

Superconductivity

An Introduction

Bearbeitet von
Reinhold Kleiner, Werner Buckel, Rudolf Huebener

3. aktualisierte Auflage 2015. Buch. 496 S. Softcover
ISBN 978 3 527 41162 7
Format (B x L): 17 x 24,4 cm

Weitere Fachgebiete > Physik, Astronomie > Elektrodynamik, Optik > Halbleiter- und Supraleiterphysik

Zu [Leseprobe](#) und [Sachverzeichnis](#)

schnell und portofrei erhältlich bei


DIE FACHBUCHHANDLUNG

Die Online-Fachbuchhandlung beck-shop.de ist spezialisiert auf Fachbücher, insbesondere Recht, Steuern und Wirtschaft. Im Sortiment finden Sie alle Medien (Bücher, Zeitschriften, CDs, eBooks, etc.) aller Verlage. Ergänzt wird das Programm durch Services wie Neuerscheinungsdienst oder Zusammenstellungen von Büchern zu Sonderpreisen. Der Shop führt mehr als 8 Millionen Produkte.

Index

a

Abrikosov, A. A., 23, 25, 159, 212, 246, 249, 260, 264
 Abrikosov vortex, *see* flux line
 ac Josephson current, *see* Josephson effect
 ALMA 435
 Ambegaokar Baratoff relation 323
 amorphous superconductor 82, 156ff
 Andreev bound states 334f
 Andreev reflection 331f
 antenna, superconducting 424, 431f, 435ff, 438, 462
 antidot 27, 300, 305ff
 APF 447
 ARPES 174ff
 A15 structure, *see* β tungsten structure

b

(Ba,Ka)BiO₃ 103
Bardeen, J. 4, 45, 76, 118, 130, 207, 414
 BCS coherence length 123
 – dependence on mean free path 220
 BCS theory 4, 45, 76, 117, 124ff
 Bean Livingston barrier 300
 Bean model 306ff
 bearing, superconducting 389, 400f
Bednorz, J. G. 5
 BEDT-TTF compounds 108f
 Berezinskii-Kosterlitz-Thouless Transition 267f
 β tungsten structure 83ff
 Bi₂212, *see* Bi₂Sr₂CaCu₂O₈
 bias reversal 447
 bismuthates 103ff
 Bi₂Sr₂CaCu₂O₈ 6, 54f, 97ff
 Bitter magnet 375
Bohr, N. 17
 Boltzmann's constant 16

boron carbides 91f
 Bose Einstein Condensation 5
 Bose glas 303
 Bragg glas 303f
 BSCCO, *see* Bi₂Sr₂CaCu₂O₈
 bubble chamber 379, 381

c

cable
 – superconducting 375ff
 – twist 386
 cable in conduit 381
 calorimeter 428f
 canonical momentum 34
 cartwheel SQUID, *see* multiloop SQUID
 magnetometer
 characteristic frequency 340
 characteristic voltage 340
 chemical shift 390
 Chevrel phases 89f
 Circuit QED 366ff
 Clogston-Chandrasekhar limit 256
 coherence length, *see also* BCS coherence length and Ginzburg Landau coherence length
 – BCS 123
 – Ginzburg Landau 41, 44
 coherent matter wave, *see* matter wave
 columnar defect 299, 303
 computer tomography 455
 condensation energy 45, 102, 126, 238f, 246, 259, 265, 267, 297
 conventional superconductivity 76ff, 117ff
Cooper, L. N. 4,
 Cooper pair 7, 35f, 117ff
 – collective pair function 45, 124ff
 – pair density and energy gap 45, 57, 128ff, 133ff

