Index

AC susceptibility
magnetic measurements, 40–41
Néel–Brown equation, 40–41
acoustic tweezers, 108–9
standing acoustic wave (SAW) based acoustic tweezers, 108–9
two-dimensional particle and cell delivery, 109
active drug targeting, magnetic drug delivery, 112–15
aggregation of nanoparticles
Kendall growth law, 163–64
nanoparticle capture, 163–64
alcohols tests, quantification, 87–88
aldehydes/tosyl epoxides, 84–85
MNPs functionalization, 84–85
Ampère’s law, atomic magnetic moments, 3
anisotropic magnetoresistance (AMR), 184–85
detectivity limits, 204
sensor properties, 183–84
antiferromagnetism, 12–16, 18–19, see also ferromagnetism
aptamers, magnetic drug delivery, 118–20
aqueous co-precipitation routes
Massart method, 54–55
MNPs synthesis, 54–55
Arrott plots
Curie–Weiss law, 35–36
magnetic measurements, 35–36
temperature dependence of magnetization, 35–36
atomic magnetic moments, 3–7
Ampère’s law, 3
Bohr magneton, 3, 4–6
Hund’s rules, 4–6
Landé g-factor, 3–4
Pauli exclusion principle, 4–5
quantum mechanical wavefunction of two identical fermions, 4–5
quenching of the orbital angular momentum, 5–6
Russell–Saunders coupling, 4
total atomic moment, 4
atomic susceptibilities calculation, 9–16
antiferromagnetism, 12–16
diamagnetism, 9–10
ferromagnetism, 12–16
paramagnetism, 11
axial magneto-aerotaxis, magnetosomes, 258–60
Beer’s law, spectrophotometry, 87
Bingham fluid model, fluid and fluid flow, 154
biocompatibility of MNPs for use in vivo, 116–18
cell toxicity, 118
magnetic drug delivery, 116–18
positron emission tomography (PET), 117
single photon emission computed tomography (SPECT), 117
surface coating, MNPs, 117–18
biological molecules attachment, magnetosomes, 268
biomineralization of magnetosomes, 262–64
biosorbents for heavy metals, magnetotactic bacteria, 267
Bloch domain walls, 20–22
Bloch T3/2 law
magnetic measurements, 31–32
spontaneous magnetization, 31–32
Bloch wave, 8
Bohr magneton, atomic magnetic moments, 3, 4–6
Bohr radius, diamagnetism, 10
Brillouin function, ferromagnetism, 12–13
Brillouin zone, 8
Brownian relaxation, magnetization of nanoparticles, 30
camptothecin, magnetic drug targeting, 127–28
capture of nanoparticles, see nanoparticle capture
carbodiimides epoxides, 81
linker molecules, 81
self-assembled monolayers (SAMs), 72
Casson model, fluid and fluid flow, 155
catalytic tweezers, 104–8
applications, 107–8
performance improvement, 106
Index

288

cell separation, magnetosomes, 268
cell sorting and separation, magnetotactic bacteria, 267
cell toxicity
biocompatibility of MNCs for use in vivo, 118
magnetic drug delivery, 118
changes in the physical properties of materials, nanometer scale, 1
Clausius–Mossotti factor
electric tweezers, 100–2
rotating nanowires, 100–2
clustered magnetic nanoparticles, MR relaxivity, 240–43
coating effect, 244–45, see also gold-coated particles
MR relaxivity of MNP s, 236–37
collection of magnetic moments, crystals, 8
contrast agents
gadolinium complexes, 233
magnetic resonance imaging (MRI), 228–29, 233, 246
MNP s for MRI contrast agents, 228–29
relaxation, MRI contrast agents, 233
types, 233
co-precipitation, MNP s synthesis, 115–16
critical exponents of phase transitions, magnetic measurements, 38–40
crystals, collection of magnetic moments, 8
Curie–Weiss law
Arrott plots, 35–36
ferromagnetism, 12–13
