

Contents

7. Star Formation	1
7.1 Observations of the Regions of Star Formation	1
7.1.1 Introduction	1
7.1.2 Observational Data	2
7.2 Spherically Symmetric Collapse of Interstellar Clouds	5
7.2.1 Heat Balance of an Optically Thin Cloud	5
7.2.2 Equations for Cloud Collapse.....	6
7.2.3 Calculational Results.....	10
7.3 Collapse of Rotating Clouds	15
7.3.1 Set of Equations and Difference Scheme Properties ..	16
7.3.2 Calculational Results.....	18
8. Pre-main Sequence Evolution	25
8.1 Hayashi Phase	25
8.1.1 Nuclear Reactions	25
8.1.2 Non-ideality of Matter.....	28
8.1.3 Evolution of Low-Mass Stars, Minimum Mass of a Star on the Main Sequence, Role of Various Factors	29
8.1.4 Evolutionary Role of the Mass Loss	32
8.2 Evolution of Rapidly Rotating Stars on Gravitational Contraction Stages	33
8.2.1 On the Distribution of Angular Velocity of Rotation ..	34
8.2.2 Method for Evolutionary Calculations	36
8.2.3 Calculation Results	39
8.3 Models for the Matter Outflow from Young Stars	44
8.3.1 Outflowing Bipolytropic Models	45
8.3.2 Outflowing Models for Isentropic Hydrogen Stars ..	49
8.3.3 Models for Outflowing Coronae of Young Stars ..	54
8.3.4 On the Phenomenon of Fuor	58

9. Nuclear Evolution of Stars	61
9.1 Sources of Uncertainty in Evolutionary Calculations	61
9.1.1 Convection	61
9.1.2 Semiconvection	62
9.1.3 Convective Non-locality and Overshooting	63
9.1.4 Opacity and Nuclear Reactions	64
9.1.5 Methods for Calculating Envelope	64
9.1.6 Other Factors	65
9.2 Evolution of Stars in Quiescent Burning Phases	66
9.2.1 Iben's Calculations	67
9.2.2 Paczynski's Calculations	74
9.2.3 Evolution of Massive Stars	76
9.2.4 Evolution of Massive Stars with Mass Loss	83
9.2.5 CAK Theory	95
9.2.6 Calculations with New Opacity Tables	103
9.3 Evolution with Degeneracy, Thermal Flashes	108
9.3.1 Core Helium Flash (CHF)	108
9.3.2 Horizontal Branch (HB)	110
9.3.3 Asymptotic Giant Branch (AGB)	111
9.3.4 Thermal Flashes in Helium-Burning Shell	116
9.3.5 The Mass Loss in AGB Stars	119
9.3.6 Evolution with Mass Loss: From AGB to White Dwarf State	121
9.3.7 On Mixing on the AGB and in Neighbourhoods	128
9.3.8 Thermal Instability in Degenerate Carbon Core	131
10. Collapse and Supernovae	125
10.1 Presupernova Models	127
10.1.1 Stellar Cores at Threshold of Hydrodynamical Stability. Energetic Method	127
10.1.2 Stellar Cores at Thermal Instability Threshold	145
10.2 Explosions Resulting from the Thermal Instability Development in Degenerate Carbon Cores	150
10.2.1 Basic Equations	150
10.2.2 Detonation	150
10.2.3 Deflagration	151
10.2.4 Spontaneous Burning and Detonation	152
10.2.5 Instabilities of Nuclear Flames	154
10.3 Collapse of Low-Mass Stellar Cores	156
10.4 Hydrodynamical Collapse of Stellar Cores	161
10.4.1 Low-Energy Window for Neutrinos	164
10.4.2 Asymmetric Neutrino Emission During Collapse of a Star with a Strong Magnetic Field	165
10.4.3 Neutrino Oscillations in Matter	168
10.4.4 Convective Instability in Collapsing Stellar Cores	169