- Cooper pair box 360f
- Cooper pairing
 - anisotropy effect 151
 - early models 117f
 - effect of lattice deformations 150ff
 - effect of paramagnetic ions 157ff
 - valence effect 152f
 - via antiferromagnetic spin fluctuations 172
 - via electron phonon interaction 117ff, 131f
 - via magnetic excitons 188ff
- Coulomb blockade 358ff
- Coulomb staircase 359
- CRESSST 428
- critical current 8, 283ff
 - depinning 296ff
 - grain boundary Josephson junction 316
 - Josephson junction 48, 55, 67f
 - pair breaking 283ff
 - Silsbee Rule 286f
 - SIS Josephson junction 323f
 - SNS Josephson junction 332f
 - SQUID 63ff
 - type I superconductor 285ff
 - type II superconductor 291ff
- critical current density, thin plate 286
- critical field, thermodynamic 213, 220
- critical magnetic field 23
- critical magnetic field, thin plate 230ff
- critical state 306f,
- critical temperature 4, 7
 - BCS formula 129
 - McMillan formula 132
- cuprates
 - antiferromagnetic state 170
 - discovery 5
 - heat capacity 173
 - magnetic penetration depth 173
 - material properties 96ff
 - phase sensitive measurements of pair wave function 177ff
 - pseudo gap 176ff
 - quasiparticle density of states 173ff
 - spin lattice relaxation rate 173
- current limiting devices 406ff
- current voltage characteristic
 - intrinsic Josephson junction 326f
 - Josephson junction under microwave irradiation 342ff
 - Josephson tunnel junction 325f
 - NbTi 311
 - Pb-In 313
 - RCSJ model 341ff
 - SFS junction 335ff
 - SIS tunnel junction 142
 - SNS junction 333
 - subharmonic structures 334
- d**
 - dc SQUIDs 27f, 63ff, 69f, 182f, 264, 300, 440ff; *see also* SQUIDs
 - de Broglie, L.* 18
 - de Broglie relation 18, 34
 - decay length 53, 138, 267, 328ff
 - decoration 24f
 - Debye frequency 79, 125
 - Debye temperature 79
 - demagnetization factor 222, 232, 233, 236, 246, 248, 258f, 288
 - density of states 19, 85, 92, 126ff, 138ff, 145ff, 161ff, 166, 173ff, 189, 192, 206, 229, 258, 439
 - detectivity 427
 - diamagnetism, effect of fluctuations 271
 - dichalcogenides 95ff
 - digital electronics 463ff
 - directly coupled magnetometer 444
 - d* orbitals 163ff
 - Drude, P.* 16
 - d* vector 169, 191
 - d* wave superconductivity 76ff
- e**
 - EDX spectrometer 429
 - EEG 455
 - Einstein, A.* 2, 5, 164, 174
 - electrical resistance, Drude model 16
 - electrical resistance, temperature dependence 1f, 11ff
 - electron gas, *see* free electron gas
 - electron holography 26
 - Eliashberg function 145
 - energy gap 45, 57, 128f, 133ff
 - anisotropy 148
 - infrared absorption 133f
 - tables 135f
 - tunnel experiments 136ff,
 - energy-momentum relation, electrons in periodic potential 19
 - energy resolution 427, 429, 447
 - energy storage, superconducting 317, 389, 398f
 - entropy 202f, 204f, 226ff,
 - ET salts, *see* BEDT-TTF compounds
 - excess current 334, 411
 - exchange interaction 121f, 193, 335
- f**
 - Fermi energy 19
 - Fermi function 20