magnetic measurements, 35–36
temperature dependence of magnetization, 35–36
de Broglie wavelength of the electron, 1

detecting MNRs
configurations, MR sensors, 195–96
detectivity limits, 201–4
fringe fields, 195–96
magnetoresistive (MR) sensors, 195–201
principle, MR sensors, 195–96
detectivity limits
anisotropic magnetoresistance (AMR), 204
giant magnetoresistance (GMR), 204
magnetoresistive (MR) sensors, 201–4
non-white noise, 203–4
sensor noise, 201–4
shot noise, 202–3
spin valves (SV), 204
thermal noise, 202–3
tunnel magnetoresistance (TMR), 204
white noises, 202–3
diamagnetism, 9–10
atomic susceptibilities calculation, 9–10
Bohr radius, 10
diamagnetic susceptibility of some materials around 293 K, 111.4
examples of diamagnets, 10
Landau diamagnetism, 10
Landau susceptibility, 10
Larmor diamagnetism, 9, 10
Lenz’s law, 9
sources of diamagnetism, 10
dipole magnets, magnetic drug targeting, 124
doxorubicin, magnetic drug targeting, 127–28
drug targeting, see magnetic drug delivery; magnetic drug targeting
eigenstates, 2
electric tweezers, 96–103
applications, 99–103
Clausius–Mossotti factor, 100–2
rotating nanowires, 98–103
transporting nanocapsules, 102–3
transporting nanowires, 96–98, 99
electrochemical deposition
gold-coated particles, 76–78
photolithography, 76–78
electrochemical potential for electrons (Fermi level), 1
enzyme immobilization, magnetosomes, 268
epichlorohydrin, epoxides, 79–80
epoxides, 79–85
aldehydes/tosyl, 84–85
carbodiimides, 81
epichlorohydrin, 79–80
ethanolamine, 79
linker molecules, 81–83
MNP s functionalization, 79–85
organic vs. aqueous, 80–81
spacer molecules, 84
SU8 epoxy resin, 79
tosyl/aldehydes, 84–85
ESIONs (extremely small iron oxide nanoparticles), MR relaxivity of MNP s, 238, 246
ethanolamine, epoxides, 79
exchange (bias) anisotropy, 18–19
externally applied magnetic field
aggregation of nanoparticles, 163–64
nanoparticle capture, 160–64
nature of, 160–63
extremely small iron oxide nanoparticles (ESIONs), MR relaxivity of MNP s, 238, 246
Fehling’s test (for aldehydes), quantification, 87
Fermi function, paramagnetism, 11
Fermi level (electrochemical potential for electrons), 1
ferrimagnetic iron oxide nanoparticles (FIONs), MR relaxivity of MNP s, 236–37, 246
ferrite nanoparticles, composition effects, MR relaxivity of MNP s, 238
ferromagnetic nanoparticles, MR relaxivity, 239–40
ferromagnetism, 12–16
atomic susceptibilities calculation, 12–16
Brillouin function, 12–13
Curie–Weiss law, 12–13
exchange interactions, 13–15
Hamiltonian of the system, 13–14
Heisenberg exchange mechanism, 13–14
magnons, 15–16
Ruderman–Kittel–Kasuya–Yosida (RKKY) model, 15
Stoner criterion, 14–15
susceptibility of local moments, 12–13
Weiss molecular field, 12–13
Zeeman energy, 12–13
field dependence of the order parameter along the critical isotherm, magnetic measurements, 37
FIONs (ferrimagnetic iron oxide nanoparticles), MR relaxivity of MNPs, 236–37, 246
fluid and fluid flow
Bingham fluid model, 154
Casson model, 155
Herschel–Bulkley fluid model, 154, 155
mammalian vasculature, 155–56
nanoparticle capture, 152–56
Navier–Stokes equations, 155–56
Newtonian fluid behavior, 152–56
fluorescence quenching/enhancement, gold-coated particles, 76
force balance, MNPs modeling, 158–60
fringe fields, detecting MNRs, 195–96
Fullprof profile refinement program, structural analysis, 46
