
Contents

Notation	xiii
Chapter 1. Introduction	1
1.1. Ferrimagnetics	1
1.2. Magnetic Dipole and Magnetization	2
1.3. A Dipole in a Magnetic Field	4
1.4. The Permeability Tensor	8
1.5. Damping	10
1.6. Exchange Interaction	18
1.7. Magnetocrystalline Anisotropy	22
1.7.1. Cubic Ferrimagnetics	24
1.7.2. Hexagonal Magnetoplumbites	30
1.7.2.1. Uniaxial Magnetoplumbite	30
1.7.2.2. Planar Magnetoplumbite	31
1.8. Dipole–Dipole Interaction: Demagnetization	33
1.9. Magnetoelastic Interaction	44
Chapter 2. Plane Waves in Ferrimagnetics	47
PART A. ELECTROMAGNETIC WAVES	47
2.1. Electromagnetic Field Equations	47
2.2. Exchange-Free Plane Waves	50
2.2.1. The Propagation Constant	50
2.2.2. Special Cases	52
2.2.2.1. Lossless Isotropic Ferrimagnetics	52
2.2.2.2. Lossless Hexagonal Planar Magnetoplumbites	61
2.2.3. Lossless Ferrimagnetics: The General Case	63
2.2.3.1. Mode Classification	63
2.2.3.2. Propagating and Nonpropagating Regions	64
2.2.4. Effect of Damping	67
2.2.5. Comparison with Waves in Magnetoplasmas	70
2.3. The Magnetostatic Approximation	71
2.4. Exchange-Dominated Plane Waves	74

PART B. MAGNETOELASTIC WAVES	79
2.5. Magnetoelastic Field Equations	79
2.6. Exchange-Free Plane Waves	80
2.6.1. The Dispersion Relation	81
2.6.2. Special Cases	83
2.6.3. General Case	86
2.6.3.1. Dispersion Curves	86
2.6.3.2. Refractive Index Diagrams	88
2.6.3.3. Polarization of Modes	91
2.7. Effect of Exchange.	93
2.8. Effect of Anisotropy.	95
 Chapter 3. Wave Propagation Across Interfaces	 97
PART A. ELECTROMAGNETIC WAVE PROPAGATION.	97
3.1. Ferrimagnetic Half Space	97
3.1.1. Reflection and Transmission Coefficients	98
3.1.2. Regions of Ordinary and Total Reflection	100
3.1.3. Phase Shift in Total Reflection	105
3.1.4. Reflection from Lossy Ferrimagnetics	111
3.1.5. Energy Flow in Total Reflection: Lateral Shift	115
3.1.6. Ray Model for Attenuated Total Reflection	122
3.2. Ferrimagnetic Slab	127
 PART B. MAGNETOELASTIC WAVES	 133
3.3. Half Space Problem	133
 Chapter 4. Magnetostatic Waves in Layered Planar Structures 143	
4.1. Ferrimagnetic Half Space	144
4.1.1. Transverse Magnetization	145
4.1.2. Arbitrary Magnetization	150
4.1.3. Experimental Results.	155
4.2. Isotropic Ferrimagnetic Slab	160
4.2.1. Magnetization in the Slab Plane.	160
4.2.1.1. Transverse Propagation: Magnetostatic Analysis	161
4.2.1.2. Transverse Propagation: Electromagnetic Analysis.	167
4.2.1.3. General Magnetostatic Analysis	170
4.2.1.4. Experimental Results and Applications	174
4.2.2. Normal Magnetization	180
4.2.2.1. Magnetostatic Field Analysis	181
4.2.2.2. Energy Distribution and Power Flow.	184
4.2.2.3. Zig-Zag Ray Model	187

