

SYMMETRIES AND SYMMETRY BREAKING IN FIELD THEORY

P. MITRA



CRC Press

Taylor & Francis Group

A CHAPMAN & HALL BOOK

SYMMETRIES AND SYMMETRY BREAKING IN FIELD THEORY

SYMMETRIES AND SYMMETRY BREAKING IN FIELD THEORY

P. MITRA

Saha Institute of Nuclear Physics
Calcutta, India



CRC Press

Taylor & Francis Group

Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business
A CHAPMAN & HALL BOOK

Taylor & Francis
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

© 2014 by Taylor & Francis Group, LLC
Taylor & Francis is an Informa business

No claim to original U.S. Government works
Version Date: 20140418

International Standard Book Number-13: 978-1-4665-8105-0 (eBook - PDF)

This book contains information obtained from authentic and highly regarded sources. Reasonable efforts have been made to publish reliable data and information, but the author and publisher cannot assume responsibility for the validity of all materials or the consequences of their use. The authors and publishers have attempted to trace the copyright holders of all material reproduced in this publication and apologize to copyright holders if permission to publish in this form has not been obtained. If any copyright material has not been acknowledged please write and let us know so we may rectify in any future reprint.

Except as permitted under U.S. Copyright Law, no part of this book may be reprinted, reproduced, transmitted, or utilized in any form by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying, microfilming, and recording, or in any information storage or retrieval system, without written permission from the publishers.

For permission to photocopy or use material electronically from this work, please access www.copyright.com (<http://www.copyright.com/>) or contact the Copyright Clearance Center, Inc. (CCC), 222 Rosewood Drive, Danvers, MA 01923, 978-750-8400. CCC is a not-for-profit organization that provides licenses and registration for a variety of users. For organizations that have been granted a photocopy license by the CCC, a separate system of payment has been arranged.

Trademark Notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe.

Visit the Taylor & Francis Web site at
<http://www.taylorandfrancis.com>

and the CRC Press Web site at
<http://www.crcpress.com>

Contents

List of Figures	vii
List of Tables	ix
Preface	xi
1 Introduction	1
1.1 Constituents of matter	1
1.2 Symmetries in elementary particle physics	3
2 Elements of classical field theory	7
2.1 Functionals	7
2.2 Classical mechanics and classical field theory	8
3 Global symmetries	13
3.1 Internal symmetries	13
3.1.1 Global gauge symmetry	15
3.1.2 Chiral symmetry	16
3.2 Translation	17
3.3 Rotations and Lorentz transformations	19
3.3.1 Commutation of δ and ∂_μ for Lorentz transformations	21
3.3.2 Algebra of the generators	22
3.4 Symmetric energy-momentum tensor	24
4 Local symmetry and constraint theory	27
4.1 Electromagnetic field	27
4.2 A constrained system in mechanics	29
4.3 Electromagnetic field without gauge fixing	30
4.4 A system with second class constraints	32
4.5 Electromagnetic field with gauge fixing	32

5	Functional integral formulation of field theory	35
5.1	Scalar field theory	37
5.2	Fermion fields in functional formalism	39
6	Nonabelian gauge symmetry	41
6.1	Classical theory	41
6.2	Quantization	44
6.3	BRS symmetry	49
7	Discrete symmetries	53
7.1	Parity in spinor field theory	54
7.2	Time reversal in spinor field theory	57
7.3	Charge conjugation	59
8	Spontaneous symmetry breaking	63
8.1	Abelian Higgs model	63
8.2	Nonabelian Higgs model	68
9	Breaking of chiral symmetry on quantization: The anomaly	71
9.1	Pauli–Villars regularization	71
9.1.1	Chiral phases in mass terms	75
9.2	Measure formulation	78
9.2.1	Chiral phases in mass terms	82
9.3	Zeta function regularization	85
9.4	Chiral gauge theory	90
9.4.1	Quantizing chiral gauge theories with local gauge anomalies	92
9.4.2	Global anomaly	95
	Index	99

List of Figures

8.1	Symmetric potential.	65
8.2	Symmetric potential with multiple minima.	65

List of Tables

7.1	Behavior of Interaction Terms under Discrete Symmetries. .	62
9.1	Choice of Phase in Measure.	83