functionalization of MNCs for in vivo drug targeting, 118–20
future directions of research, 270–71
gadolinium complexes, magnetic resonance imaging (MRI), 233
gas and solid routes
laser pyrolysis of carbonyl precursors, 61–62
MNPs synthesis, 61–62
genomics of magnetotactic bacteria, 260–61
giant magnetoresistance (GMR) biosensor prototypes, 214–18
magnetic fields present, 215
sensing of living systems, 218
sensor sensitivity, 211–12
sensors in microfluidic systems, 219–20
giant magnetoresistance (GMR), 186–88
detectivity limits, 204
sensor properties, 183–84
spin valves (SV), 187–88
GMI, see giant magnetoimpedance
GMR, see giant magnetoresistance
gold/SU8 microcarrier, MNPs functionalization, 88
gold-coated particles, 68–79, see also coating effect
alternative directions, 78–79
chemical suppliers, 76
electrochemical deposition, 76–78
fluorescence quenching/enhancement, 76
mixed SAMs, 73–75
MNPs functionalization, 68–79
photolithography, 76–78
SAM monomers, 70–73
self-assembled monolayers (SAMs), 68–75
growth under confinement
MNPs synthesis, 57–58
reverse microemulsions, 57–58
Halbach arrays, magnetic drug targeting, 124–25
Hall effect, 172–77
discovery, 172
quantifying the Hall effect, 173–74
Hall effect biosensors, 179–81
compound semiconductors, 179
integrated current lines for rapid detection, 179–81
MNPs detection for medical diagnostics, 179–81
silicon-based bio-Hall sensors, 179
Hall effect sensors
advantages, 177
applications, 172–73
design considerations, 176–77
material selection, 174–76
sensitivity, 174–76
sensor arrangements, 177
thermal stability, 176–77
Hamiltonian of the system, ferromagnetism, 13–14
Hartree–Fock approximation, paramagnetism, 11
Hartree–Fock method, 3
Heisenberg exchange mechanism, ferromagnetism, 13–14
Herschel–Bulkley fluid model, fluid and fluid flow, 154, 155
high gradient magnetic separation (HGMS), magnetic drug targeting, 122, 125
hot organic solvents, MNPs synthesis, 55–57
Hund’s rules
atomic magnetic moments, 4–6
calculation, 46
hydrodynamic size, magnetic nanoparticles (MNPs), 53
hydrogels, MNPs synthesis, 59–60
hydrothermal synthesis, MNPs synthesis, 116
hyperthermia, magnetic, magnetic drug targeting, 125–26, 269
inorganic matrices
MNPs synthesis, 60–61
Stöber method, 60
iron oxides, magnetic nanoparticles (MNPs), 52–53
Kaiser test (for primary amines), quantification, 86–87
Kendall growth law, aggregation of nanoparticles, 163–64
Kretschmann–Raether configuration, plasmonic micro-trapping, 111
Landau diamagnetism, 10
Landau susceptibility, 10
Landau theory, magnetic measurements, 35–36
Landau–Lifshitz–Gilbert (LLG) equation, magnetization reversal, 25–26
Landé g-factor, atomic magnetic moments, 3–4
Langevin equation magnetization of nanoparticles, 27, 30
superparamagnets analysis, 12
Larmor (molar) diamagnetic susceptibility, calculation, 47
Larmor diamagnetism, 9, 10
laser pyrolysis of carbonyl precursors, MNPs synthesis, 61–62, 116
Lenz’s law, diamagnetism, 9
linker molecules, 81–83
carbodiimides, 81
cyclisation, 82–83
electrophiles, 81–83
epoxides, 81–83
homo-bifunctional linkers, 81
MNPs functionalization, 81–83
nucleophiles, 81–83
liposomes, MNPs synthesis, 58–59
loading level, MNPs functionalization, 88
localized surface plasmon (LSP), plasmon nano-optical tweezers, 109–10
macroscopic considerations, 7–8