4.3. Metal-Backed Ferrimagnetic Slab	194
4.3.1. Magnetization in Slab Plane	194
4.3.1.1. Transverse Propagation: Magnetostatic Analysis	195
4.3.1.2. Transverse Propagation: Electromagnetic Analysis	197
4.3.1.3. Arbitrary Propagation: Magnetostatic Analysis	201
4.3.1.4. Effect of Finite Conductivity of Metal	203
4.3.1.5. Experimental Results	206
4.3.2. Normal Magnetization	208
4.4. Ferrimagnetic–Dielectric–Metal Structure	209
4.4.1. Transverse Magnetization in the Film Plane	211
4.4.2. Normal Magnetization	221
4.4.2.1. Dispersion Characteristics	221
4.4.2.2. Energy and Power	223
4.4.3. Arbitrary Magnetization	227
4.5. Metal–Ferrimagnetic–Metal Structure	235
4.5.1. Transverse Magnetization	235
4.5.2. Normal Magnetization	240
4.6. Double Magnetic Layered Structures	242
4.6.1. Air Gap Between Two Ferrimagnetic Substrates	242
4.6.2. Ferrimagnetic Layer Over Another Ferrimagnetic Substrate	246
4.7. Periodic Structures	248
4.8. Effect of Magnetocrystalline Anisotropy	252
4.8.1. YIG	256
4.8.2. Zn_2Y Planar Magnetoplumbite	262
4.9. Interaction of Magnetic Waves with Drifting Carriers	266
4.9.1. Physical Explanation of Amplification	266
4.9.2. Air–Ferrimagnetic–Semiconductor Composite	267
4.9.3. Metal–Dielectric–Semiconductor–YIG Structure	273
4.10. Magnetostatic Wave Oscillators	278
4.11. Transduction of Magnetostatic Waves	281

Chapter 5. Magnetoelastic Waves in Layered Planar Structures. 291

5.1. Transverse Magnetization	292
5.1.1. Ferrimagnetic Half Space	292
5.1.2. Nonmagnetic Layer Over Ferrimagnetic Substrate	297
5.1.3. Ferrimagnetic Slab	303
5.1.4. Ferrimagnetic Layered Nonmagnetic Substrate	304
5.2. Longitudinal Magnetization	308
5.2.1. The Dispersion Relation	308
5.2.2. Numerical Solution of the Dispersion Relation	312
5.2.3. Energy Loss for Leaky Waves	316
5.2.4. Effect of Magnetic Loss	319
5.2.5. Other Studies	319
5.3. Normal Magnetization	321
5.3.1. The Dispersion Equation	321
5.3.2. Dispersion Characteristics	323

5.4. Experimental Results and Devices	325
5.4.1. Excitation and Propagation Loss	325
5.4.2. Magnetoelastic Surface Wave Delay	326
5.4.3. Magnetoelastic Surface Wave Isolator	328
5.4.4. Magnetoelastic Surface Wave Oscillator	328
5.4.5. Magnetoelastic Surface Wave Convolution	331
5.4.6. Other Studies	335

Appendix A. Structure and Properties of Common Ferrimagnetics 337

A.1. Ferrimagnetic Garnet	337
A.1.1. Structure	337
A.1.2. Magnetization	338
A.1.2.1. Pure Garnet	338
A.1.2.2. Mixed Garnets	340
A.1.2.3. Substituted Garnets	340
A.1.3. Magnetocrystalline Anisotropy	341
A.1.4. Linewidth	341
A.1.5. Other Properties	341
A.2. Spinel Ferrites	341
A.2.1. Crystal Structure	341
A.2.2. Magnetization	342
A.2.3. Magnetocrystalline Anisotropy	343
A.2.4. Linewidth	343
A.3. Hexagonal Magnetoplumbites	343
A.3.1. M-Type	343
A.3.2. W-Type	344
A.3.3. Y-Type	344
A.3.4. Z-Type	344
A.3.5. U-Type	345

Appendix B. Magnetic Moment of Atoms and Ions 347

Appendix C. Coordinate Transformations 353

C.1. Eulerian Angles and Rotation Matrices	353
C.2. Transformation of Maxwell's Equations	357
C.3. The Transformed Permeability Tensor	359
C.4. Transformation of Anisotropy Field	360
C.5. Transformation of Magnetoelastic Interaction Energy	361

Appendix D. Basic Elastic Wave Theory 363

D.1. Strain	363
D.2. Stress	365

D.3. Hooke's Law: Stiffness and Compliance	365
D.4. Damping	367
D.5. Boundary Conditions	367
D.6. Elastic Energy	367
D.7. Elastic Field Equations	368
D.8. Elastic Plane Waves in an Infinite Medium	368
<i>Appendix E. Uniform Precessional Mode Frequency for Small Ellipsoids.</i>	371
<i>Appendix F. Poynting's Theorem</i>	373
<i>Appendix G. Partially Magnetized Ferrimagnetics</i>	377
<i>References</i>	381
<i>Author Index</i>	395
<i>Subject Index</i>	399