Fermi sphere 19, 44, 125, 166, 194
Feynman, R. 48
 FFLO state 193f, 256, 335
 field effect, electric 110ff
 filter
 – Chebyshev 422
 – elliptic 422, 424f
 – superconducting 420ff
 fishtail, *see* second peak
 Fiske steps 56, 351, 356
 flow resistance 277, 312f
 fluctuation conductance 268ff
 flux creep 309f
 flux flow resistance, *see* flow resistance
 flux flow step 356
 flux jumps 303, 376, 378ff
 flux line lattice 21ff, 28ff, 256ff
 flux line lattice, melting 260
 flux lines 11, 15, 23ff, 71, 196, 245 256ff,
 291ff, 296ff, 378, 385
 – hopping 300
 – imaging techniques 25ff
 – motion, dissipation of energy 292ff
 flux-locked mode 448
 flux modulation 446f
 flux noise 426, 447
 fluxoid 35
 fluxoid quantization 35
 fluxon 68, 183, 264f, 350ff, 437
 fluxon dynamics 350ff
 flux quantization 33ff, 41
 – Doll-Näbauer experiment 30ff
 – Deaver-Fairbanks experiment 30ff
 flux quantum 4
 – half integer 181ff
 flux transformer 294f, 442f
 fly-wheels 389, 400f
 Fraunhofer pattern 67ff, 186, 336
 free electron gas 16
 free energy, definition 203
 free enthalpy, definition 203
Fröhlich, H. 118, 130
 fullerenes 88ff
 fusion reactor 381, 397ff

g

gapless superconductivity 161
 gauge invariance 53
 gauge invariant phase difference 47
 generators, superconducting 401ff
Giaever, L. 56ff, 136, 275f, 294f
 Gibbs energies 202ff, 304

Ginzburg, V. L. 212
 Ginzburg Landau coherence length 41, 44f,
 55, 216ff, 220f,
 – dependence on mean free path 219f
 Ginzburg Landau equations 215
 Ginzburg Landau parameter 217, 220, 249f,
 Ginzburg Landau theory 212ff
 – free energy 212ff
 Ginzburg number 259
 GLAG theory, *see* Ginzburg Landau theory
 Golay cell 430
Gorkov, L. P. 212
 gradiometer 448, 450ff
 grain boundary 54f, 181, 184f, 316, 335, 338,
 341, 345, 384, 432, 441f, 444, 462
 grain boundary Josephson junction, *see*
 Josephson junction

h

hard superconductor 29, 226, 283, 288, 296ff
 heavy fermion superconductors 78
 – material properties 92f
 – order parameter symmetry 186ff
 HEB bolometer 430
 HEB mixer 435
 helium, boiling point 1
 heterodyne receiver 432
 high field superconductor 252f
 high temperature superconductor, *see* cuprate
 Hilbert spectrometer 432
 holon 164
 homodyne receiver 432
 hot electron bolometer, *see* HEB
 Hubbard model 172f
 hybrid magnets, *see* magnets
 hysteresis, magnetization 307f

i

IBAD 384
 $I_c R_n$ Product, SIS junction 323
 $I_c R_n$ -Produkt, SNS junction 332
 ideal diamagnetism, *see* Meissner Ochsensfeld
 Effect
 inductance parameter 62f, 440
 induction heater 404
 intermediate state 212, 231ff,
 internal energy, definition 203
 intrinsic Josephson junction, *see* Josephson
 junctions
 intrinsic pinning 299f
 inverse problem, MEG 454
 iron pnictides 7, 104ff
 irreversibility line 310

- isotope effect 87, 129f
 - cuprates 170
 - elements 130
 - experiments 130ff
 - fullerenes 132
 - MgB_2 132

j

- Josephson, B. D.* 46f
- Josephson constant 55, 460
- Josephson coupling energy 360, 362f, 441
- Josephson current, *see* Josephson effect
- Josephson effect 46ff
 - ac Josephson current 48, 55f
 - dc Josephson current 48, 65ff
- Josephson equations 47ff
- Josephson junctions 47, 53ff, 321ff
 - bridges 53
 - Fraunhofer pattern 67
 - grain boundaries 54, 181ff, 328, 335, 338, 341, 345, 432, 441f, 444, 462
 - intrinsic 54f, 56, 326f, 438
 - pendulum model 338ff, 346ff
 - SINIS 54, 462
 - SIS 53, 322f
 - SNS 53, 332f, 430, 462
 - overdamped 340
 - underdamped 340
- Josephson mixer 433f
- Josephson penetration depth 66, 264, 347, 352
- Josephson plasma frequency 343f, 347, 364, 461
- Josephson plasma oscillations 339, 350
- Josephson plasma waves 348, 350, 352
 - standing waves 350
- Josephson vortex, *see* fluxon