magnetic antibodies, magnetosomes, 268
magnetic domains, 19–26
Bloch domain walls, 20–22
classification, 20
domain walls, 20–22
magnetization reversal, 22–26
Néel domain walls, 20–22
neutron scattering, 20
magnetic drug delivery, 112–34
active drug targeting, 112–15
antibodies, 118–20
aptamers, 118–20
biocompatibility of MNCs for use in vivo, 116–18
cell toxicity, 118
functionalization of MNPs for in vivo drug targeting, 118–20
magnetic drug targeting, 120–34
MNPs as the base unit, 115–16
MNPs synthesis, 115–16
passive drug targeting, 112–15
peptides, 118–20
positron emission tomography (PET), 117
single photon emission computed tomography (SPECT), 117
surface coating, MNCs, 117–18
virus–MNP hybrids, 120
magnetic drug targeting, 120–34
camptothecin, 127–28
dipole magnets, 124
doxorubicin, 127–28
forces, 121–25
Halbach arrays, 124–25
high gradient magnetic separation (HGMS), 122, 125
hyperthermia, magnetic, 269
magnetic hyperthermia, 125–26
magnetic induced therapy, 132
magnetic resonance imaging (MRI), 132–34
magnetically induced drug release, 128
magnetofection, 132
methotrexate–MNP conjugates, 127–28
Niobe® Stereotaxis System, 124–25
paclitaxel, 127–28
studies, 127–28, 134
thermoablation, 125–26, 269
magnetic force for transporting nanoparticles, magnetic tweezers, 94
magnetic hyperthermia, magnetic drug targeting, 125–26
magnetic induced therapy, magnetic drug targeting, 132
magnetic measurements, 30–44
AC susceptibility, 40–41
Arrrott plots, 35–36
Bloch T3/2 law, 31–32
critical exponents of phase transitions, 38–40
critical phenomena, 36–40
Curie–Weiss law, 35–36
field dependence of the order parameter along the critical isotherm, 37
Landau theory, 35–36
magnetocaloric effect, 32–34
magnetometers, 30–31
Mössbauer spectroscopy, 41–42
neutron scattering, 37–40, 42–44
specific heat, 37
spin density fluctuations close to Tc, thermal variation, 37–40
spontaneous magnetization, 31–32
temperature dependence of magnetization, 31–36
thermal dependence of the initial susceptibility, 37
thermal dependence of the order parameter, 36–37
X-ray magnetic circular dichroism (XMCD), 44
magnetic nanoparticles (MNPs)
force balance, 158–60
hydrodynamic size, 53
iron oxides, 52–53
medical applications, 269
MNPs for MRI contrast agents, 228–29
nature of, 156–60
properties re MRI, 234–36
synthesis, see synthesis of MNPs
toxicity, 245–46
magnetic relaxation switch (MRS), MR relaxivity of MNPs, 241
magnetic resonance imaging (MRI), see also MR relaxivity of MNPs
contrast agents, 228–29, 233, 246
detection, 230–31
gadolinium complexes, 233
magnetic drug targeting, 132–34
MNPs properties, 234–36
potentials, 230
principles, 228–29
proton alignment, 230
relaxation, 231–32
relaxation, MRI contrast agents, 233
spatial information, 232
magnetic tweezers, 94–96
magnetic force for transporting nanoparticles, 94
rotating nanowires, 94–96
unique applications, 94
Magnetically Induced Drug Release, magnetic drug targeting, 128
magnetization of nanoparticles, 26–30
Brownian relaxation, 30
Langevin equation, 12, 27, 30
Néel relaxation time, 27
Stern–Gerlach type experiment, 28
superparamagnetic relaxation, 30
magnetization processes, 16–30
exchange (bias) anisotropy, 18–19
magnetic anisotropies, 16–19
magnetic domains, 19–26
magnetization of nanoparticles, 26–30
magneto-crystalline anisotropy constants, 17t1.6
