

# Subject Index

- Absorber thickness 37
- Absorbers 37
- Accuracy 19
- Activation energy 168, 192
- Ag-Sn alloys 233
- Albedo 170, 180
- Al-Fe alloys 223
- Al<sub>3</sub>Fe 223
- Al<sub>6</sub>Fe 225, 227
- Al<sub>13</sub>Fe<sub>4</sub> 225, 227
- Al<sub>6</sub>Mn 227
- α-Iron 214
- Amorphous alloys 231
- Amplitude of electric field vector 102
- Analyzer 45
- Angular dependence, hyperfine interaction 25, 28, 117
- Anorthosite 183
- Antiferromagnetic coupling 161, 164
- Antiferromagnetic γ-Fe 229
- Apollo 11 170-172, 175, 178, 179, 182
- Apollo 12 172, 173, 179, 180
- Apollo 14 182, 193
- Apollo 15 185
- Apollo 17 178
- Arrhenius relationship 192
- Asymmetry parameter 60, 100
- Atomic arrangement in alloys 208
- Augite (Ca, Mg, Fe)SiO<sub>3</sub> 184, 185, 189
- Austenite 214, 223
- Au-Fe alloys 222
- Au-Ni system 223
  
- Bacterial ferredoxin 163**
- Basalt (cf. also mare basalt) 183
- bcc lattice 215
- Biological molecules 139
- Biology 139
- Birefringence rotation 45
- Boltzmann equation 85
- Bonding 70
- Breit-Wigner formula 20
  
- Carbides 216
- Carbon steel 213
- Ca<sub>2</sub>Fe<sub>2</sub>O<sub>5</sub> 122
- Cementite (Fe<sub>3</sub>C) 216, 231
- Chain silicates 184
- Chemical bond 69
- Chemical information 67
- Chemical shift 22, 55
- Clebsch-Gordan coefficient 66, 102
- Clinopyroxene (Ca, Mg, Fe)SiO<sub>3</sub> 173, 175, 178, 183, 192
- Clustering of carbon 221
- Complex spectra 105
- Composition determination 111
- Cooling history 192
- Cooling rate 192
- Covalency 79
- Covalency effect 67
- Covalency parameter 87
- Covalent iron(II) compounds 88
- Covalent transition metal complexes 75
- Coulombic interaction 55
- Cross section 20
- Cu-rich alloys 233
- Curie temperatures 223
  
- Debye model 12**
- Debye temperature 12
- Debye-Waller factor 15, 16
- Detectors 40
- Diffusion 20, 233
- Diffusion coefficient 233
- Dipolar contribution to internal magnetic field 106
- Discovery 1
- Dislocation 234
- Dispersion 46
- Displacement energy 13
- Disorder (cf. order-disorder) 191, 193
- Distribution coefficient 191, 192
- Distribution of hyperfine fields 229
- Doppler effect 6, 38

