

## CONTENTS

Nonlinear Plasma Theory  
A. A. Galeev and R. Z. Sagdeev

Introduction .....	1
Chapter 1. Wave-Wave Interaction .....	5
§1.1. Resonance Interaction between Plasma Waves .....	5
§1.2. Interaction of Finite-Amplitude Waves .....	21
§1.3. Higher-Order Parametric Instabilities .....	28
§1.4. Geometric Optics Approximation .....	32
§1.5. Wave Interaction in the Random-Phase Approximation .....	34
§1.6. Weak Turbulence and the Wave Kinetic Equation .....	40
§1.7. Negative-Energy Instabilities .....	47
§1.8. Adiabatic Approximation (Interaction between High-Frequency and Low- Frequency Waves) .....	51
Chapter 2. Wave-Particle Interactions .....	55
§2.1. Wave-Particle Interaction for a Monochromatic Wave .....	55
§2.2. The Many-Wave Case (One-Dimensional Spectrum) .....	66
§2.3. The Many-Wave Case (Two- and Three- Dimensional Spectra) .....	74
§2.4. Effect of Collisions on Wave-Particle Interactions .....	82
§2.5. Quasilinear Theory of Electromagnetic Modes .....	88

§2.6. Nonresonant Wave-Particle Interactions . . . . .	94
§2.7. Quasilinear Theory of the Drift Instability . . . . .	103
Chapter 3. Nonlinear Wave-Particle Interactions . . . . .	115
§3.1. Turbulence Associated with Electron Plasma Waves . . . . .	115
§3.2. Ion-Acoustic Turbulence . . . . .	124
§3.3. Stimulated Scattering of Light in a Plasma (Basic Equations) . . . . .	128
§3.4. Relaxation of a Radiation Line in a Plasma . . . . .	132
Chapter 4. Anomalous Resistivity in a Plasma . . . . .	141
§4.1. Formulation of the Problem. Conservation Relations . . . . .	141
§4.2. Anomalous Resistivity Due to the Ion-Acoustic Instability . . . . .	148
§4.3. Quasilinear Effects in Anomalous Resistivity Due to the Ion-Acoustic Instability . . . . .	152
§4.4. Anomalous Resistivity Caused by Other Instabilities . . . . .	167
Conclusion . . . . .	170
Appendix. Thermal Fluctuations in Weak Plasma Turbulence . . . . .	172
References . . . . .	175
Wave Processes in an Inhomogeneous Plasma	
N. S. Erokhin and S. S. Moiseev	
Introduction . . . . .	181
Chapter 1. Linear Wave Conversion in an Inhomogeneous Plasma . . . . .	184
§1. Classes of Solution Intersections and Field Singularities of an Electromagnetic Wave in an Inhomogeneous Plasma . . . . .	184

1. Classification of Solution Intersections for a One-Dimensional Inhomogeneity . . . . .	184
2. Field Singularities of an Electromagnetic Wave in a Cold Plasma with One-Dimensional and Two-Dimensional Parameter Inhomogeneities . . . . .	186
§2. Superbarrier Conversion . . . . .	191
§3. Anomalous Wave Conversion . . . . .	197
1. Anomalous Intersection Points. Introductory Remarks . . . . .	197
2. Methods of Investigating Anomalous Intersections . . . . .	200
3. Certain Physical Features and Examples of Anomalous Wave Conversion . . . . .	208
§4. Certain Features of Wave Conversion and Transition Radiation in the Interaction of Beams and Charges with a Plasma . . . . .	214
1. Effect of Intersection of the Oscillations on the Operating Regime of a Beam-Plasma Discharge . . . . .	215
2. Anisotropy of the Transition Radiation of a Charge in a Weakly Inhomogeneous Isotropic Plasma . . . . .	222
§5. Self-Focusing and Absorption of Electromagnetic Waves in the Region of a Field Singularity in a Plasma with a Two-Dimensional Inhomogeneity . . . . .	224
1. Possibility of Simultaneous Absorption and Self-Focusing of Energy in an Inhomogeneous Medium . . . . .	224
2. Absorption of Electromagnetic Waves in a Toroidal System . . . . .	226
Chapter 2. Harmonic Generation, Decay Processes, and Radiation Spectra in an Inhomogeneous Plasma . . . . .	229
§1. Nonlinear Wave Interactions in an Inhomogeneous Plasma . . . . .	229
1. Nonlinear Mixing of Waves . . . . .	229
2. Decay of Finite-Amplitude Waves . . . . .	230

