

THE PINCH TECHNIQUE AND ITS APPLICATIONS TO NON-ABELIAN GAUGE THEORIES

Non-Abelian gauge theories, such as quantum chromodynamics (QCD) or electroweak theory, are best studied with the aid of Green's functions that are gauge invariant off-shell, but unlike for the photon in quantum electrodynamics, conventional graphical constructions fail. The pinch technique provides a systematic framework for constructing such Green's functions and has many useful applications.

Beginning with elementary one-loop examples, this book goes on to extend the method to all orders, showing that the pinch technique is equivalent to calculations in the background-field Feynman gauge. The pinch technique Schwinger-Dyson equations are derived and used to show how a dynamical gluon mass arises in QCD. Applications are given to the center vortex picture of confinement, the gauge-invariant treatment of resonant amplitudes, the definition of non-Abelian effective charges, high-temperature effects, and even supersymmetry. This book is ideal for elementary particle theorists and graduate students. This title, first published in 2011, has been reissued as an Open Access publication Cambridge Core.

JOHN M. CORNWALL is Distinguished Professor of Physics Emeritus in the Department of Physics and Astronomy, University of California, Los Angeles. Inventor of the pinch technique, he has made many other contributions to the formalism and applications of quantum field theory, as well as to space plasma physics. He has contributed to the technical analysis of many public policy issues, ranging from ballistic missile defense to the human genome.

JOANNIS PAPAVALASSIOU is a researcher in the Department of Theoretical Physics and IFIC, the University of Valencia–CSIC. A large part of his work has been devoted to the development of the pinch technique, both its formal foundation and its many applications, and he has published articles on quantum field theory and particle phenomenology.

DANIELE BINOSI is a researcher at the European Centre for Theoretical Studies in Nuclear Physics and Related Areas (ECT*) and Fondazione Bruno Kessler. In addition to his work on extending the pinch technique and its applications, he leads several policy-related European projects on the development of the vision and sustainability of quantum information foundations and technologies.

CAMBRIDGE MONOGRAPHS ON
PARTICLE PHYSICS,
NUCLEAR PHYSICS AND COSMOLOGY

General Editors: T. Ericson, P. V. Landshoff

1. K. Winter (ed.): *Neutrino Physics*
2. J. F. Donoghue, E. Golowich and B. R. Holstein: *Dynamics of the Standard Model*
3. E. Leader and E. Predazzi: *An Introduction to Gauge Theories and Modern Particle Physics, Volume 1: Electroweak Interactions, the 'New Particles' and the Parton Model*
4. E. Leader and E. Predazzi: *An Introduction to Gauge Theories and Modern Particle Physics, Volume 2: CP-Violation, QCD and Hard Processes*
5. C. Grupen: *Particle Detectors*
6. H. Grosse and A. Martin: *Particle Physics and the Schrödinger Equation*
7. B. Anderson: *The Lund Model*
8. R. K. Ellis, W. J. Stirling and B. R. Webber: *QCD and Collider Physics*
9. I. I. Bigi and A. I. Sanda: *CP Violation*
10. A. V. Manohar and M. B. Wise: *Heavy Quark Physics*
11. R. K. Bock, H. Grote, R. Frühwirth and M. Regler: *Data Analysis Techniques for High-Energy Physics, Second edition*
12. D. Green: *The Physics of Particle Detectors*
13. V. N. Gribov and J. Nyiri: *Quantum Electrodynamics*
14. K. Winter (ed.): *Neutrino Physics, Second edition*
15. E. Leader: *Spin in Particle Physics*
16. J. D. Walecka: *Electron Scattering for Nuclear and Nucleon Scattering*
17. S. Narison: *QCD as a Theory of Hadrons*
18. J. F. Letessier and J. Rafelski: *Hadrons and Quark-Gluon Plasma*
19. A. Donnachie, H. G. Dosch, P. V. Landshoff and O. Nachtmann: *Pomeron Physics and QCD*
20. A. Hoffmann: *The Physics of Synchrotron Radiation*
21. J. B. Kogut and M. A. Stephanov: *The Phases of Quantum Chromodynamics*
22. D. Green: *High P_T Physics at Hadron Colliders*
23. K. Yagi, T. Hatsuda and Y. Miake: *Quark-Gluon Plasma*
24. D. M. Brink and R. A. Broglia: *Nuclear Superfluidity*
25. F. E. Close, A. Donnachie and G. Shaw: *Electromagnetic Interactions and Hadronic Structure*
26. C. Grupen and B. A. Shwartz: *Particle Detectors, Second edition*
27. V. Gribov: *Strong Interactions of Hadrons at High Energies*
28. I. I. Bigi and A. I. Sanda: *CP Violation, Second edition*
29. P. Jaranowski and A. Królak: *Analysis of Gravitational-Wave Data*
30. B. L. Ioffe, V. S. Fadin and L. N. Lipatov: *Quantum Chromodynamics: Perturbative and Nonperturbative Aspects*
31. J. M. Cornwall, J. Papavassiliou, and D. Binosi: *The Pinch Technique and Its Applications to Non-Abelian Gauge Theories*

THE PINCH TECHNIQUE AND ITS APPLICATIONS TO NON-ABELIAN GAUGE THEORIES

JOHN M. CORNWALL

University of California at Los Angeles, USA

JOANNIS PAPA VASSILIOU

University of Valencia–CSIC, Spain

DANIELE BINOSI

*European Centre for Theoretical Studies in Nuclear Physics and
Related Areas, Italy*



CAMBRIDGE
UNIVERSITY PRESS



CAMBRIDGE
UNIVERSITY PRESS

Shaftesbury Road, Cambridge CB2 8EA, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India

103 Penang Road, #05-06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of Cambridge University Press & Assessment,
a department of the University of Cambridge.

We share the University's mission to contribute to society through the pursuit of
education, learning and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9781009402446

DOI: 10.1017/9781009402415

© John M. Cornwall, Joannis Papavassiliou and Daniele Binosi 2011

This work is in copyright. It is subject to statutory exceptions and to the provisions
of relevant licensing agreements; with the exception of the Creative Commons version the
link for which is provided below, no reproduction of any part of this work may take
place without the written permission of Cambridge University Press.

An online version of this work is published at doi.org/10.1017/9781009402415 under a
Creative Commons Open Access license CC-BY-NC-ND 4.0 which permits re-use,
distribution and reproduction in any medium for non-commercial purposes providing
appropriate credit to the original work is given. You may not distribute derivative works
without permission. To view a copy of this license, visit
<https://creativecommons.org/licenses/by-nc-nd/4.0>

All versions of this work may contain content reproduced under license from third parties.
Permission to reproduce this third-party content must be obtained from these third-parties directly.

When citing this work, please include a reference to the DOI 10.1017/9781009402415

First published 2011
Reissued as OA 2023

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

ISBN 978-1-009-40244-6 Hardback
ISBN 978-1-009-40243-9 Paperback

Cambridge University Press & Assessment has no responsibility for the persistence or accuracy of
URLs for external or third-party internet websites referred to in this publication
and does not guarantee that any content on such websites is, or will remain,
accurate or appropriate.