TABLE OF CONTENTS

PREFACE xi

Part I. Radiative Transfer and Internal Structure of Normal Stars

CHAPTER 1. INTRODUCTION TO THE THEORY OF RADIATIVE TRANSFER

1. Basic Concepts in the Description of a Radiation Field 3
2. Relations between Macroscopic and Microscopic Parameters Describing the Interactions between Matter and Radiation 8
3. Equation of Transfer and the Corresponding Equation of Continuity 20
4. Applications to the Physics of Stellar Interiors 31

Appendix: The Relations between Einstein's Coefficients 44

CHAPTER 2. ELEMENTARY INTRODUCTION TO THE PHYSICS OF STELLAR INTERIORS

1. General Conditions of Mechanical Equilibrium 46
2. The Equilibrium between the Gradient of the Total Pressure and the Gravitational Force per Unit Volume 47
3. The Relation between M_r and the Density ρ at a Distance r from the Center 53
4. The Expression for div g as a Function of the Local Density ρ. Poisson's Equation 54
5. The Calculation of the Gas Pressure P_{gas}. The Concept of the Mean Mass μ of a Particle of the Mixture, in Units of m_{B} (where m_{B} is the Mass in Grams of a Baryon) 55
6. A Model of the Sun at Constant Density $\rho = \bar{\rho}$ 59

CHAPTER 3. THE PHYSICS OF INTERIORS OF THE MAIN SEQUENCE STARS

1. Introduction 61
2. The Equation of Energy Equilibrium 62
3. The Expression for $\epsilon(r)$ in the Case when Energy is Produced by the p–p Chain or the C–N Cycle 63
4. The System of Differential Equations and of Boundary Conditions which Determine the Internal Structure of a Normal Star 65
5. Evolutionary Models and Solution of the Problem Concerning the Function $X(r)$ 67

6. Utilization of Boundary Conditions in the Study of Initial Models 71
7. From Initial Models to Models Corresponding to the Present State. Determination of the Age of a Star 73
8. The Present Internal Structure of the Sun 74
9. Comparison between the Present Structure of the Sun and its Structure at Age Zero 78
10. The Superficial Convective Zone of the Sun 79

Part II. White Dwarfs, Neutron Stars and Pulsars

CHAPTER 4. ELEMENTARY PROPERTIES OF A DEGENERATE FERMI GAS

1. Different 'Energy Parameters' of an Isolated Particle. Energy Groups (NR), (UR) and (RR) 91
2. The Number of Independent Identical Particles (Confined in a Macroscopic Unit of Volume) whose Momentum lies between p and $(p + dp)$ 94
3. The General Trend of the Fermi-Dirac Distribution Function. Definition of the Complete Degeneracy. The Fermi Level 98
4. Relations between the Number Density of a System of Fermions in a State of Complete Degeneracy and Energy Parameters of the Fermi Level 101
5. Energy Density (for Total and for Kinetic Energy) of a Completely Degenerate System of Independent Identical Fermions 106
6. The Mean (Total) Energy and the Mean Kinetic Energy of One Particle of a Completely Degenerate System of Independent Identical Fermions. Relations with the Fermi Level 109
7. Expressions for Partial Number Densities of Different Components of a Stellar Mixture as a Function of the Mass Density of the Mixture. Parameters μ, μ_e and μ_e' 111
8. The Pressure Produced by a System of Independent Identical Fermions in a State of Complete Degeneracy 117
9. The Domain of Separation between the State of a Perfect Gas and the State of Complete Degeneracy. Application to the Sun 122
Appendix: Establishment of the Rigorous (RR) Expressions for $u(n, m)$ and $u_k(n, m)$ 126

CHAPTER 5. WHITE DWARFS

1. A Few Historical Remarks 129
2. Polytropes and the Virial Theorem. Application to an Elementary Theory of White Dwarfs 130
3. Polytropic White Dwarfs Studied by Means of the Emden–Lane Equation 141
4. Chandrasekhar's 'Rigorous' Theory of White Dwarfs 146
Appendix: The Gravitational Binding Energy of a Star 151

