CLASSICAL AND QUANTUM ELECTRODYNAMICS AND THE B(3) FIELD

SERIES IN CONTEMPORARY CHEMICAL PHYSICS

Editor-in-Chief: M. W. Evans (*AIAS, Institute of Physics, Budapest, Hungary*)

Associate Editors: S Jeffers (*York University, Toronto*)

D Leporini (*University of Pisa, Italy*)

J Moscicki (*Jagellonian University, Poland*)

L Pozhar (*The Ukrainian Academy of Sciences*)

S Roy (*The Indian Statistical Institute*)

- Vol. 1 The Photon's Magnetic Field — Optical NMR Spectroscopy
by M. W. Evans and F. Fahari
- Vol. 2 Beltrami Fields in Chiral Media
by A. Lakhtakia
- Vol. 3 Quantum Mechanical Irreversibility and Measurement
by P. Grigolini
- Vol. 4 The Photomagneton and Quantum Field Theory: Quantum Chemistry, Vol. 1
by A. A. Hasanein and M. W. Evans
- Vol. 5 Computational Methods in Quantum Chemistry: Quantum Chemistry, Vol. 2
by A. A. Hasanein and M. W. Evans
- Vol. 6 Transport Theory of Inhomogeneous Fluids
by L. A. Pozhar
- Vol. 7 Dynamic Kerr Effect: The Use and Limits of the Smoluchowski Equation and Nonlinear Inertial Responses
by J.-L. Dejarin
- Vol. 8 Dielectric Relaxation and Dynamics of Polar Molecules
by V. I. Gaiduk
- Vol. 9 Water in Biology, Chemistry and Physics: Experimental Overviews and Computational Methodologies
by G. W. Robinson, S. B. Zhu, S. Singh and M. W. Evans
- Vol. 10 The Langevin Equation: With Applications in Physics, Chemistry and Electrical Engineering
by W. T. Coffey, Yu P. Kalmykov and J. T. Waldron
- Vol. 11 Structure and Properties in Organised Polymeric Materials
eds. E. Chiellini, M. Giordano and D. Leporini
- Vol. 12 Proceedings of the Euroconference on Non-Equilibrium Phenomena in Supercooled Fluids, Glasses and Amorphous Materials
eds. M. Giordano, D. Leporini and M. P. Tosi
- Vol. 13 Electronic Structure and Chemical Bonding
by J.-R. Lalanne
- Vol. 14 Dialogues on Modern Physics
by M. Sachs
- Vol. 15 Phase in Optics
by V. Peřinova, A. Lukř and J. Peřina

- Vol. 16 Extended Electromagnetic Theory: Space Charge in Vacuo and the
Rest Mass of the Photon
by S. Roy and B. Lehnert
- Vol. 17 Optical Spectroscopies of Electronic Absorption
by J.-R. Lalanne, F. Carmona and L. Servant

This page is intentionally left blank

World Scientific Series in Contemporary Chemical Physics – Vol. 18

CLASSICAL AND QUANTUM ELECTRODYNAMICS AND THE $B(3)$ FIELD

M W Evans & L B Crowell

AIAS, Institute of Physics, Budapest, Hungary

World Scientific

Singapore • New Jersey • London • Hong Kong

Published by

World Scientific Publishing Co. Pte. Ltd.

P O Box 128, Farrer Road, Singapore 912805

USA office: Suite 1B, 1060 Main Street, River Edge, NJ 07661

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

CLASSICAL AND QUANTUM ELECTRODYNAMICS AND THE $B(3)$ FIELD

Copyright © 2001 by World Scientific Publishing Co. Pte. Ltd.

All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system now known or to be invented, without written permission from the Publisher.

For photocopying of material in this volume, please pay a copying fee through the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA. In this case permission to photocopy is not required from the publisher.

ISBN 981-02-4149-6

Printed in Singapore by World Scientific Printers

Myron Evans dedicates this book to his wife Laura, and Lawrence Crowell dedicates it to his wife Elisheva, daughter MaryLynn and son Nathaniel. This book is also written in dedication to the recently deceased fathers of both authors.

