

Pomeron Physics and QCD

SANDY DONNACHIE,
GÜNTER DOSCH,
PETER LANDSHOFF
AND OTTO NACHTMANN

CAMBRIDGE MONOGRAPHS
ON PARTICLE PHYSICS, NUCLEAR PHYSICS
AND COSMOLOGY

Contents

<i>Preface</i>	ix
1 Properties of the S-matrix	1
1.1 Kinematics	1
1.2 The cross section	3
1.3 Unitarity and the optical theorem	6
1.4 Crossing and analyticity	6
1.5 Partial-wave amplitudes	12
1.6 The Froissart-Gribov formula	13
1.7 The Froissart bound	16
1.8 The Pomeranchuk theorem	18
2 Regge poles	21
2.1 Motivation	21
2.2 The Sommerfeld-Watson transform	25
2.3 Connection with particles	29
2.4 Regge cuts	34
2.5 Signature and parity of cuts	37
2.6 Reggeon calculus	38
2.7 Daughter trajectories	39
2.8 Fixed poles	41
2.9 Spin	44

3	Introduction to soft hadronic processes	47
3.1	Total cross sections	47
3.2	Elastic scattering	53
3.3	Spin dependence of high energy proton-proton scattering	65
3.4	Soft diffraction dissociation	67
3.5	Central production	75
3.6	Diffractive Higgs production	78
3.7	Helicity structure of the pomeron	79
3.8	Glueball production	83
3.9	The Gribov-Morrison rule	85
3.10	The odderon	87
3.11	Scattering on nuclei	89
4	Duality	91
4.1	Finite-energy sum rules	91
4.2	Duality	93
4.3	Two-component duality and exchange degeneracy	94
4.4	The Veneziano model	97
4.5	Pion-nucleon scattering	100
5	Photon-induced processes	107
5.1	Photon-proton and photon-photon total cross sections	107
5.2	Vector-meson-dominance model	108
5.3	Vector-meson photoproduction	113
5.4	Spin effects in vector-meson photoproduction	117
5.5	Diffraction dissociation	120
5.6	Pion photoproduction	122
6	QCD: perturbative and nonperturbative	129
6.1	Basics of QCD	129
6.2	Semi-hard collisions	135
6.3	Soft hadron-hadron collisions	137
6.4	The QCD vacuum	140
6.5	Nonlocal condensates	145
6.6	Loops and the non-Abelian Stokes theorem	149

6.7	Stochastic-vacuum model	151
6.8	Renormalons	155
7	Hard processes	160
7.1	Deep-inelastic lepton scattering	160
7.2	The DGLAP equation	165
7.3	The BFKL equation	167
7.4	Regge approach	172
7.5	Real photons: a crucial question	178
7.6	Perturbative evolution	179
7.7	Photon-photon interactions	182
7.8	Exclusive vector-meson production	191
7.9	Inclusive vector-meson photoproduction	204
7.10	Diffractive structure function	206
7.11	Diffractive jet production	213
7.12	The perturbative odderon	216
8	Soft diffraction and vacuum structure	219
8.1	The Landshoff-Nachtmann model	219
8.2	Functional-integral approach	227
8.3	Quark-quark scattering amplitudes	232
8.4	Scattering of systems of quarks, antiquarks and gluons	236
8.5	Evaluation of the dipole-dipole scattering amplitude	239
8.6	Wave functions of photons and hadrons	247
8.7	Applications to high-energy hadron-hadron scattering	254
8.8	Application to photoproduction of vector mesons	258
8.9	Photoproduction of pseudoscalar and tensor mesons	261
8.10	The pomeron trajectory and nonperturbative QCD	262
8.11	Scattering amplitudes in Euclidean space	267
9	The dipole approach	269
9.1	Deep-inelastic scattering	269
9.2	Production processes	274
9.3	Different approaches to dipole cross sections	278
9.4	Saturation	282

9.5	Two-pomeron dipole model	289
10	Questions for the future	295
	Appendix A: Sommerfeld-Watson transform	301
	Appendix B: The group $SU(3)$	307
	Appendix C: Feynman rules of QCD	310
	Appendix D: Pion-nucleon amplitudes	314
	Appendix E: The density matrix of vector mesons	322
	<i>References</i>	327
	<i>Index</i>	343