- Doppler broadening 9  
 Drive systems 38
- Eigenvector coefficients** 102  
 Einstein model 12  
 Einstein oscillator 12  
 Einstein temperature 12  
 Electric field gradient (EFG) 26, 59, 99, 206, 222  
 Electric field gradient tensor 59  
 Electric monopole interaction 22, 54, 55  
 Electric quadrupole interaction 26, 54, 58, 99  
 Electric quadrupole moment 26, 59  
 Electric quadrupole splitting 26, 63, 206  
 Electron configuration 67  
 Electron density 22, 56  
 Electronegativity 67  
 Electron-spin relaxation 146  
 Electronic structure 83  
 Electrostatic potential 56  
 Emission process 4  
 Energy conservation 4  
 Energy levels, paramagnetic ion 145  
 $\epsilon$  ( $\text{Fe}_2\text{C}$ ) phase 216  
 EPR and Mössbauer spectra 144  
 $\text{ErFeO}_3$  125  
 Exchange reaction ( $\text{Mg}^{2+}$ ,  $\text{Fe}^{2+}$ ) 191, 192  
 Excited state 10
- Faraday effect** 46  
 fcc lattice 215  
 $\text{Fe}^{57}$  decay scheme 36  
 Fe in  $\beta$ -Ti 234  
 Fe in Cu, Au 226  
 Fe-Al alloys 224, 225  
 $\text{FeAl}$  (B2) 224  
 $\text{Fe}_3\text{Al}$  ( $\text{DO}_3$ ) 224  
 Fe-Be alloys 227  
 Fe-Be system 205  
 Fe-C system 213  
 $\text{Fe}^{3+}/\text{Fe}^{2+}$  ratio 179, 194, 196  
 Fe-N system 213  
 Fe-Ni-Al alloys 227  
 $\text{FeOCl}$  131  
 $\text{Fe}_{80}\text{P}_{13}\text{C}_7$ ,  $\text{Fe}_{80}\text{P}_{17}\text{C}_3$  231  
 Fe-Si alloys 224  
 Fermi contact term 106  
 Ferredoxin 153, 159  
 Ferromagnetic iron-rich alloys 221  
 Ferrous fluosilicate 158  
 First-order perturbation theory 63
- Fluctuating fields 31  
 Fra Mauro formation 194
- $\gamma$ -Ray detectors 40  
 $\gamma$ -Ray optics 46  
 Goldanskii-Karyagin effect 28, 230  
 Gravitational red shift 33  
 Ground state 10
- Hadley Rille** 185  
 Hamiltonian, hyperfine interaction 101  
 Hartree-Fock calculation 69  
 Heme group 147  
 Heme proteins 141, 147  
 Hemoglobin 147  
 High potential iron protein 153, 163  
 High spin complexes 75, 83  
 High spin ferric 143, 151  
 High spin ferrous 143, 149  
 Homogeneity in sample 111  
 Hybrid orbitals 70, 75  
 Hyperfine interaction 16, 21, 53, 99, 144  
 Hyperfine interaction Hamiltonian 101  
 Hyperfine parameters 16, 99  
 — — in  $\text{FeTiO}_3$  108  
 Hyperfine splitting in  $\text{Fe}^{57}$  17, 118  
 Hyperfine structure 99  
 — —,  $\text{Fe}^{57}$  103
- Ideal solution** 192  
 Ilmenite ( $\text{FeTiO}_3$ ) 107, 113, 172, 175, 178, 179, 183  
 Intensity, Mössbauer line 16  
 Intermetallic compounds 73  
 Internal magnetic field 24, 99, 204  
 Interstitial carbon atoms 220  
 Interstitial solid solutions 211  
 Interstitial solute carbon 214  
 Invar alloys 227  
 Iodine compounds 70  
 Iron compounds 67  
 Iron(II) high spin compounds 73  
 Iron proteins 141  
 Iron-rich alloys 211  
 Iron sulphur proteins 153  
 Isomer shift 16, 22, 55, 105, 206  
 Isotopes 7, 34  
 Isotopic abundance 7
- Jahn-Teller theorem** 85  
 Jump frequency 234
- Kamakite** (Ni-Fe alloy) 180

- Landé splitting factor 65  
 Laplace's equation 60  
 Larmor precession time 32  
 Lattice vibrational anisotropy 28  
 Lava flow 183, 193  
 Lava lake 183  
 Lifetime 19  
 Ligands 73, 143  
 Ligand/lattice contribution 60  
 Line intensity 25  
 Line width 16, 18  
 Linearly polarized  $\gamma$ -rays 43  
 Lorentzian line 20, 208  
 Low spin complexes 83  
 Low spin ferric 143, 150  
 Low spin ferrous 143, 148  
 Low temperature 32  
 Low temperature martensite 218  
 Luna 16 179, 182  
 Lunar basalts 192  
 Lunar fines 171  
 Lunar geology 167  
 Lunar glass 171, 172, 175, 178, 179, 182  
 Lunar glass particles 176  
 Lunar landing sites 169  
 Lunar metallic iron 179  
 Lunar regolith 170, 175, 180, 181  
 Lunar soil 171, 172, 175, 179  
 Lunar surface 169, 170, 182  
  
 Magnetic dipole interaction 24, 54, 65, 99  
 Magnetic dipole moment 24, 65, 99  
 Magnetic ordering 109  
 Magnetic ordering temperature 109  
 Magnetic spin quantum number 63  
 Magnetic splitting 24, 65  
 Magnetic structure 117  
 — —,  $\text{Ca}_2\text{Fe}_2\text{O}_5$  125  
 — —,  $\text{FeOCl}$  131, 134  
 Magnetism 97  
 Magnetite ( $\text{Fe}_3\text{O}_4$ ) 175  
 Malus curve 45  
 Mare basalt 172, 182, 183, 185  
 Mare Fecunditatis 182  
 Mare Tranquillitatis 171, 172, 178, 179  
 Martensite 214  
 Martensitic transformation 218  
 Medical research 165  
 Metallurgy 201  
 Meteoritic iron 182  
 Methodology 35  
 Microbreccia 183  
  
