

## Contents

<i>Preface</i>	<i>page ix</i>
<b>1 Introduction</b>	<b>1</b>
1.1 What Is the Interstellar Medium?	1
1.2 The Vacuum of Space	4
1.3 Why Study the ISM?	5
<b>2 Observations</b>	<b>7</b>
2.1 Radiation Diagnostics	7
2.2 Telescopes across the Electromagnetic Spectrum	8
2.3 The Virtual Observatory	13
<b>3 Essential Background Physics</b>	<b>15</b>
3.1 Statistical Mechanics	15
3.2 Radiative Transfer	17
3.3 Quantized Absorption and Emission	19
3.4 Flux Density and Luminosity	21
3.5 The Hydrogen Atom	23
<b>4 Dust</b>	<b>26</b>
4.1 Extinction and Reddening	26
4.2 Mie Theory	29
4.3 Grain Size Distribution	31
4.4 Column Density	32
4.5 Temperature	36
4.6 Polarization	38
4.7 Cosmic Dust in the Laboratory	40
<b>5 Atomic Regions</b>	<b>43</b>
5.1 The 21 cm Transition	43
5.2 Column Density	44
5.3 Temperature	47
5.4 The Two-Phase Neutral Medium	50

## vi Contents

5.5	Gas-to-Dust Ratio	54
5.6	Equivalent Width and the Curve of Growth	55
5.7	Elemental Abundances	59
<b>6</b>	<b>Ionized Regions</b>	<b>62</b>
6.1	Photoionization and Recombination of Hydrogen	62
6.2	The Strömgen Sphere	63
6.3	Continuum Emission	70
6.4	Line Emission	74
6.5	Pulsar Dispersion	83
6.6	Heating and Cooling	84
<b>7</b>	<b>Molecular Regions</b>	<b>88</b>
7.1	Molecular Transitions	88
7.2	Rotational and Vibrational Lines	89
7.3	The Invisibility of H <sub>2</sub> in the Cold ISM	92
7.4	Tracers of Cold Molecular Gas	92
7.5	Column Density	94
7.6	Temperature	97
7.7	Heating and Cooling	98
7.8	Giant Molecular Clouds	99
7.9	Photon Dominated Regions	103
7.10	Astrochemistry	105
7.11	Dust as Big Molecules	109
<b>8</b>	<b>Dynamics</b>	<b>111</b>
8.1	Fluid Mechanics	111
8.2	The Wave Equation	113
8.3	The Jeans Criterion	114
8.4	The Virial Theorem	115
8.5	Magnetic Fields	117
8.6	Shocks	118
8.7	Expanding Supernova Remnants	122
8.8	HII Region Evolution	127
8.9	The Hot Ionized Medium	131
<b>9</b>	<b>Star Formation</b>	<b>135</b>
9.1	Gravitational Collapse	135
9.2	The Bonnor–Ebert Sphere	136
9.3	Observations of Core Collapse	140
9.4	Observations of Protostars	143
9.5	The Rate and Efficiency of Star Formation	147
9.6	Angular Momentum	151
9.7	The Circumstellar Medium	153

<b>10 The ISM on the Galactic Scale</b>	<b>163</b>
10.1 Distance Determination	163
10.2 The Distribution of Neutral Gas	165
10.3 The Distribution of Ionized Gas	169
10.4 Galactic Recycling	171
<b>11 The ISM in Other Galaxies and Beyond</b>	<b>177</b>
11.1 Nearby Galaxies	177
11.2 Extragalactic Star Formation	184
11.3 The Intergalactic Medium	191
<b>Appendix Constants in SI and cgs Units</b>	<b>195</b>
<i>Glossary</i>	197
<i>References</i>	203
<i>Index</i>	207