magneto-elastic anisotropy, 18
magnetization reversal
Landau–Lifshitz–Gilbert (LLG) equation, 25–26
magnetic domains, 22–26
magnetization dynamics, 24–26
Néel relaxation time, 24–26
Néel–Brown equation, 24–26
thin films and particles, 22–24
magneto-aerotaxis, magnetoosmesomes, 257–60
magnetoelastic effect
magnetic measurements, 32–34
temperature dependence of magnetization, 32–34
magneto-crystalline anisotropy constants, 17t1.6
magneto-elastic anisotropy, 18
magnetofoction, magnetic drug targeting, 132
magnetotipedance, 208–11
magnetotipedance biosensors, 206–20
development, 206–8
GMI biosensor prototypes, 214–18
GMI sensing of living systems, 218
GMI sensor sensitivity, 211–12
GMI sensors in microfluidic systems, 219–20
magnetism related sensing steps, 207–8
magnetotipedance, 208–11
MNPs synthesis, 212–13
magnetometers, 30–31
magneto-optical Kerr effect (MOKE), 30–31
superconducting quantum interference device (SQUID), 30–31
magneto-optical Kerr effect (MOKE), magnetometers, 30–31
magnetoresistive (MR) sensors, 181–201
advantages, 205–6
anisotropic magnetoresistance (AMR), 183–85
applications, 205–6
competing technologies, 205–6
configurations, 195–96
detecting MNRs, 195–201
detectivity limits, 201–4
fringe fields, 195–96
giant magnetoresistance (GMR), 183–84, 186–88
non-white noise, 203–4
principle, 195–96
censor noise, 201–4
shot noise, 202–3
technological development, 205–6
thermal noise, 202–3
tunnel magnetoresistance (TMR), 183–84,
189–92
types, 183–84
white noises, 202–3
magneto-resistive effect, 181–92
magneto-resistive sensor linearization, 192–95
Stoner–Wohlfarth model, 194
magnetosomes, 251, see also magnetotactic bacteria
applications, 267–70
arrangement, 255–57
axial magneto-aerotaxis, 258–60
biological molecules attachment, 268
biomineralization, 262–64
cell separation, 268
composition, 255–57
catalysis inactivation, 268
catalysis function, 257–60
catalysis magnetic antibodies, 268
catalysis magneto-aerotaxis, 257–60
magnetosomes, 257–60
magnetosomes, 257–60
morphology, 255–57
nanobodies, 269
nucleic acids isolation, 269
polar magneto-aerotaxis, 258–60

Index

magnetosomes (cont.)
proteins applications, 268–69
puriﬁcation, 265–66
size, 255–57
toxicity, 270
*Magneto*spirillum spp.
bio-mineralization of magnetosomes, 262–64
magnetosomes puriﬁcation, 265–66
mass culture, 265–66
magnetotactic bacteria, 251–71, see also magnetosomes
applications, 267–70
biosorbents for heavy metals, 267
cell sorting and separation, 267
defined, 251
distribution, 253–54
diversity, 251, 252–55
genomics, 260–61
mass culture, 265–66
meteorites/rocks magnetic poles
determination, 251
micro-robots applications, 267
nitrogen ﬁxation, 254–55
phylogeny, 252–55
physiology, 252–55
sulfur compounds metabolism, 254
toxicity, 270
magnetotaxis, magnetosomes, 257–60
magnons, ferromagnetism, 15–16
mammalian vasculature, ﬂuid and ﬂuid low, 155–56
manipulation, see magnetic drug delivery; tweezers
Massart method, MNPs synthesis, 54–55
Maxwell’s equations, nanoparticle capture, 160–61
medical applications, MNPs, 269
medical diagnostics, Hall effect biosensors, MNPs detection, 179–81
mesoporous silica nanoparticle (MSN), MR relaxivity of MNPs, 242–45
metal-organic frameworks (MOFs), MNPs synthesis, 60
meteorites/rocks magnetic poles determination, magnetotactic bacteria, 267
methotrexate–MNP conjugates, magnetic drug targeting, 127–28