 Mineralogy 167  
 Miscibility gap 223  
 Mixed hyperfine interactions 99  
 Mn carbon steel 218  
 ( $\text{Mn}_{1-x}\text{Fe}_x$ ) $_2\text{O}_3$  system 113, 116  
 Molecular orbital 69  
 Molecular orbital energy level diagram 78  
 Molecular orbital theory 67, 77  
 Molecular symmetry 91  
 Momentum conservation 5  
 Mössbauer's discovery 11  
 Mössbauer Effect Data Index 19  
 Mössbauer-Faraday effect 47  
 Mössbauer line 11  
 Mössbauer parameters 16, 53, 204  
 Mössbauer periodic table 34  
 Mössbauer spectra,  $\alpha$ -Fe 25, 42, 44  
 — —, augite 189  
 — —,  $\text{Ca}_2\text{Fe}_2\text{O}_5$  123, 124  
 — —,  $\text{ErFeO}_3$  127  
 — —, Fe-Al alloys 221, 224, 226  
 — —,  $\text{FeOCl}$  132, 133  
 — —,  $\text{Fe}_{80}\text{P}_{17}\text{C}_3$  alloys, amorphous 232  
 — —,  $\text{FeTiO}_3$  107, 112  
 — —, ferredoxin 159, 161  
 — —, hemoglobin 149–152  
 — —, invar alloys 228, 229  
 — —, lunar glass particles 176, 177  
 — —, lunar soil 173  
 — —, ( $\text{Mn}_{0.9925}\text{Fe}_{0.0075}$ ) $_2\text{O}_3$  114  
 — —, pigeonite 189  
 — —, plagioclase 195  
 — —, rubredoxin 156, 157  
 — —,  $\text{ScFeO}_3$  110  
 — —, schematic 17, 55, 64, 66  
 — —, steel 214, 217, 219  
 Motion measurements 47  
 Myoglobin 140, 147  
  
 Narrow line 21  
 Natural line width 19  
 Near-neighbor configurations 208  
 Nickel-carbon steel 218  
 Nickel iron (kamacite) 180, 182  
 Ni, Pd, Pt, X alloys 222  
 Nitrogen steel 216  
 Non-collinear antiferromagnetic structure 131  
 Non-destructive technique 223  
 Nuclear Bohr magneton 65  
 Nuclear eigenvalues 101  
 Nuclear eigenvectors 102

