

# Contents

<b>1</b>	<b>Introduction</b>	1
	Reference	5
<b>2</b>	<b>Statistical Background</b>	7
2.1	Probability Set Function	7
2.2	Random or Stochastic Variables	11
2.3	The Probability Density Function	14
2.4	The Distribution Function	19
2.5	Expectations and Moments	23
2.6	Conditional Probability and Marginal and Conditional Distributions	33
2.7	Stochastic Independence	42
2.8	Particular Distributions	47
	2.8.1 The Binomial Distribution	47
	2.8.2 The Poisson Distribution	50
	2.8.3 The Normal or Gaussian Distribution	53
2.9	The Central Limit Theorem	57
2.10	Relation Between Microscopic and Macroscopic Descriptions: Particles, the Gibbs Ensemble, and Liouville's Theorem	61
2.11	The Language of Fluid Turbulence	64
	References	70
<b>3</b>	<b>The Boltzmann Transport Equation</b>	71
3.1	Derivation of the Boltzmann Transport Equation	71
3.2	The Boltzmann Collision Operator	74
	3.2.1 Collision Dynamics	76
3.3	Conservation Laws, the H-Theorem, and the Maxwell-Boltzmann Distribution Function	82
3.4	The Boltzmann Equation and the Fluid Equations	87
3.5	The Relaxation Time Approximation	91
3.6	The Chapman-Enskog Expansion	91

3.7	Application 1: Structure of Weak Shock Waves.....	98
3.7.1	Weak Solutions and the Rankine-Hugoniot Relations .....	102
3.8	Application 2: The Diffusion and Telegrapher Equations .....	110
	References .....	119
<b>4</b>	<b>Charged Particle Transport in a Collisional Magnetized Plasma .....</b>	<b>121</b>
4.1	The Kinetic Equation and Moments for a Magnetized Plasma.....	121
4.2	Markov Processes, the Chapman-Kolmogorov Equation, and the Fokker-Planck Equation .....	127
4.2.1	A More Formal Derivation of the Chapman-Kolmogorov Equation and the Fokker-Planck Equation.....	131
4.3	Collision Dynamics, the Rosenbluth Potentials, and the Landau Collision Operator .....	135
4.4	Electron-Proton Collisions .....	142
4.5	Collisions with a Maxwellian Background .....	145
4.6	Collision Operator for Fast Ions .....	150
4.7	Proton-Electron Collisions .....	152
4.8	Transport Equations for a Collisional Electron-Proton Plasma .....	155
4.9	Application 1: Transport Perpendicular to a Mean Magnetic Field .....	161
4.10	Application 2: The Equations of Magnetohydrodynamics .....	166
4.11	Application 3: MHD Shock Waves .....	175
	References .....	184
<b>5</b>	<b>Charged Particle Transport in a Collisionless Magnetized Plasma ....</b>	<b>185</b>
5.1	Transport Equations for Non-relativistic Particles Scattered by Plasma Fluctuations .....	186
5.1.1	The Focussed Transport Equation .....	186
5.1.2	The Diffusive Transport Equation .....	192
5.2	Transport Equation for Relativistic Charged Particles .....	204
5.2.1	Derivation of the Focussed Transport Equation.....	204
5.3	The Magnetic Correlation Tensor .....	215
5.4	Quasi-linear Transport Theory of Charged Particle Transport: Derivation of the Scattering Tensor.....	226
5.5	Diffusion Perpendicular to the Mean Magnetic Field: The Nonlinear Guiding Center Theory .....	235
5.6	Hydrodynamic Description of Energetic Particles .....	240
5.7	Application 1: Diffusive Shock Acceleration .....	250
5.8	Application 2: The Modulation of Cosmic Rays by the Solar Wind.....	257
	References .....	259

**6 The Transport of Low Frequency Turbulence** ..... 261

6.1 Basic Description of Low-Frequency Turbulence..... 263

6.2 Mean Field Description of MHD Fluctuations ..... 267

6.3 The Transport Equation for the Magnetic Energy Density ..... 272

6.4 Modeling the Dissipation Terms ..... 275

References ..... 279

**Index**..... 281

Transport Processes in Space Physics and Astrophysics

Zank, G.P.

2014, XI, 286 p. 21 illus., 1 illus. in color., Softcover

ISBN: 978-1-4614-8479-0