

Contents

1. Introduction	1
1.1 The Concept of Polarized Electrons	1
1.2 Why Conventional Polarization Filters Do Not Work with Electrons	2
2. Description of Polarized Electrons	7
2.1 A Few Results from Elementary Quantum Mechanics	7
2.2 Pure Spin States	9
2.3 Statistical Mixtures of Spin States. Description of Electron Polari- zation by Density Matrices	14
3. Polarization Effects in Electron Scattering Caused by Spin-Orbit Interaction	20
3.1 The Dirac Equation and Its Interpretation	20
3.2 Calculation of the Differential Scattering Cross Section	31
3.3 The Role of Spin Polarization in Elastic Scattering	38
3.3.1 Polarization Dependence of the Cross Section	38
3.3.2 Polarization of an Electron Beam by Scattering	41
3.3.3 Behavior of the Polarization in Scattering	42
3.3.4 Double Scattering Experiments	46
3.4 Simple Physical Description of the Polarization Phenomena . .	49
3.4.1 Illustration of the Rotation of the Polarization Vector .	49
3.4.2 Illustration of the Change in the Magnitude of the Polar- ization Vector	50
3.4.3 Illustration of the Asymmetry in the Scattering of a Polar- ized Beam	53
3.4.4 Transversality of the Polarization as a Consequence of Parity Conservation. Counterexample: Longitudinal Polar- ization in β Decay	53
3.4.5 Equality of Polarizing and Analyzing Power	56
3.5 Polarization Violating Reflection Symmetry	58
3.6 Quantitative Results	62
3.6.1 Coulomb Field	62
3.6.2 Screened Coulomb Field	64

3.7	Experimental Setups	71
3.7.1	Double Scattering Experiments	71
3.7.2	Triple Scattering Experiments	74
3.8	Resonance Scattering	76
3.9	Inelastic Scattering	79
4.	Polarization Effects Caused by Exchange Processes in Electron-Atom Scattering	84
4.1	The Polarization Mechanism in Exchange Scattering	84
4.2	The Composite Spin Space of Electron and Target	91
4.3	Cross Section and Polarization in Elastic Exchange Scattering	97
4.4	Polarization Experiments in Elastic Exchange Scattering	102
4.5	Inelastic Exchange Processes with One-Electron Atoms	107
4.5.1	Spin-Dependent Electron-Impact Ionization	107
4.5.2	Spin-Dependent Effects in Electron-Impact Excitation	109
4.5.3	Emission of Circularly Polarized Light Induced by Excitation with Polarized Electrons	117
4.6	General Laws for Polarization of Light Emitted After Excitation by Polarized Electrons	121
4.7	Inelastic Exchange Processes with Two-Electron Atoms	127
4.8	Møller Scattering	137
5.	Polarized Electrons by Ionization Processes	142
5.1	Photoionization of Polarized Atoms	142
5.2	The Fano Effect and Its Consequences	144
5.2.1	Theory of the Fano Effect	144
5.2.2	Illustration of the Fano Effect. Experimental Results	151
5.2.3	Polarized Electrons Ejected from Unpolarized Atoms by Unpolarized Light	156
5.2.4	The “Perfect” Photoionization Experiment	162
5.3	Ionizing Transitions of Excited Atomic States	165
5.3.1	Autoionizing Transitions	165
5.3.2	Auger Transitions	170
5.4	Multiphoton Ionization	173
5.5	Collisional Ionization of Polarized Atoms	180
5.5.1	Collisional Ionization of Polarized Metastable Deuterium Atoms	180
5.5.2	Penning Ionization	182
6.	Further Relativistic Processes Involving Polarized Electrons	186
6.1	Bremsstrahlung and Other Relativistic Electron-Photon Processes	186
6.2	Spin-Flip Synchrotron Radiation	191

7. Polarized Electrons from Solids and Surfaces	196
7.1 Polarized Electrons from Magnetic Materials	196
7.1.1 Photoemission	197
7.1.2 Field Emission	203
7.1.3 Secondary Electron Emission	207
7.2 Polarized Electrons from Nonmagnetic Materials	209
7.3 Low-Energy Electron Diffraction (LEED)	216
8. Further Applications and Prospects	230
8.1 Polarization Analysis	230
8.1.1 Polarization Transformers	230
8.1.2 Polarization Analysis Based on Scattering Asymmetry .	233
8.1.3 Spin-Dependent Absorption	243
8.2 Sources of Polarized Electrons	245
8.3 Experiments for Measuring the Anomalous Magnetic Moment of the Electron. Electron Maser	258
8.4 High-Energy Physics	266
8.5 Electron Microscopy	271
8.6 Electron-Molecule Scattering. Why Isn't Nature Ambidextrous? .	273
8.7 Prospects	277
References	281
Subject Index	293