This page is intentionally left blank

Preface

This text discusses the implications that electromagnetism has higher symmetries that may exist either at high energy or at low energy. In it there are illustrations of the possible consequences of this hypothesis. These implications involve the prospects for classical electrodynamics as well as the domain of extremely high energy physics up to the Planck scale. This possibility would illustrate that nature is more symmetrical in general and opens the prospect for a better understanding of nonlinear optical phenomenology and curious aspects of interferometry.

This extension of electromagnetism into a higher symmetry group illustrates that a number of concepts about physics, from classical electromagnetism to the theory of elementary particle physics may require revision if this extension is not sufficiently verified under experimental test. Physicists may then be required to revise a number of the current concepts if this extension is found to satisfy a body of supporting data.

This page is intentionally left blank

CONTENTS

Preface	vii
Introduction	1
Chapter 1.	Interaction of Electromagnetic Radiation with One Fermion
1.1.	Lorentz Electron
1.2.	Radiation Induced Electron and Proton Spin Resonance
1.3.	The $B^{(3)}$ Field
1.4.	Electrodynamics as a NonAbelian Gauge Field Theory
1.5.	Limitations of the $U(1)$ Theory
1.6.	Classical Relativistic NonAbelian Electrodynamics
1.7.	Relativistic Quantum Description
1.8.	Nonrelativistic Quantum Description
1.9.	Schrödinger Equation with Intrinsic Spin
1.10.	Resonance Conditions in RFR
1.11.	Chemical Shifts in NMR
1.12.	Classical Derivation of the Inverse Faraday Effect
	References
Chapter 2.	The Field Equations of Classical $O(3)_b$ Electrodynamics
2.1.	Introduction
2.2.	The $O(3)_b$ Field Equations
2.3.	Basic S. I. Units
2.4.	The $O(3)_b$ Vacuum Equations
2.4.1.	The Coefficient g in the Vacuum
2.4.2.	The $O(3)_b$ Field Tensor in the Vacuum
2.5.	Reduction to Maxwell's Equations
2.6.	The Fundamental Laws of $O(3)_b$ Electrodynamics
2.7.	The Lorentz Force Equation in $O(3)_b$ Electrodynamics
2.8.	Continuity Equation and Lorentz Condition in $O(3)_b$ Electrodynamics
2.9.	Primitive Concepts, Axioms and Constitutive Relations of $O(3)_b$ Electrodynamics
2.10.	The Inverse Faraday Effect
2.11.	The effective $A^{(3)}$ Potential, Photoelectric and Compton Effects and Radiation Reaction

2.12.	Summary	73
	References	74
Chapter 3.	Origin of Electrodynamics in the General Theory of Gauge Fields	77
3.1.	Closed Loop in Minkowski Space	77
3.2.	Gauge Transformations	80
3.2.1.	Gauge Transformation in the $O(3)_b$ Group	84
3.3.	The Sagnac Effect	86
3.4.	Observation of $B^{(3)}$ in the Topological Phase	92
3.5.	The NonAbelian Stokes Theorem and the Electromagnetic Phase	102
3.6.	Link between B Cyclic Theorem and the NonAbelian Stokes Theorem	109
	References	111
Chapter 4.	Nonlinear Propagation in $O(3)_b$ Electrodynamics: Solitons and Instantons	115
4.1.	Limitation in the $U(1)$ Theory	115
4.2.	Identification of the Harmuth and $O(3)_b$ Field Equations	116
4.3.	Structure of the $O(3)_b$ and Harmuth–Barrett Field Equations	118
4.4.	Link between the $O(3)_b$ Equations and the Sine–Gordon Equations	122
4.5.	Instantons	127
4.6.	Higher Order Soliton Equations	132
	References	136
Chapter 5.	Physical Phase Effects in $O(3)_b$ Electrodynamics	137
5.1.	Phase Effects	137
5.1.1.	The Optical Ahronov–Bohm Effects	147
5.1.2.	Phase Shift of the Inverse Faraday Effect	152
5.2.	Phase Shift of the Optical Josephson Effect	155
5.3.	Phase Factor of the Optical Hall Effect	156
	References	156
Chapter 6.	Quantum Electrodynamics and the $B^{(3)}$ Field	159
6.1.	Introduction to Quantum Electrodynamics	159
6.2.	A Brief Introduction to Differential Forms	168
6.3.	The Physical Basis for NonAbelian Electrodynamics	170

