

Contents (Volume II)

Preface to Volume II	v
CHAPTER 9	
Elastic Ferromagnets	437
9.0. An Overview of Basic Equations	437
9.1. Scope of the Chapter	443
9.2. Model of Interactions	444
A. Gyroscopic Nature of the Spin Density	445
B. Spin–Lattice Model of Interactions	446
9.3. Balance Equations	449
A. Global Balance Equations	449
B. Local Balance Equations	450
C. The Clausius–Duhem (C–D) Inequality	452
D. Boundary Conditions	453
9.4. Constitutive Theory	453
A. Saturated Ferromagnetic Elastic Insulators	453
B. Free Energy	456
C. Correspondence Between the Microscopic Model and the Continuous Representation	458
D. Infinitesimal Strains	460
E. Centrosymmetric Cubic Crystals	461
F. Uniaxial Crystals	463
G. Elementary Dissipative Processes	464
H. Small Fields Superposed on a Constant Bias Magnetic Field	466
9.5. Résumé of Basic Equations	469
9.6. Coupled Magnetoelastic Waves in Ferromagnets	472
A. Preliminary Remarks	472
B. Plane Harmonic Waves	474
C. Damping of Magnetoelastic Waves	482
D. Magnetoelastic Faraday Effect	484
9.7. Applications of the Magnon–Phonon Coupling	487
A. Pumping and Temporal Magnon–Phonon Conversion	487
B. Drift-Type Amplification of Magnetoelastic Waves	490

viii Contents (Volume II)

9.8. Other Works	490
A. Continuum Descriptions of Ferromagnetic Deformable Bodies	490
B. Wave Propagation	491
C. Ferrimagnetic Deformable Bodies	492
Problems	497
CHAPTER 10	
Magnetohydrodynamics	502
10.1. Scope of the Chapter	502
10.2. Basic Equations of Electromagnetic Fluids	503
10.3. Magnetohydrodynamic Approximation	507
10.4. Perfect Magnetohydrodynamics	512
A. Field Equations	512
B. “Frozen-In” Fields	513
C. Bernoulli’s Equation in Magnetohydrodynamics	514
D. Kelvin’s Circulation Theorem in Magnetohydrodynamics	515
E. Alfvén Waves	515
F. Generalized Hugoniot Condition	516
10.5. Incompressible Viscous Magnetohydrodynamic Flow	518
A. Magnetohydrodynamic Poiseuille Flow	518
B. Magnetohydrodynamic Couette Flow	520
10.6. One-Dimensional Compressible Flow	521
10.7. Shock Waves in Magnetohydrodynamics	525
A. Classification of Magnetohydrodynamic Shock Waves	526
B. Shock Structure	530
10.8. Magnetohydrodynamic Equilibria	530
10.9. Equilibrium of Magnetic Stars	533
10.10. Magnetohydrodynamic Stability	537
A. The Energy Method	537
B. Equilibrium States and Perturbations	539
C. Quantities Conserved in the Perturbation	540
D. Elementary Perturbations	540
E. Change in the Energy Integrals	543
F. Application to the Linear Pinch	545
Problems	547
CHAPTER 11	
Electrohydrodynamics	551
11.1. Scope of the Chapter	551
11.2. Field Equations	552
11.3. Charge Relaxation	554
11.4. Stability Condition	554
11.5. Helmholtz and Bernoulli Equations	555
A. Generalization of the Helmholtz Equation	555
B. Vorticity Generation in a Space-Charge-Loaded Electric Field	556
C. Generalization of Bernoulli’s Equations	556
11.6. Equilibrium of a Free Interface	557

11.7. Effect of Free Charges at an Interface	558
11.8. Electrohydrodynamic Stability	561
11.9. Electrohydrodynamic Flow in a Circular Cylindrical Conduit	567
11.10. Electrogasdynamic Energy Converter	569
Problems	573

