

# Contents

## Part I Measuring Stars

|          |   |    |
|----------|---|----|
| <b>1</b> | <b>Classifying and Describing Stars</b> .....   | 3  |
| 1.1      | Celestial Motions and Times.....                | 3  |
| 1.2      | Celestial Coordinates.....                      | 5  |
| 1.3      | Precession and Epochs .....                     | 7  |
| 1.4      | The Magnitude Scale.....                        | 11 |
|          | Problems .....                                  | 12 |
| <b>2</b> | <b>Introduction to Binary Systems</b> .....     | 13 |
| 2.1      | The Two-Body Problem.....                       | 13 |
| 2.2      | The Orbital Shape .....                         | 15 |
| 2.3      | Time-Dependent Orbits .....                     | 18 |
| 2.4      | The Orbital Elements.....                       | 21 |
| 2.5      | Spectroscopic Binaries .....                    | 24 |
|          | Problems .....                                  | 28 |
| <b>3</b> | <b>Measuring Other Stellar Properties</b> ..... | 29 |
| 3.1      | Distances and Parallax .....                    | 29 |
| 3.2      | Temperature and Blackbody Spectrum.....         | 30 |
| 3.3      | Radii and Eclipsing Binaries.....               | 34 |
| 3.4      | Boltzmann and Saha Equations.....               | 38 |
|          | Problems .....                                  | 43 |

## Part II Equations and Processes

|          |  |    |
|----------|--|----|
| <b>4</b> | <b>Stellar Evolution Equations</b> ..... | 47 |
| 4.1      | The Energy Equation .....                | 48 |
| 4.2      | Hydrodynamic Equation .....              | 50 |
| 4.3      | Composition Equations .....              | 51 |
| 4.4      | Virial Theorem .....                     | 55 |

|                                |   |            |
|--------------------------------|---|------------|
| 4.5                            | Total Energy .....                                      | 56         |
| 4.6                            | Timescales .....  | 58         |
|                                | Problems .....  | 61         |
| <b>5</b>                       | <b>Gas and Radiation Pressures</b> .....                | <b>63</b>  |
| 5.1                            | Gas Pressure .....                                      | 65         |
| 5.2                            | Radiation Pressure .....                                | 67         |
| 5.3                            | Degeneracy Pressure .....                               | 68         |
| 5.4                            | Internal Energy of Gas and Radiation .....              | 71         |
| 5.5                            | Adiabatic Exponent .....                                | 73         |
|                                | Problems .....  | 75         |
| <b>6</b>                       | <b>Radiative Transfer and Stellar Atmospheres</b> ..... | <b>77</b>  |
| 6.1                            | The Radiation Field .....                               | 77         |
| 6.2                            | Radiative Transfer .....                                | 80         |
| 6.3                            | Radiative Heat Flux .....                               | 83         |
| 6.4                            | Model Atmospheres .....                                 | 85         |
|                                | Problems .....  | 89         |
| <b>7</b>                       | <b>Nuclear Processes</b> .....                          | <b>91</b>  |
| 7.1                            | Nuclear Fusion .....                                    | 91         |
| 7.2                            | Hydrogen Burning .....                                  | 95         |
|                                | 7.2.1 The p-p Chains .....                              | 95         |
|                                | 7.2.2 The CNO Cycle .....                               | 97         |
| 7.3                            | Burning Heavier Nuclei .....                            | 99         |
| 7.4                            | Neutron Capture Processes .....                         | 101        |
|                                | Problems .....  | 102        |
| <b>Part III Stellar Models</b> |   |            |
| <b>8</b>                       | <b>Simple Stellar Models</b> .....                      | <b>107</b> |
| 8.1                            | Polytropes .....  | 107        |
| 8.2                            | Polytrope Solutions .....                               | 113        |
| 8.3                            | The Eddington Standard Model .....                      | 115        |
| 8.4                            | The Eddington Luminosity .....                          | 116        |
|                                | Problems .....  | 117        |
| <b>9</b>                       | <b>Stability</b> .....                                  | <b>119</b> |
| 9.1                            | Thermal Stability .....                                 | 119        |
| 9.2                            | Thermal Instability .....                               | 121        |
| 9.3                            | Thin-Shell Instability .....                            | 122        |
| 9.4                            | Dynamical Instabilities .....                           | 124        |
| 9.5                            | Convection .....  | 126        |
| 9.6                            | Mixing Length Theory .....                              | 129        |
|                                | Problems .....  | 131        |

|   |         |
|---|---------|
| <b>10 Stellar Birth</b> .....                   | 133     |
| 10.1 The Jeans Criteria .....                   | 133     |
| 10.2 Formation of a Protostar .....             | 137     |
| 10.3 Contraction to Main Sequence .....         | 142     |
| Problems .....                                  | 145     |
| <b>11 Main Sequence Structure</b> .....         | 147     |
| 11.1 High-Mass Stars .....                      | 147     |
| 11.2 Low-Mass Evolution .....                   | 156     |
| 11.3 Late-Stage Evolution .....                 | 158     |
| Problems .....                                  | 162     |
| <b>12 Compact Remnants</b> .....                | 163     |
| 12.1 White Dwarfs .....                         | 163     |
| 12.2 Neutron Stars .....                        | 169     |
| 12.3 Pulsars .....                              | 172     |
| 12.4 Black Holes .....                          | 175     |
| Problems .....                                  | 178     |
| <br><b>Part IV Dynamical Systems</b>            |         |
| <b>13 Binary Evolution</b> .....                | 181     |
| 13.1 The Roche Model .....                      | 181     |
| 13.2 Mass Transfer Stability .....              | 184     |
| 13.3 Unstable Mass Transfer and Mass Loss ..... | 188     |
| 13.4 Binary Evolution Example .....             | 191     |
| Problems .....                                  | 195     |
| <b>14 Star Cluster Dynamics</b> .....           | 197     |
| 14.1 Cluster Timescales .....                   | 197     |
| 14.2 Globular Cluster Structure .....           | 203     |
| 14.3 Globular Cluster Evolution .....           | 207     |
| Problems .....                                  | 211     |
| <b>15 Dynamical Evolution of Binaries</b> ..... | 213     |
| 15.1 Dynamical Formation .....                  | 213     |
| 15.2 Binary Interactions .....                  | 216     |
| 15.3 N-Body Integration .....                   | 218     |
| 15.4 Binary–Cluster Interactions .....          | 220     |
| Problems .....                                  | 221     |
| <br><b>A Useful Constants</b> .....             | <br>223 |
| A.1 Physical Constants .....                    | 223     |
| A.2 Astronomical Constants .....                | 224     |

|          |   |     |
|----------|---|-----|
| <b>B</b> | <b>Atomic Properties of Selected Elements</b> ..... | 225 |
| B.1      | Atomic Properties of Selected Elements .....        | 225 |
| <b>C</b> | <b>Closest and Brightest Stars</b> .....            | 229 |
| C.1      | Closest Stars .....                                 | 229 |
| C.2      | Brightest Stars .....                               | 230 |
|          | <b>Solutions</b> .....                              | 231 |
|          | <b>Index</b> .....                                  | 259 |



<http://www.springer.com/978-1-4419-9990-0>

An Introduction to the Evolution of Single and Binary Stars

Benacquista, M.J.

2013, XII, 262 p. 68 illus., 31 illus. in color., Softcover

ISBN: 978-1-4419-9990-0