micelle microemulsion, MNPs synthesis, 116
micelles, MNPs synthesis, 58–59
micro-robots applications, magnetotactic bacteria, 267
MNPs, see magnetic nanoparticles
MOFs (metal-organic frameworks), MNPs synthesis, 60
Mössbauer spectroscopy
magnetic measurements, 41–42
superparamagnetic relaxation, 41–42
MR relaxivity of MNPs, 236–45
clustered MNPs, 240–43
coating effect, 243–45
control, 236–45
extremely small iron oxide nanoparticles (ESIONs), 238, 246
ferrimagnetic iron oxide nanoparticles (FIONs), 236–37
ferrite nanoparticles, composition effects, 238
ferromagnetic nanoparticles, 239–40
magnetic relaxation switch (MRS), 241
mesoporous silica nanoparticle (MSN), 242–43
size-dependent MR relaxivity, 236–38
MRI, see magnetic resonance imaging
MRS (magnetic relaxation switch), MR relaxivity of MNPs, 241
MSN (mesoporous silica nanoparticle), MR relaxivity of MNPs, 242–43
nanobodies, magnetosomes, 269
nanocapsules, transporting, electric tweezers, 102–3
nanocomposites from solution routes, MNPs synthesis, 58–61
nanogels, MNPs synthesis, 59–60
nanomaterial scale, changes in the physical properties of materials, 1
nanoparticle capture, 151–68
aggregates capture, 164–68
aggregation of nanoparticles, 163–64
capture angle approach, 164–66
capture of nanoparticles or nanoparticle aggregates, 164–68
externally applied magnetic ﬁeld, 160–64
fluid and ﬂuid low, 152–56
Maxwell’s equations, 160–61
MNPs modeling, 156–60
MNPs, nature of, 156–60
modeling considerations, 151
Newtonian ﬂuid behavior, 152–56
partial capture, 166–68
physical mechanisms, 151–68
total capture, 166–68
nano-trapping with plasmonic antennas, tweezers, 111
nanowires, rotating
electric tweezers, 98–103
magnetic tweezers, 94–96
nanowires, transporting, electric tweezers, 96–98, 99
Navier–Stokes equations, fluid and ﬂuid low, 155–56
Néel domain walls, 20–22
Néel relaxation time
magnetization of nanoparticles, 27
magnetization reversal, 24–26
Index

Néel–Brown equation, 40–41
AC susceptibility, 40–41
magnetization reversal, 24–26
neutron scattering
magnetic domains, 20
magnetic measurements, 37–40, 42–44
Ninhydrin test (for primary amines),
quantification, 86–87
Niobe® Stereotaxis System, magnetic drug
targeting, 124–25
non-white noise
detectivity limits, 203–4
magnetoresistive (MR) sensors, 203–4
nucleic acids isolation, magnetosomes, 269
nucleic acids, RNA transcription, optical
tweezers, 93
optical tweezers, 91–94
advantages, 94
Rayleigh particle gradient force, 91–92
RNA transcription, 93
scattering force, 92–93
optoelectronic tweezers, 103
organic matrices, MNPs synthesis, 58–60
hydrogels, 59–60
liposomes, 58–59
metal-organic frameworks (MOFs), 60
micelles, 58–59
nanogels, 59–60
polymer matrices, 58
solid lipid nanoparticles, 59–60
organized surfactant assemblies, MNPs
synthesis, 57–58
paclitaxel, magnetic drug targeting, 127–28
paramagnetism
atomic susceptibilities calculation, 11
Fermi function, 11
Hartree–Fock approximation, 11
paramagnetic susceptibility of some transition
metals around 293 K, 11
Zeeman splitting, 11
passive drug targeting, magnetic drug delivery,
112–15
Pauli exclusion principle, atomic magnetic
moments, 4–5
peptides, magnetic drug delivery, 118–20
PET, see positron emission tomography
photoelectron emission microscopy (PEEM),
structural analysis, 45
photolithography
