

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
- antibodies, magnetic drug delivery, 118–20
- 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 MNCs 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, MNCs, 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 T_{3/2} 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

- 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 MNPs, 236–37
- collection of magnetic moments, crystals, 8
- contrast agents
- gadolinium complexes, 233
 - magnetic resonance imaging (MRI), 228–29, 233, 246
 - MNPs for MRI contrast agents, 228–29
 - relaxation, MRI contrast agents, 233
 - types, 233
- co-precipitation, MNPs 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
 - magneto-resistive (MR) sensors, 195–201
 - principle, MR sensors, 195–96
- detectivity limits
- anisotropic magnetoresistance (AMR), 204
 - giant magnetoresistance (GMR), 204
 - magneto-resistive (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, 11t1.4
 - 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
 - MNPs 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 MNPs, 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 MNPs, 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 MNPs, 236–37, 246
- ferrite nanoparticles, composition effects, MR relaxivity of MNPs, 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 MNPs, 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 magnetoimpedance (GMI)
 - 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 MNCs 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
Arrott plots, 35–36
Bloch T_{3/2} 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 *T_c*, 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, magnetosomes, 257–60
- magnetocaloric effect
 - magnetic measurements, 32–34
 - temperature dependence of magnetization, 32–34
- magneto-crystalline anisotropy constants, 17t1.6
- magneto-elastic anisotropy, 18
 - magnetofection, magnetic drug targeting, 132
- magnetoimpedance, 208–11
- magnetoimpedance 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
 - magnetoimpedance, 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
- magneto-resistive (MR) sensors, 181–201
 - advantages, 205–6
 - anisotropic magneto-resistance (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 magneto-resistance (GMR), 183–84, 186–88
 - non-white noise, 203–4
 - principle, 195–96
 - sensor noise, 201–4
 - shot noise, 202–3
 - technological development, 205–6
 - thermal noise, 202–3
 - tunnel magneto-resistance (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
 - enzyme immobilization, 268
 - function, 257–60
 - magnetic antibodies, 268
 - magneto-aerotaxis, 257–60
 - magnetotaxis, 257–60
 - morphology, 255–57
 - nanobodies, 269
 - nucleic acids isolation, 269
 - polar magneto-aerotaxis, 258–60

- magnetosomes (*cont.*)
 proteins applications, 268–69
 purification, 265–66
 size, 255–57
 toxicity, 270
- Magnetospirillum* spp.
 biomineralization 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, 267
 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 flow,
 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, 242–43
- 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
- nanometer 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 flow, 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 flow,
 155–56
- Néel domain walls, 20–22
- Néel relaxation time
 magnetization of nanoparticles, 27
 magnetization reversal, 24–26

- Néel–Brown equation
 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
- plasmon 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)
 biocompatibility 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/meteorites 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
 hydroxyls, 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 T_{3/2} 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
 - photoelectron 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
 - T1 (positive) contrast agents, 61
 - thermal decomposition, 116
 - yield (productivity), 63
- T1 ('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
plasmon 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