CHAPTER 6. NEUTRON STARS

1. Introduction: (R_Z) Reactions (Electron Captures and β-Disintegrations) 154
2. Neutronization by a Degenerate Gas of Free Electrons 159
3. (R_A) Reactions Leading to an Increase of Atomic Weight of Nuclei 162
4. The Different Domains of Mass Density 163
5. Different Forms of Equilibrium Equations for (R_Z) Reactions 166
6. Equilibrium Equations for (R_A) Reactions 172
7. The Domain A: Determination of A and Z Corresponding to an Equilibrium with Respect to Reactions (R_Z) and (R_A) 174
8. The Domain B: A Mixture of Free Electrons, Free Neutrons and Nuclei (A, Z) 176
9. The Domain C: A Mixture of Free Electrons, Free Protons and Free Neutrons 178
10. The Structure of Neutron Stars. Their Radius as a Function of Their Mass 181

CHAPTER 7. PULSARS

1. The Discovery of Pulsars 187
2. The First Investigations and the First General Properties 191
3. Pulsar Distances 198
4. Pulsar Ages 222
5. Luminosity Problems and the Pacini Model 228
6. The Problem of Association of Pulsars with Supernovae 233
7. The 'Celibacy' of Radio Pulsars (and Binary Character of the 'X-ray' Pulsars) 234

Part III. Newton's Law, Binary Systems and Galactic X-ray Sources

CHAPTER 8. THEORY OF SPECTROSCOPIC AND ECLIPSING BINARIES. STELLAR MASSES

1. The Newtonian Form of Kepler's Third Law 241
2. Elementary Interpretation of Observations 243
3. The Values of Stellar Masses. Relations between Masses, Luminosities and Spectral Classes 264
Appendix A. On Keplerian Motion 265
Appendix B. Inductions Leading from Kepler's Empirical Laws to Newton's Law of Gravitation 272

CHAPTER 9. GALACTIC X-RAY SOURCES

1. Introduction 282
2. The Classification Problem 301
3. A few Particularly Interesting Galactic X-ray Sources 302
Appendix: A Dictionary of Abbreviations in the Field of Galactic Sources. Conversion of Names. Tables 308

Part IV. Cosmology: Elementary Theory and Basic Observational Data

CHAPTER 10. ELEMENTARY THEORETICAL COSMOLOGY: THE NEWTONIAN APPROACH

1. Introduction 315
2. The Fundamental Principles 316
3. The Kinematics of a Model of Cosmic Fluid. Hubble's law 318
4. A few Observational Data 323
5. The Friedmann Model of Universe 324
6. The Ratio of the Age of the Friedmann Universe to the 'Hubble Time' as a Function of Ω 341
7. The Radiation Model of the Early Universe 342

CHAPTER 11. BASIC CONCEPTS OF RELATIVISTIC COSMOLOGY

1. Introduction 348
2. Some Elementary Relativistic Concepts 348
3. The Characteristic Properties of Non-Euclidean Spaces 356
4. The Geodesic Principle 375

CHAPTER 12. RELATIVISTIC EFFECTS IN OBSERVATIONAL COSMOLOGY. THE COSMOLOGICAL REDSHIFT IN EXPANDING UNIVERSE

1. A Bi-dimensional Model of an Expanding Universe. Fixity in Mobility: The Comoving Coordinates 383
2. Tri-dimensional Friedmann Relativistic Models of Expanding Universe 384
3. The Cosmological Redshift 387
4. The Metric (Mathematical) Linear Distance of a Source 397
5. The Classical Distance of a Source as a Function of its Redshift 400
6. The Relativistic Variation of the Angular Diameter, for Sources of a given Linear Diameter, as a Function of their Redshift 401
7. A Physical Interpretation of the Metric Distance 406
8. The Relativistic Variation of the Integrated (Bolometric) Brightness, for Point Sources of given Luminosity, as a Function of their Redshift 407
9. The Brightness of an Extended Source per Unit Solid Angle 414
10. The Source Counts 416

Appendix: Relations between the Magnitudes, the Luminosities and the Cosmological Redshift 430

CHAPTER 13. BASIC DATA IN OBSERVATIONAL COSMOLOGY: ACTIVE GALACTIC NUCLEI AND CLUSTERS OF GALAXIES

1. Introduction 434
2. Active Galactic Nuclei (Quasars and Similar Objects) 434

3. Clusters of Galaxies 453
4. Superclusters of Galaxies? 454
5. General Comments on the Confrontation of Cosmological Theories with Observational Data 456
Appendix: A Dictionary of Abbreviations in the Field of Extragalactic Objects 462

TABLE OF VALUES 467

INDEX 469