k

- Kamerlingh-Onnes, H.* 1ff, 11, 22, 130, 240, 373
- Knight shift 164ff, 173, 175, 189, 193
- Kondo effect 160
- Kosterlitz Thouless Transition, *see* Berezinskii
- Kosterlitz Thouless transition

l

- Landau, L. D.* 5, 41, 50, 212
- LaO/STO 111
- Large Hadron Collider 396
- laser ablation 299, 316
- latching logic 464
- Lawrence Doniach model 263

- layered superconductors 78, 94f, 101, 260, 262ff,
- levitated train 29, 389
- levitation 13ff, 22, 317, 374
- load line 461
- local oscillator 433ff,
- lock in transition 265
- LOFF state, *see* FFLO state
- London, F.* 30, 36, 130
- London, H.* 36
- London equations 36, 42
- London penetration depth 35, 37ff, 216ff
- Lorentz, H. A.* 16
- Lorentz contraction 350, 355
- Lorentz microscopy 26ff
- lower critical field 23, 40, 246ff,
 - layered superconductors 264
- Low Temperature Scanning Electron Microscopy 26f

m

- macroscopic wave function, *siehe* matter wave
- MAGLEV, *see* levitating train
- magnetic flux, definition 4
- magnetic penetration depth, *see also* London penetration depth
 - dependence on mean free path 220
 - conventional superconductors 207
 - unconventional superconductors 207
- magnetic resonance imaging 394ff
- magnetization 221ff
 - of hard superconductors 301ff
- magnetization curve, type II superconductor 246
- magneto cardiography, *see* MCG
- magneto encephalography, *see* MEG
- magneto-optics 25ff, 303, 309
- magnets 374ff
 - coil protection 386f
 - current feeding 375, 384
 - energy storage 398f
 - high temperature superconductor 381ff
 - hybrid 380
 - levitated trains 405f
 - magnetic resonance imaging 394f
 - magnetic separation 404f
 - motors and generators 401f
 - NbTi 380f, 393, 435
 - Nb_3Sn 380f, 392, 417, 419
 - nuclear fusion 397ff
 - nuclear magnetic resonance 390ff
 - particle accelerators 395ff
 - permanent 388ff

- stability 376ff,
- wires 375ff
- manometer, superconducting 243
- matching 265, 305f
- matter wave 4f, 18, 20, 33
- coherent 4f, 21, 34, 40, 45ff, 59ff, 76, 117, 126f
- Matthias rule 82
- McCumber parameter, *see* Stewart-McCumber parameter
- MEG 453f
- Meissner, W.* 4, 22
- Meissner effect, paramagnetic 184
- Meissner Ochsensfeld Effect 4, 22ff, 35ff, 191, 201, 221ff
- Meissner phase, *siehe* Meissner state
- Meissner state, stability 224ff
- melt texturing 389
- MgB₂ 86
- micro calorimeter 428f
- mixer 431ff,
- MOD 384
- motors, superconducting 401ff
- MRI, *see* magnetic resonance imaging
- Müller, K. A.* 5
- multiband superconductivity 494f
- multifilament wire 315, 378ff
- multiloop SQUID magnetometer 444f
- multipole filter 422
- muon spin resonance (μ SR) 28, 40, 105f, 191, 262f

n

- NbN 75,84,135,434f
- NbSe₂ 26, 78, 95f, 261
- Nb₃Sn 8, 76, 85f, 253, 314, 380ff
- NbTi 8, 76, 310, 380, 393
- NDE 457f
- NEP 427, 431
- neutron scattering 24f, 190
- nitrogen, boiling point 6
- NMR, *see* nuclear magnetic resonance
- noise 1/f, 426, 446, *see also* thermal noise
- noise parameter 441
- noise temperature 427
- noise, white 426
- non-destructive evaluation, *see* NDE
- non-equilibrium processes 272ff
- nuclear magnetic resonance 164, 173, 390ff
- Nyquist noise, *see* thermal noise

