CAMBRIDGE

Cambridge University Press
978-1-108-48078-9 — Essential Statistical Physics
Malcolm P. Kennett
Index
More Information

Index

adsorption, 107, 117
air, 90
aluminium, 183
ammonia, 63
angle-dependent magnetoresistance oscillations (AMRO), 149
angle-resolved photoemission spectroscopy (ARPES), 149
angular momentum
  quantization, 17
  rigid rotor, 62
anomalous skin effect, 149
antiferromagnetism, 56, 192, 193
anyons, 126
argon, 1, 90
attractor, 44
average value, 5
Avogadro's number, 71

ballistic motion, 11, 98
Bayes' theorem, 23
benzene, 63
Bessel, F. W., 151
binary alloy, 193, 217
binomial distribution, 4, 11
  large-N limit, 14
  mean, 12
binomial theorem, 4, 9, 17
biophysics, 193
bits, 33
black hole, 38, 153
  Sagittarius A*, 38
blackbody
  cavity, 163
  imperfect, 170
  perfect, 170
  radiation, 61, 161, 162, 165, 169, 185
  spectrum, 166–168
Boltzmann distribution, 52, 210
Boltzmann equation, 89
Boltzmann factor, 52, 209
  generalized, 113
Boltzmann's constant, 21, 71
Boltzmann, L. E., 2, 30
Bose–Einstein condensate, 173, 175
Bose–Einstein condensation, 2, 104, 161, 170, 172, 174, 186, 187, 239
  experiment, 187
Bose–Einstein distribution, 125, 132, 133, 136, 137, 162, 163, 170, 178, 181, 184, 185
bosons, 69, 107, 122, 125–127, 130–132, 136, 161
bridge equation, 50, 52, 55, 112, 121
  canonical ensemble, 50, 80
  grand canonical ensemble, 113, 121
  microcanonical ensemble, 37
broken symmetry, 46, 194, 214
Brown, R., 86, 95
Brownian motion, 7, 86, 95

C_{60}, 63
canonical ensemble, 25, 48, 50, 54, 80, 107
carbon dioxide, 63, 72, 90
carbon-12, 154
cavity modes, 161
central limit theorem, 15, 21, 27, 77, 196
chain rule, 237
Chandrasekhar mass, 156
  rotations, 157
chaos, 1
characteristic pressure
  adsorption, 118
characteristic temperature
  electronic transitions, 72
  rotations, 63, 72, 110
  translations, 64
  vibrations, 72
chemical equation, 119
chemical equilibrium, 118–121
chemical potential, 107, 108, 111, 113, 115, 119, 187
  Bose–Einstein condensate, 176
  bosons, 132, 170, 176, 178, 187
  fermions, 131, 139, 140, 143, 157, 178, 187
  ideal gas, 109, 110
  phonons, 181
  photons, 161, 162, 185
  white dwarf, 154
chemical reaction, 107, 118, 119
chemical symbol, 118
chemotaxis, 7
Clark, A., 151

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE
Cambridge University Press
978-1-108-48078-9 — Essential Statistical Physics
Malcolm P. Kennett
Index
More Information

classical limit, 61, 69, 78, 125
  bosons, 132
  fermions, 131
classical particles, 41, 126, 128
closed system, 25
coin toss experiment, 4, 5, 8, 17
collision time, 98, 99
complex fluids, 94
compressibility
  number, 115
condensate fraction, 172, 173, 175
conductance, 103
conductivity, 103
constraints, 16, 25, 111
continuity equation, 43
Cooper pair, 175
copper, 149, 183
Cornell, E. A., 173
cosmic microwave background radiation, 167, 168
Coulomb interaction, 150, 190
Coulomb potential, 188
critical density
  Bose–Einstein condensation, 173
critical exponents, 213
critical point, 199, 201, 208, 212
critical speed
  superfluid, 174, 175
critical temperature, 194, 216
  Bose–Einstein condensation, 172
  one-dimensional Ising model, 208
Curie temperature, 17, 194
  iron, 17
  mean field estimate, Ising model, 198
current, 103
current density, 103

