

Contents

1	Introduction	1
2	Propagation of Light	5
2.1	Preliminaries	6
2.1.1	Basic Properties of the Electromagnetic Wave	6
2.1.2	Young's Experiment	9
2.2	Scalar Diffraction Theory	13
2.2.1	The Rayleigh–Sommerfeld Diffraction Formula	13
2.2.2	Fresnel Approximation	16
2.2.3	The Airy Disk	19
2.3	The Coherence Function	25
2.3.1	Varieties of the Coherence Function	26
2.3.2	Generalised van Cittert–Zernike Theorem	32
2.3.3	Incoherent Sources of Light: Stars	34
2.3.4	Quasi-Monochromatic Approximation	37
2.4	Young's Experiment Revisited	44
2.4.1	The Coherence Function in Young's Experiment	45
2.4.2	ABCD Method	50
2.4.3	Power Spectrum of the Fringe Pattern	51
2.4.4	Heuristic Approach	56
2.5	Higher Order Correlation Functions: Intensity Interferometry	62
3	Imaging Process: Propagation Through Optical Systems	73
3.1	Fourier Optics	74
3.1.1	The Optical Transfer Function	76
3.1.2	Optical Aberrations: The Zernike Polynomials	82
3.2	The Coherence Function	88
3.2.1	Image Intensity Distribution	88
3.2.2	Coherent Imaging	92
3.2.3	Coherence Properties in the Image Plane	99
3.3	Propagation Through Interferometers	103
3.3.1	Young's Experiment with a Lens	104
3.3.2	Apertures of Finite Size	110

3.3.3	Spectra of Finite Width	116
3.3.4	Objects of Finite Size	122
3.3.5	Considerations on the Interferometric Field of View	128
3.3.6	Masked Field of View	132
3.4	The uv-Plane	139
3.4.1	Large Apertures, Short Baseline: The LBT	141
3.4.2	Large Apertures, Long Baselines: The VLTI	144
3.4.3	Image Reconstruction: General Principles	149
4	Atmospheric Turbulence	157
4.1	Kolmogorov Turbulence	158
4.1.1	First Principles	158
4.1.2	Index of Refraction Fluctuations	159
4.2	Statistical Properties of the Perturbed Complex Wave	164
4.2.1	Thin Layer Turbulence Model	164
4.2.2	Multiple Layers, the Fried Parameter	166
4.2.3	Anisoplanatic and Temporal Effects	172
4.3	Propagation Through Optical Systems	178
4.3.1	Fringe Motion	178
4.3.2	Image Motion	190
4.3.3	Zernike Representation of Atmospheric Turbulence	194
4.3.4	Scintillation	198
4.3.5	Speckle Pattern and Seeing Disk	200
4.4	Speckle Interferometry	208
5	Instrumental Techniques	217
5.1	Combination of Two Telescopes	218
5.1.1	Fizeau Configuration	218
5.1.2	Michelson Configuration	222
5.1.3	Co-Axial Combination	226
5.2	Multi-Aperture Combination: Michelson Configuration	234
5.2.1	Multi-Axial and Co-Axial Combination	234
5.2.2	Aspects of Beam Combination	239
5.3	Multi-Aperture Combination: Direct Imaging	243
5.3.1	Fizeau Configuration	244
5.3.2	Hypertelescope	246
5.3.3	Interferometric Remapped Array Nulling: IRAN	249
5.3.4	Nulling Interferometer	257
5.4	Layout of Interferometer Arrays	263
5.4.1	Many Apertures	263
5.4.2	Few Apertures	268
5.4.3	Delay Lines	271

6	Observing Through Atmospheric Turbulence	275
6.1	Visibility Measurement Through Atmospheric Turbulence	276
6.1.1	Power Spectrum of the Fringe Pattern	283
6.1.2	ABCD Method	287
6.2	Beating Atmospheric Turbulence	293
6.2.1	Fringe Tracking	293
6.2.2	Dual-Feed System	301
6.2.3	Closure Phase	306
6.3	Adaptive Optics	310
6.3.1	Wave Front Sensing	311
6.3.2	Closed Loop Operation	313
7	Modern Interferometers	317
A	Appendix	319
A.1	The Fourier Transform	319
A.2	Atmospheric Transmission Bands	322
	References	325
	Index	337