

Contents

1	Introduction	1
2	The Classical Bosonic String	7
2.1	The Relativistic Particle	7
2.2	The Nambu-Goto Action	10
2.3	The Polyakov Action and Its Symmetries	12
2.4	Oscillator Expansions	23
2.5	Examples of Classical String Solutions	31
3	The Quantized Bosonic String	35
3.1	Canonical Quantization of the Bosonic String	35
3.2	Light-Cone Quantization of the Bosonic String	42
3.3	Spectrum of the Bosonic String	46
3.4	Covariant Path Integral Quantization	53
3.5	Appendix: The Virasoro Algebra	59
4	Introduction to Conformal Field Theory	63
4.1	General Introduction	63
4.2	Application to Closed String Theory	85
4.3	Boundary Conformal Field Theory	93
4.4	Free Boson Boundary States	101
4.5	Crosscap States for the Free Boson	103
5	Parametrization Ghosts and BRST Quantization	107
5.1	The Ghost System as a Conformal Field Theory	107
5.2	BRST Quantization	110
6	String Perturbation Theory and One-Loop Amplitudes	121
6.1	String Perturbation Expansion	121
6.2	The Polyakov Path Integral for the Closed Bosonic String	126
6.3	The Torus Partition Function	146
6.4	Torus Partition Functions for Rational CFTs	152
6.5	The Cylinder Partition Function	157

6.6	Boundary States and Cylinder Amplitude for RCFTs	163
6.7	Crosscap States, Klein Bottle and Möbius Strip Amplitudes	166
6.8	Appendix: D-brane Tension	171
7	The Classical Fermionic String	175
7.1	Motivation for the Fermionic String	175
7.2	Superstring Action and Its Symmetries	176
7.3	Superconformal Gauge	180
7.4	Oscillator Expansions	189
7.5	Appendix: Spinor Algebra in Two Dimensions	192
8	The Quantized Fermionic String	195
8.1	Canonical Quantization	195
8.2	Light-Cone Quantization	200
8.3	Spectrum of the Fermionic String, GSO Projection	202
8.4	Path Integral Quantization	208
8.5	Appendix: Dirac Matrices and Spinors in d Dimensions	210
9	Superstrings	223
9.1	Spin Structures and Superstring Partition Function	223
9.2	Boundary States for Fermions	232
9.3	D-branes	235
9.4	The Type I String	241
9.5	Stable Non-BPS Branes	251
9.6	Appendix: Theta-Functions and Twisted Fermionic Partition Functions	254
10	Toroidal Compactifications: 10-Dimensional Heterotic String	263
10.1	Motivation	263
10.2	Toroidal Compactification of the Closed Bosonic String	264
10.3	Toroidal Partition Functions	280
10.4	The $E_8 \times E_8$ and $SO(32)$ Heterotic String Theories	284
10.5	Toroidal Orbifolds	294
10.6	D-branes on Toroidal Compactifications	308
11	Conformal Field Theory II: Lattices and Kač-Moody Algebras	321
11.1	Kač-Moody Algebras	321
11.2	Lattices and Lie Algebras	327
11.3	Frenkel-Kač-Segal Construction	337
11.4	Fermionic Construction of the Current Algebra: Bosonization	340
11.5	Unitary Representations and Characters of Kač-Moody Algebras	343
11.6	Highest Weight Representations of $\widehat{su}(2)_k$	349
12	Conformal Field Theory III: Superconformal Field Theory	355
12.1	$N = 1$ Superconformal Symmetry	355
12.2	$N = 2$ Superconformal Symmetry	370
12.3	Chiral Ring and Topological Conformal Field Theory	382

13	Covariant Vertex Operators, BRST and Covariant Lattices	391
13.1	Bosonization and First Order Systems	391
13.2	Covariant Vertex Operators, BRST and Picture Changing	403
13.3	D-branes and Space-Time Supersymmetry	411
13.4	The Covariant Lattice	415
13.5	Heterotic Strings in Covariant Lattice Description	422
14	String Compactifications	427
14.1	Conformal Invariance and Space-Time Geometry	427
14.2	T-Duality and Buscher Rules	432
14.3	Compactification	439
14.4	Mathematical Preliminaries	450
14.5	Calabi-Yau Manifolds	473
14.6	Compactification of the Type II String on CY Threefolds	487
14.7	Compactification of the Heterotic String on CY Threefolds	497
14.8	Appendix: Some Riemannian Geometry, Hodge Duals, etc.	508
15	CFTs for Type II and Heterotic String Vacua	521
15.1	Motivation	521
15.2	Supersymmetric Orbifold Compactifications	522
15.3	Orientifold Compactifications	534
15.4	World-Sheet Aspects of Supersymmetric Compactifications	544
15.5	Gepner Models	567
15.6	Four-Dimensional Heterotic Strings via Covariant Lattices	578
16	String Scattering Amplitudes and Low Energy Effective Field Theory	585
16.1	Generalities	585
16.2	String Scattering Amplitudes	588
16.3	From Amplitudes to the Low Energy Effective Field Theory	615
16.4	Effective Supergravities in Ten and Eleven Dimensions	622
16.5	Effective Action for D-branes	630
16.6	Appendix: Integrals in Veneziano and Virasoro-Shapiro Amplitudes	636
17	Compactifications of the Type II Superstring with D-branes and Fluxes	641
17.1	Brane Worlds and Fluxes	641
17.2	Supersymmetry, Tadpoles and Massless Spectra	644
17.3	Flux Compactifications	657
17.4	Fluxes and $SU(3)$ Structure Group	663
17.5	Appendix	670
18	String Dualities and M-Theory	675
18.1	General Remarks	675
18.2	Simple Examples: Modular Invariance and T-Duality	677
18.3	Extended Objects: Some Generalities	680

18.4	Central Charges and BPS Bound	684
18.5	Brane Solutions in Supergravity	688
18.6	Non-perturbative Dualities	705
18.7	M-Theory	716
18.8	F-Theory	724
18.9	AdS/CFT Correspondence	733
Index		775

Basic Concepts of String Theory

Blumenhagen, R.; Lüst, D.; Theisen, S.

2013, XII, 784 p., Hardcover

ISBN: 978-3-642-29496-9