de Haas van Alphen effect, 149
Debye T^3 law, 182, 183
Debye frequency, 181
Debye model, 80, 181–184, 186, 189
  phonon density of states, 184
Debye temperature, 182
degeneracy, 56, 62, 67, 70, 81
  spherical rotor, 63
  symmetric rotor, 63
degeneracy pressure, 145
degenerate electron gas, 152
density of states, 30, 87, 133–136
  k-space, 134
  magnons, 185
  one dimension, 135
  phonons, 181, 183, 184
  photons, 162
  three dimensions, 134
  two dimensions, 135
detailed balance, 209, 210
deuterium hydride, 85
diatomic gas, 78, 83, 110
diatomic molecule, 63, 72
differential
  enthalpy, 235
  exact, 229
  grand potential, 236
  heat, 231
  Helmholtz free energy, 235
  inexact, 229
  work, 230
diffusion, 11, 22, 98
  coefficient, 86, 98, 101
  equation, 98
dilute limit, 81, 127
dimensionless parameters, 35
dispersion relation, 162
displacement
  root mean square, 98
distinguishable particles, 67, 81, 125–127
DNA, 2
domain wall, 202–204
Dulong and Petit law, 79, 80, 183
Dulong, P. L., 80

effusion, 94, 104, 169
  rate, 95
Einstein model, 80
electric field, 103
  photons, 162
electrical noise, 2
electron, 67, 69, 125, 127, 148, 152, 154
  rest mass energy, 155
  spin, 17
electron degeneracy pressure, 156
  white dwarf, 152
electroweak symmetry, 214
emissivity, 170
energy, 52, 114, 116
  bosons, 177
  conservation of, 55
  Fermi gas, 144
  fluctuations, 53, 54
  gas of polyatomic molecules, 72
  ideal gas, 71
  magnons, 185
  phonons, 182
  quantum simple harmonic oscillator, 60
energy density
  blackbody radiation, 165, 166, 168
  photons, 164
energy eigenstates, 16, 25
  particle in a box, 134
energy eigenvalues
  linear rotor, 63
  particle in a box, 64, 87, 134

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE
Cambridge University Press
978-1-108-48078-9 — Essential Statistical Physics
Malcolm P. Kennett
Index
More Information

simple harmonic oscillator, 59
spherical rotor, 63
symmetric rotor, 63
energy flow, 27, 28, 125, 230
energy fluctuations
ideal gas, 71
energy level, 125, 130
energy window, 30, 146
ensemble average, 41, 45, 221
enthalpy, 235
entropy, 2, 19, 28, 37, 50, 53, 56, 231
blackbody radiation, 187
Boltzmann, 21, 27, 32, 36, 41
classical harmonic oscillator, 84
Fermi gas, 146
gas of polyatomic molecules, 72
Gibbs, 31–33, 41, 112, 146
ideal gas, 71
information, 21, 33
measure of ignorance, 2, 19, 21, 32, 146
of mixing, 73–75
quantum harmonic oscillator, 84
Shannon, 32
zero temperature, 56
environment, 33, 48
equation of state, 227
van der Waals, 75
equations of motion, 2, 30, 42
equilibration, 26, 41, 209
equilibrium, 2, 26, 45, 55, 78, 110
average, 25
thermodynamic, 227
equilibrium constant, 120, 121
equipartition theorem, 47, 78, 79, 83, 84, 90, 97, 183, 184
ergodic hypothesis, 45, 46, 218
ergodicity, 45
exchange energy, 191, 193
exchange interactions, 190
extensive variable, 54, 136, 228

Fermi energy, 131, 139, 140, 144, 145, 148, 151, 154, 157
white dwarf, 154
Fermi function, 131, 139
Fermi gas, 139
Fermi level, 144
Fermi liquid theory, 151
Fermi sea, 148
Fermi surface, 149
Fermi temperature, 140, 157
white dwarf, 152
Fermi wavevector, 149
Fermi–Dirac distribution, 117, 125, 131–133, 136, 137, 139, 157
fermion degeneracy pressure, 153, 157
fermions, 69, 107, 115, 125–127, 130, 131, 136, 139
ferromagnetism, 17, 46, 190, 192, 193, 199
Ising model, 198
Fick's law, 100, 101
fluctuation–dissipation theorem, 53
fluctuations, 30
flux, 94
force
fluctuating, 96
forced oscillator, 44
Fourier series, 166
fractional statistics, 126
fugacity, 111, 113, 239

gamma function, 143, 222–224
Gaussian distribution, 14, 89
Gaussian integral, 222
Geim, A. K., 158
genetic drift, 7
geometric series, 59, 130
giant molecular cloud, 105
Gibbs ensemble, 119
Gibbs factor, 113
Gibbs free energy, 114, 119, 121, 236
Gibbs, J. W., 2, 25, 73, 128
Gibbs–Duhem relation, 124, 234
glassy systems, 46, 56, 190
Glauber dynamics, 210
grand canonical ensemble, 25, 107, 113, 115, 119, 121, 125, 128, 129
grand canonical partition function, 111–114, 121, 125, 130
adsorption, 117
blackbody radiation, 187
bosons, 130
fermions, 130
Maxwell–Boltzmann particles, 128, 129
two-level system, 116
grand potential, 113, 114, 121, 236
adsorption, 117
bosons, 130, 186
fermions, 130, 145
Maxwell–Boltzmann particles, 129
graphene, 158
gravitational potential
stellar interior, 153
ground state
macroscopic occupation, 172