§ 2. Generation of Harmonics of an Electro-magnetic Wave in an Inhomogeneous Plasma . . . . .	233
§ 3. Spectrum of Radiation Trapped in a Plasma Cavity . . . . .	237
Chapter 3. Penetration of Wave Barriers in an Inhomogeneous Plasma. . . . .	238
§ 1. Introductory Remarks . . . . .	238
§ 2. Nonlocal Effects in an Inhomogeneous Plasma . . . . .	240
1. Linear Regeneration and Field "Bulges" for the Extraordinary Wave in an Inhomogeneous Magnetic Field . . . . .	241
2. Linear Regeneration of a Wave with Incomplete Phase Mixing of the Resonance Particles . . . . .	246
3. Linear Nonlocal Wave Conversion in an Inhomogeneous Plasma . . . . .	249
4. Nonlinear Nonlocal Conversion of Transverse Waves into Longitudinal Waves . .	250
References . . . . .	251
Theory of Neoclassical Diffusion	
A. A. Galeev and R. Z. Sagdeev	
Introduction . . . . .	257
Chapter 1. Kinetic Theory for Plasma Equilibrium in an Axially Symmetric System . . . . .	263
§ 1. Transport Coefficients for a Low-Density Plasma (Summary of Results) . . . . .	263
§ 2. Transport Coefficients for a Low-Density Plasma (Qualitative Picture) . . . . .	264
1. Diffusion in a Highly Tenuous Plasma . . . . .	264
2. Electrical Diffusion Effects . . . . .	268
3. Plasma Conductivity in a Weakly Inhomogeneous Magnetic Field . . . . .	269
4. Thermal Conductivity of a Tenuous Plasma . . . . .	270
5. Plasma Diffusion for Intermediate Collision Frequencies . . . . .	271
§ 3. Individual Particle Motion . . . . .	272

§ 4. Simple Model for Plasma Equilibrium in a Torus . . . . .	277
§ 5. Effect of Electron-Electron Collisions . . . . .	284
§ 6. Neoclassical Ion Thermal Conductivity . . . . .	287
§ 7. Pinch Effect for Trapped Particles . . . . .	289
§ 8. Thermoelectric and Thermal Diffusion Effects . . . . .	290
§ 9. Transport Coefficient in a Slightly Tenuous Plasma . . . . .	291
§ 10. Equilibrium of a Tenuous Plasma in a Tokamak and Limiting Plasma Pressure . . . . .	295
§ 11. Thermal Balance in the Tokamak . . . . .	300
§ 12. Neoclassical Diffusion in a Tokamak with Magnetic Surfaces of Arbitrary Shape . .	305
Chapter 2. Toroidal Stellarators . . . . .	307
§ 1. Drift Trajectories of Trapped Particles Near the Stellarator Axis . . . . .	307
§ 2. Numerical Calculations for the Motion of Single Particles in a Stellarator . . . . .	314
§ 3. Superbanana Diffusion in a Stellarator with a Small Toroidal Factor (Qualitative Analysis) . . . . .	317
1. Low Collision Frequencies . . . . .	318
2. Very Low Collision Frequencies . . . . .	319
3. Possibility of a Superbanana Plateau . . . . .	321
§ 4. Transport Coefficients in a Toroidal Stellarator (Calculations for Particular Cases) . . . . .	323
1. Banana Kinetic Equation . . . . .	323
2. High Collision Frequencies . . . . .	325
3. Low Collision Frequencies . . . . .	328
4. Plasma Transport Coefficients in the Absence of an Electric Field . . . . .	330
§ 5. Diffusion in a Stellarator with Imperfect Magnetic Surfaces . . . . .	331
§ 6. Transport Processes in a Large-Aspect-Ratio Stellarator . . . . .	332
Appendix 1. Matrix Elements of the Collision Operator . . . . .	335
Appendix 2. Stabilization Criterion for the Dissipative Trapped Particle Instability . . . . .	337
References . . . . .	340

Universal Coefficients for Synchrotron Emission from Plasma Configurations .. B. A. Trubnikov	345
Appendix 1. Equivalence of the Form Factor for a Slab and a Cylinder and the Effect of Reflectors .....	348
Appendix 2. Analysis of the Numerical Calculations .....	352
Appendix 3. Absorption Coefficients .....	356
Appendix 4. Form Factor for a Torus .....	360
Appendix 5. Comparison of $\Phi_{\text{tor}}$ with the Rosenbluth Results .....	366
Appendix 6. Energy Balance in Thermonuclear Reactors .....	370
Appendix 7. Ultrarelativistic Case .....	374
References .....	378