alternative directions, 78–79
electrochemical deposition, 76–78
gold-coated particles, 76–78
plasmonic nano-optical tweezers, 109–10
localized surface plasmon (LSP), 109–10
surface plasmon polariton (SPP), 109–10
plasmonic micro-trapping, tweezers, 111
polar magneto-aerotaxis, magnetosomes,
258–60
polymer matrices, MNPs synthesis, 58
positron emission tomography (PET)
bio-compatibility of MNCs for use in vivo, 117
magnetic drug delivery, 117
productivity (yield), MNPs synthesis, 63
proteins applications, magnetosomes, 268–69
quantification, 85–88
alcohols tests, 87–88
Fehling’s test (for aldehydes), 87
Kaiser test (for primary amines), 86–87
MNPs functionalization, 85–88
Ninhydrin test (for primary amines), 86–87
spectrophotometry, 87
quantum mechanical concepts, 2–3
quantum mechanical wavefunction of two identical
fermions, 4–5
quenching of the orbital angular momentum, atomic
magnetic moments, 5–6
Rayleigh particle, gradient force, 91–92
relaxivity of MNPs, MR, see MR relaxivity
of MNPs
research future directions, 270–71
reverse microemulsions, MNPs synthesis, 57–58
RNA transcription, optical tweezers, 93
rocks/meteors magnetic poles determination,
magnetotactic bacteria, 267
rotating nanowires
electric tweezers, 98–103
magnetic tweezers, 94–96
Ruderman–Kittel–Kasuya–Yosida (RKKY) model,
ferromagnetism, 15
Russell–Saunders coupling, atomic magnetic
moments, 4
SAMs, see self-assembled monolayers
SAW (standing acoustic wave) based acoustic
tweezers, 108–9
Schrödinger equation, 2–3
self-assembled monolayers (SAMs)
amines, 72
biotin, 73
carbodiimides, 72
carboxylic acids, 72
chain, 71
chemical suppliers, 76
gold-coated particles, 68–75
head groups, 71–73
hydroxyl, 71
mixed SAMs, 73–75
NHS esters, 73
SAM monomers, 70–73
tail groups, 70–71
self-induced back-action (SIBA) trapping, tweezers, 111–12
sensor noise, detectivity limits, 201–4
shot noise
detectivity limits, 202–3
magnetoresistive (MR) sensors, 202–3
SIBA (self-induced back-action) trapping, tweezers, 111–12
silicon-based bio-Hall sensors, 179
single photon emission computed tomography (SPECT)
biocompatibility of MNCs for use in vivo, 117
magnetic drug delivery, 117
solid lipid nanoparticles, MNPs synthesis, 59–60
solid routes, MNPs synthesis, 62
spacer molecules
epoxides, 84
MNPs functionalization, 84
specific heat, magnetic measurements, 37
SPECT, see single photon emission computed tomography
spectrophotometry
Beer’s law, 87
quantification, 87
spin density fluctuations close to $T_c$, thermal variation, magnetic measurements, 37–40
spin valves (SV)
detectivity limits, 204
giant magnetoresistance (GMR), 187–88
spontaneous magnetization
Bloch T3/2 law, 31–32
magnetic measurements, 31–32
temperature dependence of magnetization, 31–32
SPP (surface plasmon polariton), plasmon nano-optical tweezers, 109–10
standing acoustic wave (SAW) based acoustic tweezers, 108–9
Stern–Gerlach type experiment, magnetization of nanoparticles, 28
Stöber method, MNPs synthesis, 60
Stoner criterion, ferromagnetism, 14–15
Stoner–Wohlfarth model, magnetoresistive sensor linearization, 194
structural analysis, 45–46
Fullprof profile refinement program, 46
photoluminescence emission microscopy (PEEM), 45
transmission electron microscopy (TEM), 45
studies, magnetic drug targeting, 127–28, 134
SU8 epoxy resin, 79
gold/SU8 microcarrier, 88