H-theorem, 30
Hamilton's equations, 30, 42, 43
Hamiltonian, 42, 128
particle in a box, 134
rigid rotor, 62
simple harmonic oscillator, 59
Hawking, S. W., 38
heat, 229, 230

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE
Cambridge University Press
978-1-108-48078-9 — Essential Statistical Physics
Malcolm P. Kennett
Index
More Information

heat bath, 48, 65, 107
heat bath algorithm, 210
heat capacity, 53, 58, 233, 238
  aluminium, 183
  bosons, 177, 179, 239
  classical harmonic oscillator, 84
  cusp for bosons, 179
  Debye model, 182, 183
  electrons, 149
  Fermi gas, 145
  gas of polyatomic molecules, 73
  ideal gas, 71
  magnons, 185
  metal, 149
  phonons, 150, 182
  quantum harmonic oscillator, 84
  relation between C_V and C_P, 238
  two-level system, 58
Heaviside step function, 139
Heisenberg model, 191, 219
helium-3, 69, 127, 175
  superfluidity, 175
helium-4, 69, 127, 154, 174, 179
  superfluidity, 174
Helmholtz free energy, 52, 80, 107, 109, 113, 119, 235
  ideal gas, 70
  one-dimensional Ising model, 207
  uncoupled subsystems, 66
hemoglobin, 118
Herschel, F. W., 151
Hertzsprung–Russell diagram, 152
Higgs boson, 127, 214
Hilbert space, 16
holes, 148
hydrogen, 85, 105, 118, 154
  atom, 127

ideal gas, 2, 65, 70, 79, 86, 88, 91, 92, 109
ideal gas constant, 71
ideal gas law, 1, 70–72, 227
importance sampling, 209, 210
impurities
  in crystals, 2
indistinguishable particles, 67, 68, 74, 81, 125–127
information theory, 2, 33, 193
initial conditions, 1, 26, 43, 210, 227
  pathological, 44
initial state, 42, 125
intensive variable, 229
interaction potential, 75, 181
iron, 17, 190
irreversibility, 2
irreversible process, 26, 33, 75, 227
isentropic process, 228
Ising model, 190, 192, 193, 209, 216
  binary alloy, 217
  liquid–gas transition, 212
  mean field theory, 195
  Monte Carlo simulation, 209, 220
  one dimension, 202
  Onsager solution, 193, 208
  solution in one dimension, 205
  three dimensions, 213
  two dimensions, 193, 203, 220
Ising spin, 192
Ising, E., 192
isobaric process, 228
isochoric process, 108, 228
isolated system, 25, 27
isothermal process, 108, 228
isotope, 95, 175
isotropic fluid, 94

Ketterle, W., 173
kinetic theory, 86, 91, 102
kurtosis, 7

Lagrange multiplier, 32, 48, 111, 112
lambda peak, 179, 180
Landau level, 159
Landau theory, 213, 216
Landau, L. D., 150, 174
Landauer, R. W., 33
Langevin equation, 96, 98
Langmuir adsorption isotherm, 117, 118, 130
latent heat, 201
lattice
  bipartite, 192
  cubic, 192
  kagome, 56
  square, 192
  triangular, 192
law of mass action, 118, 119, 121
laws of thermodynamics, 55, 231
  first, 55, 231
  second, 2, 30, 56, 232
  third, 56, 233
  zeroth, 55, 231
lead, 183
Lee, D. M., 175
Legendre transform, 234, 235
Lennard–Jones potential, 75, 99
Lenz, W., 192
Liouville's theorem, 41, 43, 45
liquid, 190
liquid crystals, 94
liquid helium, 174
liquid–gas transition, 212
Lorentzian distribution, 16

macrostate, 16, 19, 55
  spin, 18
magnetic dipole interaction, 190

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE
Cambridge University Press
978-1-108-48078-9 — Essential Statistical Physics
Malcolm P. Kennett
Index
More Information