6.4.	The Quantized $U(1)$ and $O(3)_b$ Electrodynamic Field	179
6.4.1.	Numerical Results	182
6.4.2.	Discussion of these Results	204
6.5.	Quantum Electrodynamics of Elementary Scattering	206
6.6.	Physics of Quantum Electrodynamics of Electrons and Photons with the $B^{(3)}$ Field	212
6.7.	Nonrelativistic Estimate of the $B^{(3)}$ Contribution to the Lamb Shift	217
6.8.	Derivation of the $1/f$ Spectrum from NonAbelian Electrodynamics	222
6.9.	Analogy from Classical Field to NonAbelian Quantum Electrodynamics	227
	References	234
Chapter 7.	Quantum Chaos, Topological Indices and Gauge Theories	237
7.1.	Introduction	237
7.2.	Topological Number and Quantum Vortices	238
7.3.	Density Operator Methods	241
7.4.	Hamiltonian Chaotic Systems	246
7.5.	Quantum Geometry and Bohm's Theory	248
7.6.	Discussion and Problems	257
	References	259
Chapter 8.	Field Theory of $O(3)_b$ QED and Unification with Weak and Nuclear Interactions	261
8.1.	Discussion	261
8.2.	Basics of Relativistic $O(3)_b$ QED	262
8.3.	Renormalization of $O(3)_b$ QED	275
8.4.	$B^{(3)}$ Field as a Vacuum Symmetry	282
8.5.1.	$SU(2) \times SU(2)$ Electroweak Theory with One Higgs Field	285
8.5.2.	The $SU(2) \times SU(2)$ Extended Standard Model	286
8.5.3.	Duality and Chiral Breaking	293
8.5.4.	Discussion of the Theory, its Problems and their Remedies	294
8.6.1.	Chiral and Vector Field in $SU(2) \times SU(2)$ Electroweak Field	296
8.6.2.	Axial-Vector $SU(2) \times SU(2)$ Fields: A First Look	297

8.6.3. Chiral and Vector Gauge Theories from Chiral Gauge Theories on the Physical Vacuum	301
8.6.4. The Occurrence of $O(3)_b$ Electrodynamics on the Physical Vacuum	304
8.6.4.1. The $SU(4)$ Model	305
8.6.5. Duality in Grand Unified Field Theory, and Recent LEP1 Data	306
References	310
Chapter 9. Potential Application of $O(3)_b$ QED	313
9.1. Computation, Biophysics and $B^{(3)}$ Induced Entangled States	313
9.2. $B^{(3)}$ Field and the Sequencing of DNA	330
Chapter 10. Duality and Fundamental Problems	339
10.1. Foundations for $SU(2)$ Electromagnetism	339
10.2. Rotations between Spacetime Conjugate Variables and Their Fluctuations in Quantum Gravity	343
10.3. Duality: Questions, Numerical Probes, and Quantum Uncertainty	353
10.4. Gravitation with One Killing Isometry	371
10.5. Brief Discussion on String Theory	381
10.5.1. Map between the String Surfaces and the Spacial 2-Surface	403
10.6. Overview of Conformal Groups	414
10.7. Conformal Structure of the Vacuum	420
10.8. Conformal Group and Gauge Theories According to Weighted Projective Spaces	425
10.9. Conformal Theory of W_∞ String Vortices	431
10.10. Concluding Statements on Duality	434
References	437
Appendix 1 — Applications of Stokes' Theorem	441
Appendix 2 — Bianchi IX Cosmologies	444
References	445
Index	447