
Contents

<i>Preface</i>	xi
<i>Acknowledgements</i>	xix
<i>List of abbreviations</i>	xxii
1 Historical introduction	1
1.1 Eclipse observations of prominences: Middle Ages to 1868	1
1.2 Visual and spectroscopic observations of prominence loops: Secchi and Young	3
1.3 Early observations of cool loops with the spectroheliograph, spectrohelioscope and birefringent filter	5
1.4 Coronagraph observations of hot loops in the green and red coronal lines: Lyot and Dunn	10
1.5 Start of the space era: rocket observations of the Sun in the EUV and X-ray regions of the spectrum	13
1.6 Pre-Skylab solar satellites: OSO 1 to OSO 7	17
1.7 The advent of Skylab	20
1.8 Chronological summary	21
<i>References</i>	24
2 Cool loops: observed properties	27
2.1 Introduction	27
2.2 Limb observations in H α and other visible region lines	29
2.2.1 Introduction	29
2.2.2 Velocities and accelerations	30
2.2.3 Magnetic fields	32
2.3 Disk observations in H α	33
2.3.1 Introduction	33
2.3.2 General properties	36
2.3.3 Diameter, height and other geometrical parameters	40
2.3.4 Velocities and accelerations	44
2.4 Observations in EUV lines	46
2.4.1 Introduction	46
2.4.2 Active region loop systems: general characteristics	50
2.4.3 Properties of individual loops	54

2.5	Physical conditions in cool loops	62
2.5.1	Introduction	62
2.5.2	Analysis of disk observations in H α	63
2.5.3	Analysis of limb observations in the visible and near-visible regions	70
2.5.4	Diagnostic techniques for EUV lines	72
2.5.5	Analysis of observations in EUV lines	78
2.6	Summary of data: cool loops	83
	<i>References</i>	86
3	Hot loops: observed properties	92
3.1	Introduction	92
3.2	Observations in the visible region	94
3.2.1	Introduction	94
3.2.2	Properties of loops observed in λ 530.3	96
3.2.3	Observations in $\lambda\lambda$ 637.4, 569.4, and other lines	97
3.2.4	Observations in the continuum	98
3.3	Observations in EUV lines	98
3.3.1	Introduction	98
3.3.2	Active region loop systems: general characteristics	101
3.3.3	Properties of individual loops	109
3.4	Observations in X-rays	112
3.4.1	Introduction	112
3.4.2	Active region loop systems: general characteristics	116
3.4.3	Properties of individual active region loops	122
3.4.4	Properties of individual active region interconnecting loops	125
3.4.5	Properties of individual quiet region loops	127
3.5	Observations at radio wavelengths	130
3.5.1	Introduction	130
3.5.2	Properties of individual loops	133
3.6	Physical conditions in hot loops	135
3.6.1	Introduction	135
3.6.2	Analysis of observations in the visible region	136
3.6.3	Analysis of observations in EUV lines	138
3.6.4	Analysis of observations in X-rays	142
3.6.5	Analysis of observations at radio wavelengths	148
3.7	Relationship between loops observed in different spectral regions	153
3.7.1	Introduction	153
3.7.2	Relationship between X-ray and radio loops	153
3.7.3	Spatial relationship between hot and cool EUV loops	154
3.8	Summary of data: hot loops	155
	<i>References</i>	159
4	Flare loops: observed properties	166
4.1	Introduction	166
4.2	The role of loops in flares: an overview	169
4.3	Disk and limb observations in the visible region	174
4.3.1	Flare loop systems: general characteristics	174

4.3.2 Properties of individual loops	177
4.3.3 Relationship between loops observed in H α and λ 530.3	180
4.4 Observations in EUV lines	181
4.4.1 Introduction	181
4.4.2 Loop structure of EUV flares	183
4.5 Observations in X-rays	196
4.5.1 Introduction	196
4.5.2 Loop structure of soft X-ray flares	198
4.5.3 Properties of hard X-ray (HXR) bursts	205
4.5.4 Spatial and temporal relationships between hard and soft X-ray flare emission	215
4.6 Observations at radio wavelengths	216
4.6.1 Introduction	216
4.6.2 Properties of individual bursts/loops	218
4.7 Spatial and temporal relationships between flare emissions observed in different spectral regions	223
4.7.1 Introduction	223
4.7.2 H α and hard X-rays	223
4.7.3 H α and microwave	224
4.7.4 EUV and hard X-rays	227
4.7.5 Hard X-rays and microwave	228
4.8 Physical conditions in flare loops	229
4.8.1 Introduction	229
4.8.2 Analysis of observations in the visible region	230
4.8.3 Analysis of observations in EUV lines	233
4.8.4 Analysis of observations in soft and hard X-rays	238
4.8.5 Analysis of observations at radio wavelengths	242
4.9 Summary of data: flare loops	245
<i>References</i>	250
5 Structure, dynamics and heating of loops	261
5.1 Introduction	261
5.2 Coronal magnetic field models	267
5.2.1 Introduction	267
5.2.2 Force-free fields	268
5.2.3 Potential fields	274
5.3 Model equations for the coronal plasma	278
5.3.1 The MHD approximation	278
5.3.2 The MHD equations	280
5.4 Steady-state structure of loops	288
5.4.1 Introduction	288
5.4.2 Static models of individual loops	291
5.4.3 Steady-flow models of individual loops	304
5.5 Thermal stability and dynamics	312
5.5.1 Introduction	312
5.5.2 Global thermal stability	316
5.5.3 Loop dynamics	321

5.6 MHD stability and dynamics	328
5.6.1 Introduction	328
5.6.2 MHD stability	332
5.6.3 MHD waves	345
5.6.4 Non-ideal effects in waves	357
5.7 The heating of coronal loops	365
5.7.1 Introduction	365
5.7.2 AC heating mechanisms	370
5.7.3 DC heating mechanisms	375
5.8 Flare loops	383
5.8.1 Flare loop dynamics	383
5.8.2 Flare loop heating	385
5.9 Summary and conclusion	386
<i>References</i>	391
6 The plasma loop model of the coronae of the Sun and stars	403
6.1 Solar magnetic fields	404
6.1.1 The origin of magnetic fields	405
6.1.2 Photospheric magnetic fields	413
6.1.3 Chromospheric magnetic fields	421
6.1.4 Summary	423
6.2 Magnetic fields and coronal plasma loops	425
6.2.1 Magnetic topology in the corona	425
6.2.2 Global electrodynamics	429
6.3 Plasma loops in stellar coronae	437
6.3.1 Hot loops in stellar coronae	438
6.3.2 Cool loops in stellar coronae	450
6.3.3 Physical conditions in stellar coronal plasma loops	452
6.3.4 Coronal emission and other stellar properties	462
6.3.5 Theory of stellar magnetism	466
6.3.6 Prospects	469
<i>References</i>	471
<i>Additional notes</i>	481
<i>Name index</i>	485
<i>Subject index</i>	491

Frontispiece courtesy of Dr L. Golub (SAO) and Dr J. Harvey (NOAO) using data obtained by SAO, NOAO/Kitt Peak, NASA/GSFC, NOAA/SEL and IBM Research.