magnetic domains, 2, 202
magnetic moment
  fermions, 151
magnetic susceptibility, 160, 195
  Ising model, 199, 221
magnetism, 17, 193
magnetization, 18, 34, 35, 194
  Ising model, 198, 199
  one-dimensional Ising model, 202, 207
magnons, 69, 127, 161, 180, 184, 186
main sequence star, 153
many-body localization, 46
Markov chain, 209
Mawell, J. C., 2
Maxwell relations, 236, 237
Maxwell's equations, 161
Maxwell–Boltzmann distribution, 129, 131–133, 136, 137
Maxwell–Boltzmann particles, 187
Maxwell–Boltzmann statistics, 127–129, 137
Maxwell–Boltzmann velocity distribution, 86–89, 94, 95
  moments, 89, 104
mean field theory, 216
  Ising model, 202
mean free path, 98–101
mean square displacement
  random walk, 10, 24
mesons, 127
metals, 148
  electrical transport, 103
methane, 63
Metropolis algorithm, 209, 210
microcanonical ensemble, 25, 36, 41, 44, 54, 107
microstate, 16, 19, 25, 27, 31, 37, 50, 87, 125
  accessible, 41
  Ising model, 193
  spin, 18
mole, 71
molecular chaos, 30
molecular collisions, 93
molecular dynamics simulation, 2, 45
molecular motors, 2, 7
moment of inertia, 62
monatomic gas, 70, 109
Monte Carlo simulation, 2, 45, 209, 220
  initial conditions, 209
  initial state, 210
  Monte Carlo steps, 210
Mott insulator, 115
multinomial theorem, 68
multiplicity function, 18, 19, 27, 30, 37
  spins, 18, 34
muon, 127
myoglobin, 118
Nernst, W. H., 233
neural networks, 193
neutrino, 69, 127
neutron, 69
  ultra-cold, 83
neutron degeneracy pressure, 156
neutron star, 153, 156, 157
  interior, 157
Newton's second law, 96, 153
nitrogen, 82, 83, 90
non-ergodic systems, 46
non-ideal gas, 75, 77, 83
normal fraction, 173, 175
normal modes, 161, 180
normalization, 89
Novoselov, K. S., 158
nuclear fusion, 153
number density, 70, 89, 99, 109, 155
  photons, 163
number fluctuations, 115
  fermions, 147

occupation number, 67–69, 129
  quantum simple harmonic oscillator, 60
Onsager, L., 208
open system, 25
order, 190
order parameter, 193, 213, 216
Osheroff, D. D., 175
oxygen, 1, 82, 90, 100, 118
oxygen-16, 154

paramagnetism, 17, 194, 199, 212
partial pressure, 111, 124
particle bath, 107
particle exchange, 127
particle in a box, 16, 64, 87
particle number, 107, 114, 130
  bosons, 170
  two-level system, 116
partition function, 48, 49, 80, 112, 113
  approximate for Ising model, 196
  classical, 61, 75
  classical simple harmonic oscillator, 61
  derivatives, 52
  distinguishable particles, 67, 127
  gas of polyatomic molecules, 72
  ideal gas, 70
  indistinguishable particles, 69, 70
  Ising model, 194
  linear rotor, 63
  non-ideal gas, 77
  one-dimensional Ising model, 205
  particle in a box, 64
  quantum simple harmonic oscillator, 59
  rigid rotor, 62

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE
Cambridge University Press
978-1-108-48078-9 — Essential Statistical Physics
Malcolm P. Kennett
Index
More Information

single particle, 56, 127, 128
uncoupled subsystems, 66
Pauli exclusion principle, 69, 116, 127, 190
Penzias, A. A., 167
periodic boundary conditions, 134, 162, 205
Petit, A. T., 80
phase of matter, 190
phase space, 16, 41–45, 61, 88
volume, 44
phase transition, 2, 173, 180, 190
first order, 201, 216
liquid–gas, 193, 212
second order, 201, 213, 216
phonons, 69, 80, 127, 150, 161, 174, 180, 181, 186, 189
photons, 69, 127, 161, 162, 180, 185
in the Sun, 2, 7
Physics Nobel Prize
1918, 166
1978, 167
1996, 175
2001, 173
2010, 158
Pippard, A. B., 149
Planck length, 38
Planck's constant, 165
Planck's formula, 61, 165, 167, 185
Planck, M. K. E. L., 165
Poincaré recurrence theorem, 30
polarization
longitudinal, 162
phonons, 181
photons, 162
transverse, 162
polyatomic molecules, 56, 72
polymer folding, 2, 7, 23, 38
potential difference, 103
pressure, 54, 92, 110, 111
bosons, 177, 188
Fermi gas, 145
ideal gas, 70
isotropic fluid, 94
momentum transfer, 92
Mount Everest, 105
partial, 111, 124
radiation, 168
pressure gradient
stellar interior, 154
principle of maximum entropy, 28, 29, 32
probability, 3
axioms, 3
microstates, 111
tree diagram, 4
probability density, 5, 88
incompressible, 44
phase space, 43
quantum, 126
probability distributions, 2, 5
central moments, 7
continuous, 5
discrete, 5
mean, 7
moments, 6
standard deviation, 7
variance, 7
proton, 67, 69, 154, 159