superconducting quantum interference device (SQUID), magnetometers, 30–31
superparamagnetic relaxation
magnetization of nanoparticles, 30
Mössbauer spectroscopy, 41–42
superparamagnetism, 30, 115
bead array counter concept, 207
superparamagnetic beads (SPBs), 179, 195–96, 219–20
superparamagnetic behavior, 194–95
superparamagnetic labels, 207–8
superparamagnetic nanoparticles, 234–36
surface coating, MNCs, see gold-coated particles
biocompatibility of MNCs for use in vivo, 117–18
magnetic drug delivery, 117–18
surface plasmon polariton (SPP), plasmon nano-optical tweezers, 109–10
SV, see spin valves
synthesis of MNPs, 52–63, 115–16
aqueous co-precipitation routes, 54–55
co-precipitation, 115–16
gas and solid routes, 61–62
growth under confinement, 57–58
hot organic solvents, 55–57
hydrothermal synthesis, 116
inorganic matrices, 60–61
laser pyrolysis of carbonyl precursors, 61–62, 116
magnetoimpedance biosensors, 212–13
Massart method, 54–55
micelle microemulsion, 116
nanocomposites from solution routes, 58–61
organic matrices, 58–60
organized surfactant assemblies, 57–58
particle aggregation prevention, 116
reverse microemulsions, 57–58
solid routes, 62
Stöber method, 60
$T_1$ (positive) contrast agents, 61
thermal decomposition, 116
yield (productivity), 63
$T_1$ (‘positive’) contrast agents, MNPs synthesis, 61
targeting, drug, see magnetic drug delivery;
magnetic drug targeting
TEM (transmission electron microscopy), structural analysis, 45
temperature dependence of magnetization, 31–36
Arrott plots, 35–36
Curie–Weiss law, 35–36
magnetocaloric effect, 32–34
spontaneous magnetization, 31–32
thermal decomposition, MNPs synthesis, 116
thermal dependence of the initial susceptibility,
magnetic measurements, 37
thermal dependence of the order parameter,
magnetic measurements, 36–37
thermal noise
detectivity limits, 202–3
magnetoresistive (MR) sensors, 202–3
thermoablation, magnetic drug targeting, 125–26, 269
TMR, see tunnel magnetoresistance
tosyl/aldehydes epoxides, 84–85
MNPs functionalization, 84–85
toxicity cell toxicity, biocompatibility of MNCs for use in vivo, 118
magnetic nanoparticles (MNPs), 245–46
magnetosomes, 270
magnetotactic bacteria, 270
transmission electron microscopy (TEM), structural analysis, 45
transporting nanocapsules, electric tweezers, 102–3
transporting nanowires, electric tweezers, 96–98, 99
tunnel magnetoresistance (TMR), 189–92
detectivity limits, 204
sensor properties, 183–84
tweezers, 91–112
acoustic tweezers, 108–9
catalytic tweezers, 104–8
electric tweezers, 96–103
magnetic tweezers, 94–96
nano-trapping with plasmonic antennas, 111
optical tweezers, 91–94
optoelectronic tweezers, 103
plasmonic nano-optical tweezers, 109–10
plasmonic micro-trapping, 111
self-induced back-action (SIBA) trapping, 111–12
two-dimensional particle and cell delivery, acoustic tweezers, 109
ultrasmall superparamagnetic iron oxide nanoparticles (USPIO), MR relaxivity of MNPs, 238
virus-MNP hybrids, magnetic drug delivery, 120
Weiss molecular field, ferromagnetism, 12–13
white noises detectivity limits, 202–3
magnetoresistive (MR) sensors, 202–3
shot noise, 202–3
thermal noise, 202–3
X-ray magnetic circular dichroism (XMCD), magnetic measurements, 44
yield (productivity), MNPs synthesis, 63
Zeeman energy, ferromagnetism, 12–13
Zeeman splitting Mössbauer spectroscopy, 41–42
paramagnetism, 11