CONTENTS

PREFACE ix

ACKNOWLEDGEMENTS x

CHAPTER 1 INTRODUCTION TO QUIESCENT SOLAR PROMINENCES (E R Priest) 1

1.1 Basic Description 1
1.1.1 Different Types 1
1.1.2 Properties 3
1.1.3 Development 3
1.1.4 Structure 4
1.1.5 Eruption 4
1.2 Basic Equations of MHD 7
1.2.1 Magnetohydrostatics 10
1.2.2 Waves 11
1.2.3 Instabilities 12
1.3 Prominence Puzzles 12

CHAPTER 2 OVERALL PROPERTIES AND STEADY FLOWS (B Schmieder) 15

2.1 Basic Properties 15
2.1.1 Description and Classification 15
2.1.2 Fine Structure in Hα 17
2.1.3 Evolution of Filaments During the Solar Cycle 19
2.2 Physical Characteristics : Density and Temperature 22
2.2.1 Density and Ionization Degree 22
2.2.2 Non LTE Models 24
2.2.3 Turbulent Velocity and Electron Temperature 26
2.3 Velocity Field and Mass Flux 28
2.3.1 Instrumentation 28
2.3.2 Hα Profile Analysis 31
2.3.3 Vertical Motions 31
2.3.4 Horizontal Motions 34
2.3.5 Oscillations 37
2.4 Instability 38
2.4.1 Disparition Brusque of Filaments 38
2.4.2 Model Support 45
2.4.3 Post-Flare Loops and Loop Prominences 45
2.5 Conclusion 46

CHAPTER 3 PROMINENCE ENVIRONMENT (O Engvold) 47

3 .1 Introduction 47
3 .2 Helmet Streamers 48
3 .2 .1 Eclipse Photography 48
3 .2 .2 Morphology 48
3 .2 .3 Location of Current Sheet 51
3 .2 .4 Brightness 52
3 .3 Coronal Cavities 52
3 .3 .1 Brightness and Structure 52
3 .3 .2 Temperature and Density 53
3 .4 Filament Channels 54
3 .4 .1 Association with Neutral Lines 54
3 .4 .2 Poleward Migration of Filament Channels 55
3 .4 .3 Presence of Prominences 55
3 .4 .4 Temperature and Electron Pressure 59
3 .4 .5 Cool Matter in the Filament Channels 59
3 .5 Prominence-Corona Transition Region 61
3 .5 .1 Line Emission 61
3 .5 .2 Empirical Modelling 61
3 .5 .3 A Fragmented and Dynamic Transition Region 64
3 .6 Prominences and Environment 66
3 .6 .1 Magnetic Fields and Chromospheric Structure 66
3 .6 .2 Association with Supergranulation Network 66
3 .6 .3 Dynamics 68
3 .6 .4 The Mass of Coronal Cavity and Prominence 68
3 .6 .5 Coronal Voids - a Source of Prominence Mass? 71
3 .7 Modelling of the Helmet Streamer/Prominence Complex 72
3 .7 .1 Helmet Streamer and Cavity 72
3 .7 .2 Magnetic Field Topology 73
3 .7 .3 Siphon-Type Models 74
3 .8 Conclusions 75

CHAPTER 4 OBSERVATION OF PROMINENCE MAGNETIC FIELDS (J L Leroy) 77

4 .1 Historical Steps 77
4 .2 Investigations Based on the Polarimetry of Spectral Lines 79
4 .2 .1 Zeeman Effect 79
4 .2 .2 Hanle Effect 83
4 .2 .3 180° Ambiguity 85
4 .2 .4 Instrumental Achievements 87
4 .3 Indirect Magnetic Field Determinations 89
4 .4 Magnetic Field at the Photospheric Level 90
4 .5 Main Features of the Magnetic Field in Quiescent Prominences 93
4 .5 .1 Field Strength 93
4 .5 .2 Angle with Horizontal 99

4 .5 .3 Angle with Prominence Axis 100
4 .5 .4 Magnetic Structure with Normal or Inverse Polarity 102
4 .5 .5 Homogeneity of the Field 107
4 .6 Some Important Problems 109
4 .6 .1 Magnetic Field in Sub Arc Second Structures 109
4 .6 .2 Paradox of Fine Vertical Structures 109
4 .6 .3 Determination of Currents 110
4 .6 .4 Evolution of Prominence Magnetic Structure 111

CHAPTER 5 THE FORMATION OF SOLAR PROMINENCES (J M Malherbe) 115

5 .1 Introduction 115
5 .2 Overview of Observations 116
5 .3 Main MHD Instabilities Involved in Prominence Formation 130
5 .3 .1 Radiative Thermal Instability 130
5 .3 .2 Resistive Instabilities 131
5 .4 Steady Reconnection in Current Sheets 132
5 .4 .1 Incompressible and Compressible Theories 132
5 .4 .2 Unification of Different Regimes 133
5 .5 Static Models 133
5 .5 .1 Condensation in a Loop 134
5 .5 .2 Condensation in an Arcade 134
5 .5 .3 Condensation in a Sheared Magnetic Field 134
5 .5 .4 Condensation in a Current Sheet 135
5 .6 Dynamic Models: Injection from the Chromosphere into Closed Loops 135
5 .6 .1 Surge-Like Models 135
5 .6 .2 Evaporation Models 136
5 .7 Dynamic Models: Condensation in Coronal Current Sheets 138
5 .7 .1 Numerical Simulations 138
5 .7 .2 Role of Shock Waves in Condensation Process 138
5 .8 Unsolved Problems 140
5 .9 Conclusion 141

CHAPTER 6 STRUCTURE AND EQUILIBRIUM OF PROMINENCES (U Anzer) 143

6 .1 Introduction 143
6 .2 Prominence Models 144
6 .2 .1 Global Structure 144
6 .2 .1 .1 Two-Dimensional Equilibria 144
6 .2 .1 .1 .1 Models with Normal Magnetic Polarity 144
6 .2 .1 .1 .2 Models with Inverse Magnetic Polarity 149
6 .2 .1 .1 .3 Force-Free Fields 152
6 .2 .1 .2 Quasi-Three-Dimensional Models 154
6 .2 .1 .3 Support by Alfven Waves 154
6 .2 .2 Internal Structure and Thermal Equilibrium 155

6.2.2.1 Hydrostatic Equilibrium 155
6.2.2.2 Thermal Equilibrium 158
6.3 Concluding Remarks 164

CHAPTER 7 STABILITY AND ERUPTION OF PROMINENCES (A W Hood) 167

7.1 Introduction 167
7.2 Description of MHD Instabilities 168
7.3 Methods of Solution 170
7.3.1 Normal Modes 170
7.3.2 Energy Method 172
7.3.3 Non Equilibrium 174
7.4 Effect of the Dense Photosphere 176
7.4.1 Physical Arguments 176
7.4.2 Ballooning Modes 177
7.5 Coronal Arcades 178
7.5.1 Distributed Current Models - Eruptive Instability 178
7.5.2 Localised Modes - Small Scale Structure 180
7.5.3 Arcades Containing a Current Sheet 181
7.6 Thermal Stability 183
7.7 Resistive Instabilities - Tearing Modes 184
7.7.1 Introduction 184
7.7.2 Estimate of Tearing Mode Growth Rate 186
7.7.3 Effect of Line Tying 187
7.8 Simple Model of Prominence Eruption and a Coronal Mass Ejection 188
7.9 Conclusions and Future Work 189

REFERENCES 193

INDEX 213