o

- Ochsensfeld, R.* 4f, 22
- order parameter, *see* pair wave function

- organic superconductors 107ff
- oscillator, superconducting 437ff

p

- pair breaking 160f
- pair breaking critical current 283ff
- pair wave function
 - *d* symmetry 166ff
 - *s* symmetry 125ff
 - phase sensitive measurements 177ff
 - sub-dominant components 186ff
- Palladium-Hydrogen 87f
- pancake vortex 262
- paramagnetic limit 256
- paramagnetic Meissner effect 184
- parity 78
- particle-wave duality 17f
- Pauli, W.* 19
- Pauli limiting field, *see* paramagnetic limit
- Pauli principle 19
- peak effect 315
- permanant current, *see* persistent current
- persistent current 12ff, 42f
- persistent mode 375, 393
- PET 397, 455
- phase slip center 277
- phase transition, order of 205
- phonon detection 439
- phonon generation 439
- phonons 79
- photo effect 174
- picene 109
- pickup loop 442
- π Josephson junction 177ff, 335ff
- pinning 29, 294, 296ff
- pinning center 29, 294, 296ff
- pinning force 29, 298f, 310ff
- Planck, M.* 16
- Planck's constant 18
- pnictide, *see* iron pnictide
- pressure, effect on superconducting state 239ff
- proximity effect 329ff
- pseudo gap 176ff
- powder-in-tube method 383
- p* wave superconductivity 77ff

q

- quality factor 341, 414, 420ff, 449
- quantum computer 111, 362ff, 467f
- quantum fluctuations 358, 427
- quantum hall effect 374
- quantum interference 45ff
- quantum interference filter, *see* SQIF

- quantum resistance 358
- quantum tunneling, macroscopic 364ff
- quasiparticle 124ff
 - density of states, swave pairing 19, 128
 - density of states, *d*wave pairing 173
 - energy-momentum relation, *p* wave pairing 169
 - energy-momentum relation, *s* wave pairing 125
 - recombination time 274f
- qubit 362ff, 467f
- quench 376
- r**
- Rabi oscillations 361ff
- RABITS 384
- Rapid single flux quantum logic, *see* RSFQ
- RCSJ model 337ff
- receiver, integrated 431ff
- recombination time 274f, 439
- reentrant superconductivity 77, 91, 160ff
- relaxation processes 273ff
- resistance, *see* electrical resistance
- resonators
 - particle accelerators 395ff
 - communication technology 420ff
- rf SQUID 365, 448f
- RSFQ 464ff
- RSJ model 338
- return current 324, 341
- Rutgers formula 229
- Ruthenates 103ff
- s**
- Sagnac interferometer 46
- scanning tunneling microscopy 28
- Schrieffer, J. R. 4
- Schrödinger equation 18
- screen room, magnetic 451
- second peak 304
- sensitivity, *see* detectivity
- sensors, sensitivity 426f
- Shapiro steps 56, 343ff, 425, 432f, 460ff
- shield, superconducting 389
- Shubnikov phase 23ff, 256ff
- signal-to-noise ratio 427
- Silsbee rule 286f
- Sine Gordon equation 348
- single electron electrometer 359
- single electron transistor 359
- single electron tunneling 358ff
- SINIS junction, *see* Josephson junction
- SIS junction, *see* Josephson junction
- SIS mixer 432ff
- skin effect 414
- skin depth 414
- slew rate 448
- SMES 398ff
- SNS junction, *see* Josephson junction
- soliton 350
- Sommerfeld, A. 17
- Sommerfeld coefficient 206f, 230
- specific heat 205ff, 228ff
 - conventional superconductors 205ff
 - Sn 205ff
 - Rutgers formula 229
 - unconventional superconductors 207f
- spinon 164
- splat cooling 156
- sponge model 245, 302
- SQUID 27, 59ff, 300f, 425, 428, 440ff
- SQUID, applications 454ff
- SQUID magnetometer, designs 440ff
- SQUID magnetometer, readout 444ff
- SQUID microscope 456f
- SQUID multichannel systems 454f
- SQUID susceptometer 454
- SQIF 450
- Sr₂RuO₄ 78, 103ff, 165
 - flux line lattice 189
 - pair wave symmetry 191f
 - 3K phase 189f
- stability parameter (against quench) 377
- Stewart McCumber parameter 341
- superconducting elements 78ff
- superconducting quantum interferometer, *see* SQUID
- superconductivity
 - discovery 2
 - conventional, *see* conventional superconductivity
 - improvement at non-equilibrium 275f
 - unconventional, *see* unconventional superconductivity
- superconductor-ferromagnet interface 335ff
- superconductor, hanging 29
- superconductor, high frequency behavior 413ff
- superconductor-insulator interface 321ff
- superconductor-normal conductor interface 328ff
- superconductor of first kind, *see* type I superconductor
- superconductor of second kind, *see* type II superconductor
- supercooling 251
- superfluidity 5
- surface impedance 219, 414f