10.4.5	Two-Dimensional and Three-Dimensional Calculations of Neutrino Convection	170
10.5	Magnetorotational Model of Supernova Explosion	174
10.5.1	Mechanism of Magnetorotational Explosion	175
10.5.2	Basic Equations	175
10.5.3	Cylindrical Approximation	177
10.5.4	Calculational Results	179
10.5.5	Two-Dimensional Calculations	183
10.5.6	Symmetry Breaking Of the Magnetic Field, Anisotropic Neutrino Emission and High Velocity Neutron Star Formation	189
11.	Final Stages of Stellar Evolution	193
11.1	White Dwarfs	194
11.1.1	Case $T = 0$	194
11.1.2	Account for a Finite Value of T and Cooling	199
11.1.3	Cooling of White Dwarfs Near the Stability Limit with the Inclusion of Heating by Non-equilibrium β -Processes	204
11.1.4	On the Evolution of Magnetic Fields in White Dwarfs	207
11.1.5	Nova Outbursts	209
11.2	Neutron Stars	212
11.2.1	Cold Neutron Stars	213
11.2.2	Hot Neutron Stars	216
11.2.3	Cooling of Neutron Stars	220
11.2.4	Magnetic Field Decay in Neutron Stars	224
11.2.5	Stars with Neutron Cores	225
11.3	Black Holes and Accretion	226
11.3.1	Spherically Symmetric Accretion	226
11.3.2	Accretion at an Ordered Magnetic Field	230
11.3.3	Conical Accretion on to a Rapidly Moving Black Hole	233
11.3.4	Disk Accretion in Binaries	236
12.	Dynamic Stability	261
12.1	Hierarchy of Time Scales	261
12.2	Variational Principle and Small Perturbations	263
12.2.1	Variational Principle in General Relativity	263
12.2.2	Newtonian and Post-Newtonian Limits	265
12.2.3	Method of Small Perturbations in Newtonian Theory	268
12.3	Static Criteria for Stability	272
12.3.1	Non-rotating Stars	272
12.3.2	Criteria for Rotating Stars	274

12.3.3	Removal of Degeneracy of Neutral Oscillatory Modes in Rotating Isentropic Stars.....	276
12.3.4	Numerical Examples	277
12.4	Star Stability in the Presence of a Phase Transition	279
12.4.1	Evaluation of Variations $\delta\varepsilon$ and $\delta^2\varepsilon$	280
12.4.2	Other Forms of Stability Criterion	283
12.4.3	Rough Test for Stability	284
12.4.4	Derivation of Stability Condition for a Phase Transition in the Centre of Star	287
13.	Thermal Stability.....	289
13.1	Evolutionary Phases Exhibiting Thermal Instabilities	289
13.1.1	Instability in Degenerate Regions	289
13.1.2	Instabilities in the Absence of Degeneracy	293
13.2	Thermal Instability Development in Non-degenerate Shells..	294
13.2.1	Stability of a Burning Shell with Constant Thickness.....	294
13.2.2	Calculations of Density Perturbations	296
13.2.3	A Strict Criterion for Thermal Stability	299
14.	Stellar Pulsations and Stability	301
14.1	Eigenmodes.....	301
14.1.1	Equations for Small Oscillations	301
14.1.2	Boundary Conditions.....	305
14.1.3	p -, g - and f -Modes.....	307
14.1.4	Pulsational Instability	309
14.2	Pulsations in Stars with Phase Transition	310
14.2.1	Equations of Motion in the Presence of a Phase Transition.....	310
14.2.2	Physical Processes at the Phase Jump	313
14.2.3	Adiabatic Oscillations of Finite Amplitude	313
14.2.4	Decaying Finite-Amplitude Oscillations.....	315
14.3	Pulsational Stability of Massive Stars	316
14.3.1	The Linear Analysis.....	317
14.3.2	Non-linear Oscillations	320
14.4	On Variable Stars and Stellar Seismology	322
References	325	
List of Symbols and Abbreviations.....	365	
Some Important Constants	377	
Subject Index	379	