quantum concentration, 65, 109, 120, 171
quantum degeneracy, 140
quantum Hall effect, 115
fractional, 126, 159
quantum number, 16, 151, 188
quantum particles, 125, 126, 129, 136
quantum statistical mechanics, 65, 125
quantum statistics, 125
quasi-static process, 228
quasiparticle, 151

random walk, 7, 17, 21, 98
biased, 11, 23
one dimension, 7, 8
two dimensions, 7
unbiased, 11
randomness, 5
Raoult's law, 124
Rayleigh–Jeans formula, 166, 167
renormalization, 150
reservoir, 48
resistance, 103
reversible process, 227
Richardson, R. C., 175
Riemann zeta function, 164, 166, 239
rigid rotor, 62
linear, 62, 63
spherical, 62
symmetric, 62, 63
root mean squared (rms) distance, 11
rubidium-87, 174

Sackur, O., 71
Sackur–Tetrode equation, 71
Schottky anomaly, 58, 59
Schrödinger equation, 1, 16, 30, 64
separation of variables, 64, 161
Shubnikov de Haas oscillations, 149
simple harmonic oscillator, 16, 79
classical, 61, 162
quantum, 59
Sirius, 151
skew, 7
solar mass, 156
solar sail, 186
solid, 190
Sommerfeld expansion, 140, 144

© in this web service Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-1-108-48078-9 — Essential Statistical Physics
Malcolm P. Kennett
Index
More Information

sound speed, 181
  helium-4, 175
specific heat
  helium-4, 180
speed
  distribution in an ideal gas, 90
  most probable, 90
spin, 17, 69
  operator, 191
spin degeneracy, 87, 155
spin waves, 184
spin-statistics theorem, 126
spins, 2, 34
  in a magnetic field, 190
  non-interacting, 17, 190
spontaneous symmetry breaking, 214
standard deviation, 7
state
  thermodynamic, 229
state function, 228
statistical ensembles, 25, 41, 54
statistical mechanics, 1, 37, 55
steepest descents, 224
Stefan–Boltzmann constant, 170, 185
Stefan–Boltzmann law, 169, 170, 185
step function, 131
Stirling's formula, 11, 31, 34, 70, 222, 224
stock prices, 2, 7
strategy of least bias, 32
stress, 93
  shear, 94
  tensile, 94
stress tensor, 93, 94
Sun, 152
  luminosity, 186
superconductivity, 175, 190
superfluidity, 2, 161, 174, 175, 186, 190
  laboratory frame, 175
supernova, 153
  SN 2003fg, 156
symmetry breaking field, 214

tau lepton, 127
temperature, 28, 231
temporal average, 41, 45
tensor, 94
Tetrode, H. M., 71
thermal average, 133, 135
thermal contact, 26
thermal de Broglie wavelength, 65, 70
thermal energy, 35
thermally isolated system, 25
thermodynamic limit, 55, 147
thermodynamic potentials, 233
thermodynamics, 1, 26, 37, 55, 227
transfer matrix, 206
transport, 86, 102
two-level system, 56
  energy, 56
  fermions, 115
  heat capacity, 58
  partition function, 56

ultra-cold atoms, 25, 173
uncoupled subsystems, 65, 82
undistinguished particles, 128, 137
universality, 213
uranium, 95, 104
uranium hexafluoride, 63, 95

van der Waals equation of state, 75, 77, 83
vapour, 117
variance, 7
velocity
  root mean square, 90
viscosity, 105, 174
  superfluid, 175

W boson, 127, 214
water, 118
wavefunction, 125–127
white dwarf, 2, 151, 153, 156, 157
  Eridani B, 151
  interior, 155
  mass, 155
  Sirius B, 151
Wieman, C. E., 173
Wien's displacement law, 165
Wilson, R. W., 167
work, 229, 230

Z boson, 127, 214
zero temperature, 139

© in this web service Cambridge University Press www.cambridge.org