Gauge Field Theories

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2nd Edition

STEFAN POKORSKI

规范场理论

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Gauge Field Theories, Second Edition

Quantum field theory forms the present theoretical framework for our understanding of the fundamental interactions of particle physics. This up-dated and expanded text examines gauge theories and their symmetries with an emphasis on their physical and technical aspects.

Beginning with a new chapter giving a systematic introduction to classical field theories and a short discussion of their canonical quantization and the discrete symmetries C, P and T, the book provides a brief exposition of perturbation theory, the renormalization programme and the use of the renormalization group equation. It then explores topics of current research interest including chiral symmetry and its breaking, anomalies, and low energy effective lagrangians and some basics of supersymmetry. A chapter on the basics of the electroweak theory is now included.

PROFESSOR POKORSKI, a distinguished theoretical physicist, has presented here a self-contained text for graduate courses in physics, the only prerequisite is some grounding in quantum field theory.

Born in 1942, Professor Stefan Pokorski received his PhD in theoretical physics in 1967 from Warsaw University, where he is now holder of the Chair in Theoretical Particle Physics. He has been a member of the Polish Academy of Science since 1991 and was Director of the Institute for Theoretical Physics, University of Warsaw, from 1984 to 1994 and President of the Polish Physical Society from 1992 to 1994. A visiting scientist at CERN and the Max-Planck Institute for Physics, Munich, for periods of time totalling almost ten years, Professor Pokorski has also made regular visits to universities and laboratories around the world. Professor Pokorski has had many scientific articles published in leading international journals and in recent years has concentrated on physics beyond the standard model and supersymmetry.

Erratum for the Book:

S. Pokorski, Gauge Field Theories

(2nd Edition)

Cambridge University Press

Last update: February 15, 2008

Place:	**Instead of:**	**Should be:**
p. 109, lines below eq. (2.153):	It can be proved, for example, by induction, that ...	It can be proved that ...
line 1 below eq. (2.154):	The effective action ...	An easy way to prove eq. (2.154) is to consider the relation between the functionals $W[J]$ and $W'[J]$ for the fields Φ and $\bar{\Phi}$, respectively, and similarly $Z[J]$ and $Z'[J]$ †. The effective action ...
p. 110, 2 lines above eq. (2.156):	Also, we can prove, for example, by induction, that ...	Similarly to eq. (2.154) one can prove that ...
p. 185, line 1 below eq. (5.26):	... reads	... reads (see p. 266 for the discussion of the running $\alpha(q^2)$)
p. 214, line 2 below eq. (6.20):	the 1PI Green's function $\Gamma^{(n)}$ by ...	the 1PI Green's function $\Gamma^{(n)}$ (in a complete discussion one should include 1P reducible Green's functions as well; such an extension is straightforward) by ...
p. 411, line 2 from the bottom:	and process-dependent corrections consisting ...	and corrections, often called process-dependent, consisting ...
p. 412, starting at line 5 under Fig. 12.5:	the splitting into universal and process-dependent parts is gauge-dependent and to get physical ...	the splitting into universal and so-called process-dependent parts is gauge-dependent: the vertex and box corrections contain also contributions which are independent of the external legs and cancel the gauge dependence of the corrections to the gauge boson propagators. To get physical ...
line 13 under Fig. 12.5:	of at least part of the process-dependent corrections ...	of the external leg independent vertex corrections ...
line 1 in the footnote‡:	is cancelled by the vertex corrections. ...	is cancelled by the external leg independent part of vertex corrections. ...

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Gauge Field Theories, 2nd ed. (ISBN 978-0-521-47816-8) by Stefan Pokorski first published by Cambridge University Press 2000.

In memory of Osterns – my mother's family

Preface to the First Edition

This book has its origin in a long series of lectures given at the Institute for Theoretical Physics, Warsaw University. It is addressed to graduate students and to young research workers in theoretical physics who have some knowledge of quantum field theory in its canonical formulation, for instance at the level of two volumes by Bjorken & Drell (1964, 1965). The book is intended to be a relatively concise reference to some of the field theoretical tools used in contemporary research in the theory of fundamental interactions. It is a technical book and not easy reading. Physical problems are discussed only as illustrations of certain theoretical ideas and of computational methods. No attempt has been made to review systematically the present status of the theory of fundamental interactions.

I am grateful to Wojciech Królikowski, Maurice Jacob and Peter Landshoff for their interest in this work and strong encouragement. My warm thanks go to Antonio Bassetto, Wilfried Buchmüller, Wojciech Królikowski, Heinrich Leutwyler, Peter Minkowski, Olivier Piguet, Jacek Prentki, Marco Roncadelli, Henri Ruegg and Wojtek Zakrzewski for reading various chapters of this book and for many useful comments, and especially to Peter Landshoff for reading most of the preliminary manuscript.

I am also grateful to several of my younger colleagues at the Institute for Theoretical Physics in Warsaw for their stimulating interactions. My thanks go to Andrzej Czechowski for his collaboration at the early stage of this project and for numerous useful discussions. I am grateful to Wojciech Dębski, Marek Olechowski, Jacek Pawełczyk, Andrzej Turski, Robert Budzynski, Krzysztof Meissner and Michał Spalinski, and particularly to Paweł Krawczyk for checking a large part of the calculations contained in this book.

Finally my thanks go to Zofia Ziółkowska for her contribution to the preparation of the manuscript.

Stefan Pokorski
Warsaw, 1985

Preface to the Second Edition

This new edition offers a substantial extension of topics covered by the book. The main additions are Chapter 1 and Chapter 12 and extended Appendices. Chapter 1 makes the book more self-contained. It gives a systematic introduction to classical field theories and a brief discussion of their canonical quantization, as some intuition based on canonical quantization proves to be very useful even if the main emphasis is on the path integral approach. Also in Chapter 1 the reader can find a thorough discussion of discrete symmetries C, P and T.

Chapter 12 gives a concise but systematic and self-contained introduction to the electroweak theory. This is an important completion for a modern book on quantum field theory and fundamental interactions, which was missing in the first edition. Appendices A, C and D are new. In particular, Appendix C contains the complete set of Feynman rules for the Standard Model, including counterterms, which is not easily available in the literature. The new Appendix A is a substantial extension of the previous Appendix C. Several smaller changes and corrections have been made in a number of places in the text. An important addition is Section 7.7, in which the modern approach to effective field theories is presented.

I hope that the additions leave intact the main feature of the book: it is still not easy reading!

I am grateful to many people for their help in the completion of this second edition. Very special thanks go to Piotr Chankowski. His help and collaboration in writing Chapters 1 and 12 and the Appendices was absolutely invaluable. Thanks, Piotr. I also thank Mikolaj Misiak and Janusz Rosiek for their collaboration on Sections 7.7 and 15.6, respectively.

I am deeply indebted to Howie Haber for his careful reading of a large part of the new material. I am grateful to Zygmunt Ajduk, Ratindranath Akhoury, Riccardo Guida, Krzysztof Meissner, Marek Olechowski, Jacek Pawełczyk, Carlos Savoy and Kay Wiese for their numerous comments and corrections. I would also like to

thank Peter Landshoff for his constant encouragement and patience during quite a few years before this edition finally materialized.

Comments and corrections are welcome by e-mail at pokorski@fuw.edu.pl They will be made accessible at the www page: http://www.fuw.edu.pl/~pokorski/

Stefan Pokorski
Warsaw, 1999

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