- Nuclear electric quadrupole moment 26, 59  
 Nuclear magnetic dipole moment 24, 65, 99  
 Nuclear radius 57  
 Nuclear resonance fluorescence 10  
 Nuclear spin operator 63  
 Nuclear spin quantum number 63  
 Nuclear transition energy 7  
 Nuclear Zeeman effect 16, 24, 65
- Oceanus Procellarum** 172, 180  
 Octahedral co-ordination 143  
 Octahedral interstice 215, 218  
 Olivine (Mg, Fe)<sub>2</sub>SiO<sub>4</sub> 172, 178, 183  
 Orange soil 176, 178  
 Orbital contribution to internal magnetic field 106  
 Orbital splittings 83  
 Order-disorder (Mg<sup>2+</sup>, Fe<sup>2+</sup>) 191  
 Order-disorder alloys 224  
 Orthopyroxene (Mg, Fe)SiO<sub>3</sub> 173, 183, 184, 188, 192  
 Oscillator 12  
 Oxidation 233  
 Oxidation state 67  
 — of iron 188, 196  
 — of soil 175  
 Oxygen fugacity 178, 182, 189
- Palus Putredinus** 185  
 Partial field gradient 91  
 Partial isomer shift 81  
 Partial pressure of oxygen 168  
 Partial quadrupole splitting 91  
 Pauling electronegativity 73  
 Phase analysis 112  
 Phase diagram, Fe-C 213  
 Phase transition 113  
 Physical metallurgy 201  
 Phonons 12  
 Photon energy 5  
 π-Acceptor 67  
 π-Back bonding 79  
 π-Back donation 77  
 π-Orbitals 77  
 Pigeonite (Ca, Mg, Fe)SiO<sub>3</sub> 185, 185, 189  
 Plagioclase (Na<sub>x</sub>Ca<sub>1-x</sub>Al<sub>2-x</sub>Si<sub>2+x</sub>O<sub>8</sub>) 172, 183, 194  
 Plant-type ferredoxin 163  
 Point-charge formalism 91  
 Point defect 234
- Polarimetry 45  
 Polarization effect 43, 208  
 Polarized γ-rays 43, 118  
 Polarizer 45  
 Population, nuclear levels 32  
 Precipitation 225  
 Preferred orientation 230  
 Pre-Mössbauer time 3  
 Principal axes (EFG) 60  
 Proteins 139  
 Pulse height spectra 40  
 Pyroxene (Ca, Mg, Fe)SiO<sub>3</sub> 172, 175, 184, 194  
 Pyroxferroite (Fe, Ca)SiO<sub>3</sub> 173  
 Pyrrhotite (Fe<sub>1-x</sub>S) 175
- Quadrupole Hamiltonian** 59  
 Quadrupole moment 26, 59  
 Quadrupole splitting 16, 26, 58, 63, 82  
 Quenching of steel 214
- Radial function** 69  
 Rare earth orthoferrites 125  
 Rate constant 168, 192  
 Recoil 3  
 Recoil energy 4  
 Recoil-free 3  
 Recoil-free fraction 14, 16  
 Reference standard materials 23  
 Regular solution 191  
 Relative line intensities 25, 28  
 Relativistic correction 57  
 Relativistic effects 16, 32  
 Relativity factor 57  
 Relaxation effects 31  
 Relaxation time 31  
 Resonance 10  
 Resonance fluorescence 10  
 Ru(II) compounds 88  
 Rubredoxin 153, 156
- Scattering technique 41  
 ScFeO<sub>3</sub> 110  
 Second-order Doppler effect 32  
 Shielding 58  
 Shift operator 63  
 Shorty crater 176, 178  
 σ-bonding 79  
 σ-donor 67  
 Sign, internal magnetic field 26, 106  
 —, nuclear quadrupole moment 59  
 —, quadrupole splitting 144, 158

- Silicates 172, 179  
 Site distribution determination 115  
 Site enthalpy difference 117  
 Site occupancy 168, 190  
 Site preference 168  
 SnO<sub>2</sub> 233  
 Solar wind 182  
 Solid solubility 223  
 Solid solution 208  
 Sources 36  
 Spectrochemical series 80  
 Spectrum analysis 203  
 Spin directions in Ca<sub>2</sub>Fe<sub>2</sub>O<sub>5</sub> 122  
 Spin-hamiltonian 144  
 Spin-orbit coupling 87  
 Spin orientations 117  
 Spin reorientation 125  
 — — in rare earth orthoferrites 126  
 Spinach ferredoxin 162  
 Spinodal decomposition 227  
 Standard free Gibbs energy 192  
 Sternheimer antishielding factor 61  
 Sternheimer shielding factor 61  
 Stripping technique 38  
 Strong-field approximation 83  
 Substitutional solid solutions 208  
 Superparamagnetic particles 180  
 Superparamagnetism 31, 180  
  
 Taurus Mountains-Littrow Region 176  
 Temperature dependence of site distribution 116  
 Temperature shift 32  
  
 Tempering of steel 214  
 Tetrahedral co-ordination 143  
 Tetrahedral interstice 215, 218  
 Texture 230  
 Thermal scanning technique 223  
 Thermal motions 6  
 Thermal red shift 32  
 Thermal spike 13  
 Thickness effects 37  
 Tin(IV) compounds 72  
 Townes-Dailey approach 88  
 Transferred hyperfine interaction 146  
 Transition energies 102  
 Transition mechanism of spin reorientation 126  
 Transition probabilities 102  
 Transition range of spin reorientation 125  
 Transmitter experimentes 46  
 Troilite (FeS) 172, 181  
  
 Uncertainty principle 18  
  
 Valence bond theory 70  
 Valence electron contribution 60  
 Velocity modulation 39  
 Vibrational amplitude 12, 30  
 Vibrational anisotropy 28  
 Vibrational frequency 12  
  
 Xanthine oxidase 164  
 Xenon compounds 72  
 $\chi$ -Phase (Fe<sub>3</sub>C<sub>2</sub>) 217  
  
 Zeeman effect 16, 24, 65  
 Zeeman splitting 204