

# Contents

	<i>Preface</i>	<i>page</i>	xi
	<i>Acknowledgements</i>		ix
<b>1</b>	<b>A brief history of spectroscopy</b>		1
<b>2</b>	<b>The relevant regions of the electromagnetic spectrum</b>		6
2.1	The limits of optical spectrography		8
<b>3</b>	<b>Geometrical optics</b>		10
3.1	Rays and wavefronts		10
3.2	Instrumental optics		11
3.3	Centred systems		12
3.4	Gaussian optics		12
3.5	Optical layout		20
3.6	Apertures, stops, fields, irises and pupils		20
3.7	Ray bundles		23
3.8	The Helmholtz–Lagrange invariants		23
3.9	Surface brightness		25
3.10	Black body radiation		25
<b>4</b>	<b>Optical aberrations</b>		28
4.1	The Seidel aberrations		29
4.2	Zero-order aberration		29
4.3	First-order aberrations		29
4.4	Theorems		35
4.5	Aberration coefficients for mirrors		37
4.6	The achromatic doublet		39
<b>5</b>	<b>Fourier transforms: a brief revision</b>		41
5.1	Fourier transforms		41
5.2	Theorems		42
5.3	Convolutions		42
5.4	The Wiener–Khinchine theorem		45

5.5	Useful functions	45
5.6	More theorems	49
5.7	Aliasing	51
<b>6</b>	<b>Physical optics and diffraction</b>	<b>52</b>
6.1	Fraunhofer diffraction	52
6.2	Two-dimensional apertures and oblique incidence	55
<b>7</b>	<b>The prism spectrograph</b>	<b>57</b>
7.1	Introduction	57
7.2	The traditional prism spectrograph	57
7.3	The focal curve theorem	59
7.4	The Littrow mounting	59
7.5	The Pellin–Broca prism	60
7.6	Focal isolation	61
<b>8</b>	<b>The plane grating spectrograph</b>	<b>63</b>
8.1	The shape of a monochromatic line spectrum	63
8.2	Blazing of gratings	67
8.3	Apodising	68
8.4	Order overlap and free spectral range	69
8.5	Grating ghosts and periodic errors	70
8.6	The complete grating equation	72
8.7	Differential dispersion	76
8.8	Mounting configurations	76
<b>9</b>	<b>The concave grating spectrograph</b>	<b>89</b>
9.1	The Rowland grating	89
9.2	The concave grating as a spectrograph	92
9.3	The concave grating as a monochromator	96
9.4	The aberrations of the Rowland grating	97
9.5	Practical details of design	98
<b>10</b>	<b>The interference spectrograph</b>	<b>101</b>
10.1	The phase angle	101
10.2	The Fabry–Perot étalon spectrograph	102
10.3	Fabry–Perot theory	102
10.4	The Fabry–Perot monochromator	104
10.5	The Fabry–Perot CCD spectrograph	108
10.6	Fore-optics	110
10.7	Reference fringes	111
10.8	Extraction of the spectrum	111
10.9	Choice of the resolution and gap	112
10.10	The ‘crossed’ Fabry–Perot spectrograph	113

<b>11 The multiplex spectrometer</b>	114
11.1 The principles of Fourier spectrometry	114
11.2 The multiplex advantage	117
<b>12 Detectors</b>	120
12.1 Silver halide photography	121
12.2 Elementary electronic detectors	122
12.3 Detectors with spatial resolution	123
12.4 Exposure limitations	124
12.5 CCD software	125
12.6 CCD calibration	126
12.7 Spectrograph calibration	126
<b>13 Auxiliary optics</b>	128
13.1 Fore-optics	128
13.2 The astronomical telescope as fore-optics	130
13.3 Focal reducers	132
13.4 Schmidt-camera spectrography	134
13.5 Scattered light and baffling	134
13.6 Absorption cells	136
13.7 Fibre optical input	137
<b>14 Optical design</b>	139
14.1 First steps	139
14.2 Initial layout	139
14.3 The drawing board	140
14.4 Computer ray tracing	140
14.5 Refinement of the optical design	141
14.6 Requirements of a ray-tracing program	144
<b>15 Mechanical design and construction</b>	150
15.1 The optical layout	150
15.2 Optical materials	162
15.3 Transparent optical materials	163
15.4 Reflectors	163
15.5 Metals for construction	165
15.6 Other materials	167
<b>16 Calibration</b>	168
16.1 Sensitivity calibration	168
16.2 Wavelength calibration	169
16.3 Small spectral shifts and radial-velocity measurement	170
16.4 Absorption measurements	170

<b>17 The alignment of a spectrograph</b>	172
17.1 The optical alignment	172
17.2 The focus	173
<b>Appendix 1 Optical aberrations</b>	175
<b>Appendix 2 Wavelengths of spectral lines for calibration</b>	179
<b>Appendix 3 The evolution of a Fabry–Perot interference spectrograph</b>	183
<b>Appendix 4 The common calibration curve in silver halide spectrophotometry</b>	186
<i>Bibliography</i>	187
<i>Index</i>	188