CHAPTER 12
Ferrofluids **574**

12.1. Scope of the Chapter	574
12.2. Constitutive Equations of Ferromagnetic Fluids	575
12.3. Theory of Ferrofluids	577
A. Equilibrium Constitutive Equations	577
B. Nonequilibrium Constitutive Equations	579
C. Balance Laws	580
12.4. Existence and Stability of a Constant Magnetization in a Moving Ferrofluid	582
12.5. Ferrohydrodynamic Approximation	585
12.6. Some General Theorems in Ferrohydrodynamics	587
A. Generalization of the Helmholtz Equation	587
B. Generalization of the Bernoulli Equation	588
12.7. Ferrohydrostatics	589
A. Equilibrium of a Free Surface	589
B. Energy Conversion	590
12.8. Ferrohydrodynamic Flow of Nonviscous Fluids	591
A. Preliminary Remarks	591
B. Steady Two-Dimensional Source Flow	593
12.9. Simple Shear of a Viscous Ferrofluid	596
12.10. Stagnation-Point Flow of a Viscous Ferrofluid	598
12.11. Interfacial Stability of Ferrofluids	603
12.12. Other Problems in Ferrofluids	608
Problems	609

CHAPTER 13
Memory-Dependent Electromagnetic Continua **611**

13.1. Scope of the Chapter	611
13.2. Constitutive Equations	612
13.3. Thermodynamics of Materials with Continuous Memory	613
13.4. Quasi-Linear and Linear Theories	620
A. Quadratic Memory Dependence	621
B. Finite-Linear Theory	622
C. Linear Theory	624
D. Linear Isotropic Materials	627
E. General Polynomial Constitutive Equations	629
13.5. Rigid Bodies	630
A. Continuous Memory	630
B. Polynomial Constitutive Equations	631

x Contents (Volume II)

13.6. Dispersion and Absorption	632
13.7. A Simple Atomic Model	634
13.8. Free Motion of an Electron Under Magnetic Field	637
13.9. Electromagnetic Waves in Memory-Dependent Solids	641
13.10. Electromagnetic Waves in Isotropic Viscoelastic Materials	647
13.11. Nonlinear Atomic Models for Polarization	652
13.12. Constitutive Equations of Birefringent Viscoelastic Materials	657
A. Rate-Dependent Materials	659
B. Linear, Continuous Memory of Strains	660
13.13. Propagation of Waves in Birefringent Viscoelastic Materials	661
13.14. Photoviscoelasticity	666
Problems	673

CHAPTER 14

Nonlocal Electrodynamics of Elastic Solids	675
14.1. Scope of the Chapter	675
14.2. Constitutive Equations	677
14.3. Thermodynamics	679
14.4. Linear Theory	682
14.5. Material Symmetry	686
14.6. Nature of Nonlocal Moduli	688
14.7. Nonlocal Rigid Solids	693
14.8. Electromagnetic Waves	694
14.9. Point Charge	696
14.10. Rigid Magnetic Solids	696
14.11. Superconductivity	699
14.12. Piezoelectric Waves	702
14.13. Infrared Dispersion and Lattice Vibrations	704
14.14. Memory-Dependent Nonlocal Electromagnetic Elastic Continua . .	707
14.15. Linear Nonlocal Theory for Electromagnetic Elastic Solids . . .	710
14.16. Natural Optical Activity	712
14.17. Anomalous Skin Effects	713
Problems	715

CHAPTER 15

Relativistic Electrodynamics of Continua	716
15.1. Scope of the Chapter	716
15.2. Space-Time, Notation	717
A. Space-Time	717
B. Special Relativity	718
C. General Relativity	718
D. Inertial Frames and Rest Frame	720
E. Proper Time, Timelikeness	721
F. Space and Time Decomposition	722
G. Antisymmetric Tensors and Axial Four-Vectors	724

Contents (Volume II) xi

15.3.	Relativistic Kinematics of Continua	725
	A. Motion, Strain Tensors	725
	B. Relativistic Rate of Strain	727
	C. Contravariant Convective Time Derivative	728
15.4.	Covariant Formulation of Maxwell's Equations in Matter	729
	A. Electromagnetic Fields	729
	B. Integral Formulation of Maxwell's Equations	731
	C. Four-Vector Formulation of Maxwell's Equations	733
15.5.	Relativistically Invariant Balance Laws	734
15.6.	Electromagnetic Interactions with Matter	738
15.7.	Thermoelastic Electromagnetic Insulators	741
15.8.	Electromagnetic Fluids	743
	A. General Nondissipative Case	743
	B. Linear Electromagnetic Constitutive Equations	744
	C. Elementary Dissipative Processes	745
	D. Relativistic Perfect Magnetohydrodynamics	746
15.9.	Further Problems in the Relativistic Electrodynamics of Continua	747
	Problems	748
	References	753
	Index	I1