Metals: The Scaling Behavior	87
6.1	Magnetic Field Dependence of the Quasiparticle Effective Mass	87
6.2	Quasiparticles and the Temperature Dependence of the Effective Mass	90
6.3	Scaling Behavior of the Effective Mass and Energy Scales.	93
6.3.1	Schematic Phase Diagram of a HF Metal.	95
6.3.2	Non-Fermi Liquid Behavior of $YbRh_2Si_2$	97
6.3.3	Heat Capacity and the Sommerfeld Coefficient.	98
6.4	General Properties of the Phase Diagrams of Heavy-Fermion Metals.	99
	References.	109
7	Highly Correlated Fermi Liquid in Heavy-Fermion Metals: Magnetic Properties	111
7.1	Magnetization.	111
7.2	Magnetoresistance.	113

7.2.1	Longitudinal Magnetoresistance	113
7.2.2	Transverse Magnetoresistance in the HF Metal CeCoIn ₅	114
7.2.3	Electric Resistivity of HF Metals	119
7.3	Magnetic Entropy	120
7.4	Magnetic Susceptibility	121
7.4.1	Magnetic Susceptibility and Magnetization Measured on CeRu ₂ Si ₂	121
7.5	Magnetic-Field-Induced Reentrance of the LFL Behavior and Spin-Lattice Relaxation Rates	123
7.6	The Relations Between Critical Magnetic Fields B_{c0} and B_{c2} in HF Compounds	127
7.7	Scaling Behavior of the HF CePd _{1-x} Rh _x Ferromagnet	130
	References	136
8	Metals with a Strongly Correlated Electron Liquid	139
8.1	Entropy, Linear Expansion, and Grüneisen's Law	139
8.1.1	Entropy, Linear Expansion, and Grüneisen's Law	140
8.2	The $T - B$ Phase Diagram, the Hall Coefficient, and the Magnetic Susceptibility	142
8.3	The Impact of FCQPT on Ordinary Continuous Phase Transitions in HF Metals	146
8.3.1	The Comparison of $T - B$ Phase Diagrams for YbRh ₂ Si ₂ and CeCoIn ₅	147
8.3.2	The Tricritical Point in the $B - T$ Phase Diagram of YbRh ₂ Si ₂	150
8.3.3	Low Temperature Entropy of YbRh ₂ Si ₂	152
	References	153
9	Quasi-classical Physics Within Quantum Criticality in HF Compounds	155
9.1	Second Wind of the Dulong-Petit Law at a Quantum Critical Point	155
9.2	Transport Properties Related to the Quasi-classical Behavior	162
9.3	Quasi-classical Physics and T -Linear Resistivity	168
	References	176
10	Magnetoresistance in the HF Metal at Zero Temperature	179
10.1	Introduction	179
10.2	The HF Metal CeCoIn ₅	180
10.3	The HF Metal YbRh ₂ Si ₂	187
10.4	Main Results	196
	References	197

11	Zero Temperature Magnetoresistance of the HF Metal: Enigma of $\text{Sr}_3\text{Ru}_2\text{O}_7$.	199
11.1	Introduction: Flat Bands and Enigma of Metamagnetic Quantum Critical Regime in $\text{Sr}_3\text{Ru}_2\text{O}_7$	199
11.2	Magnetoresistivity.	201
11.3	Fermion Condensation.	203
11.4	Phase Diagram	204
11.5	Jumps	205
11.6	Entropy	209
11.7	Scaling Behavior	210
11.8	Main Results	212
	References.	212
12	Fermion Condensation in Finite Systems	215
12.1	Finite Systems	215
12.2	Merging of Landau Levels in Two-Dimensional Electron System in Silicon	226
	References.	232
13	Asymmetric Conductivity of Strongly Correlated Compounds.	235
13.1	Normal State	235
13.1.1	Suppression of the Asymmetrical Differential Resistance in $\text{YbCu}_{5-x}\text{Al}_x$ in Magnetic Fields.	240
13.2	Superconducting State	241
13.3	Relation to the Baryon Asymmetry in the Early Universe	247
	References.	249
14	Violation of the Wiedemann-Franz Law in HF Metals	251
	References.	259
15	High Magnetic Fields Thermodynamics of Heavy Fermion Metals	261
15.1	Introduction	261
15.2	Phase Diagram	265
15.3	Results and Discussion	266
15.3.1	Kinks	269
15.4	Main Results	271
	References.	272
16	Baryon Asymmetry Resulting from FCQPT in the Early Universe.	273
16.1	Introduction	273
16.2	Model	274

16.3	The Asymmetry of the Universe	279
	References.	282
17	Quantum Criticality of Spin Liquids in Novel Insulators and Magnets.	285
17.1	Thermodynamic Properties of Quantum Spin Liquid in Insulators	286
17.1.1	Model	286
17.1.2	Phase Diagram	290
17.1.3	The Thermodynamic Properties	290
17.2	Scaling in Dynamic Susceptibility of Herbertsmithite and HF Metals	297
17.2.1	Theory of Dynamic Spin Susceptibility of Quantum Spin Liquid and Heavy-Fermion Metals	298
17.2.2	Scaling Behavior of the Dynamic Susceptibility	300
17.3	Spin–Lattice Relaxation Rate of Quantum Spin Liquid	304
17.4	Heat Transport in Magnetic Fields by Quantum Spin Liquid in Insulators	306
	References.	314
18	Quantum Criticality of Heavy-Fermion Compounds.	317
18.1	Quantum Criticality of High-Temperature Superconductors and HF Metals	317
18.2	Quantum Criticality of Quasicrystals	321
18.3	Quantum Criticality at Metamagnetic Phase Transitions	329
18.3.1	Typical Properties of the Metamagnetic Phase Transition in $Sr_3Ru_2O_7$	329
18.3.2	Metamagnetic Phase Transition in HF Metals	331
18.4	Universal Behavior of Two-Dimensional ^3He at Low Temperatures	332
18.5	Scaling Behavior of HF Compounds and Kinks in the Thermodynamic Functions	340
18.6	New State of Matter	342
	References.	343
19	Conclusions	345
	References.	348
	Index	351

Theory of Heavy-Fermion Compounds

Theory of Strongly Correlated Fermi-Systems

Amusia, M.; Popov, K.; Shaginyan, V.; Stefanowicz, W.

2015, XXII, 359 p. 140 illus., 23 illus. in color., Hardcover

ISBN: 978-3-319-10824-7