surface reactance 414
 surface resistance 414f
s wave superconductivity 76ff
 Swihart velocity 348

t

tapes, superconducting 375ff
 TaS_2 95f
 thermal conductivity 209ff
 thermal noise 341f, 426f, 441f
 thermal switch 209
 thermodynamic potentials, *see* Gibbs functions
 thermodynamics, general relations 201ff
 thermometer, superconducting 428ff
 time reversal symmetry 52, 191
 TMTSF compounds 107ff
 transformer, superconducting 409ff
 transition edge thermometer 428
 transition temperature, *see* critical temperature
 tricrystals 181ff
 tunnel diode 434ff
 tunnel effect 28, 47, 57ff
 tunnel junction 67, 136ff
 – normal conductor - normal conductor 137ff
 – normal conductor - superconductor 140f
 – superconductor - superconductor 141ff
 tunneling
 – direct 322
 – via localized states 322
 – resonant 322
 – incoherent 322
 – coherent 322
 – spin polarized 440
 tunneling spectroscopy 147ff
 – cuprates 173ff
 – Pd-D 147
 – UPd_2Al_3 188ff
 tunnel resistance 323
 two-band superconductivity 86, 148, 194f
 type I superconductors 23, 40
 – dependence on κ 250
 type II superconductors 23, 40
 – phase diagram 252
 – dependence on κ 250

u

Uemura plot 164
 UMTS 424
 uncertainty principle
 – space-momentum 122
 – energy – time 161, 358
 – particle number-phase 360
 unconventional superconductivity 76ff, 163ff

UPd_2Al_3 93f, 187ff
 upper critical magnetic field 23, 246ff
 – anisotropic superconductors 254
 – cuprates 253f
 – layered superconductors 254f
 – thin plate 254
 UPt_3 93f, 187ff
 URhGe 94

v

vector potential 34
 voltage standard 48, 55, 344, 459ff
 – programmable 463
 vortex, *see* flux line
 vortex gas 262
 vortex glass 261, 300, 303
 vortex liquid 260f, 266ff
 vortex phases, layered superconductors 261ff
 vortex structure, layered superconductor 264ff

w

wall energy 231
 washboard potential 339, 357, 363f
 washer SQUID 441f
 wave vector 18
 WDX spectrometer 429
 Weston cell 460
 WIMP 428
 Wohleben effect, *see* paramagnetic Meissner effect

y

Y123, *see* $\text{YBa}_2\text{Cu}_3\text{O}_7$
 $\text{YBa}_2\text{Cu}_3\text{O}_7$ 97ff
 YBCO, *see* $\text{YBa}_2\text{Cu}_3\text{O}_7$

z

zero bias anomaly 335
 zero field steps 353f

