

Quantum Field Theory and String Theory

NATO ASI Series

Advanced Science Institutes Series

A series presenting the results of activities sponsored by the NATO Science Committee, which aims at the dissemination of advanced scientific and technological knowledge, with a view to strengthening links between scientific communities.

The series is published by an international board of publishers in conjunction with the NATO Scientific Affairs Division

A	Life Sciences	Plenum Publishing Corporation New York and London
B	Physics	
C	Mathematical and Physical Sciences	Kluwer Academic Publishers Dordrecht, Boston, and London
D	Behavioral and Social Sciences	
E	Applied Sciences	
F	Computer and Systems Sciences	Springer-Verlag Berlin, Heidelberg, New York, London, Paris, Tokyo, Hong Kong, and Barcelona
G	Ecological Sciences	
H	Cell Biology	
I	Global Environmental Change	

Recent Volumes in this Series

Volume 328 — Quantum Field Theory and String Theory
edited by Laurent Baulieu, Vladimir Dotsenko, Vladimir Kazakov,
and Paul Windey

Volume 329 — Nonlinear Coherent Structures in Physics and Biology
edited by K. H. Spatschek and F. G. Mertens

Volume 330 — Coherent Optical Interactions in Semiconductors
edited by R. T. Phillips

Volume 331 — Hamiltonian Mechanics: Integrability and Chaotic Behavior
edited by John Seimenis

Volume 332 — Deterministic Chaos in General Relativity
edited by David Hobill, Adrian Burd, and Alan Coley

Volume 333 — Perspectives in the Structure of Hadronic Systems
edited by M. N. Harakeh, J. H. Koch, and O. Scholten

Volume 334 — Frontier Topics in Nuclear Physics
edited by Werner Scheid and Aurel Sandulescu

Volume 335 — Hot and Dense Nuclear Matter
edited by Walter Greiner, Horst Stöcker, and André Gallmann



Series B: Physics

Quantum Field Theory and String Theory

Edited by

Laurent Baulieu and **Vladimir Dotsenko**

Université Pierre et Marie Curie (Paris VI)
Paris, France

Vladimir Kazakov

Université Pierre et Marie Curie (Paris VI)
and École Normale Supérieure
Paris, France

and

Paul Windey

Université Pierre et Marie Curie (Paris VI)
Paris, France

Springer Science+Business Media, LLC

Proceedings of a NATO Advanced Research Workshop on
New Developments in String Theory, Conformal Models, and Topological Field Theory,
held May 10-21, 1993,
in Cargèse, France

NATO-PCO-DATA BASE

The electronic index to the NATO ASI Series provides full bibliographical references (with keywords and/or abstracts) to more than 30,000 contributions from international scientists published in all sections of the NATO ASI Series. Access to the NATO-PCO-DATA BASE is possible in two ways:

—via online FILE 128 (NATO-PCO-DATA BASE) hosted by ESRIN, Via Galileo Galilei, I-00044 Frascati, Italy

—via CD-ROM "NATO Science and Technology Disk" with user-friendly retrieval software in English, French, and German (©WTV GmbH and DATAWARE Technologies, Inc. 1989). The CD-ROM also contains the AGARD Aerospace Database.

The CD-ROM can be ordered through any member of the Board of Publishers or through NATO-PCO, Overijse, Belgium.

Library of Congress Cataloging-in-Publication Data

Quantum field theory and string theory / edited by Laurent Baulieu ...
[et al.].

p. cm. -- (NATO ASI series. B, physics : v. 328)

"Published in cooperation with NATO Scientific Affairs Division".

"Proceedings of a NATO Advanced Research Workshop on New Developments in String Theory, Conformal Models, and Topological Field Theory, held May 10-21, 1993, in Cargèse, France"--CIP t.p. verso.

Includes bibliographical references and index.

ISBN 978-1-4613-5735-3 ISBN 978-1-4615-1819-8 (eBook)

DOI 10.1007/978-1-4615-1819-8

I. Quantum field theory--Congresses. 2. String models--Congresses. 3. Quantum gravity--Congresses. I. Baulieu, Laurent. II. North Atlantic Treaty Organization. Scientific Affairs Division. III. NATO Advanced Research Workshop on New Developments in String Theory, Conformal Models, and Topological Field Theory (1993 : Cargèse, France) IV. Series NATO ASI series. Series B, Physics, v. 328.

QC174.45.A1036265 1994

530.1'43--dc20

94-44814

CIP

Additional material to this book can be downloaded from <http://extra.springer.com>.

ISBN 978-1-4613-5735-3

©1995 Springer Science+Business Media New York
Originally published by Plenum Press, New York in 1995
Softcover reprint of the hardcover 1st edition 1995

10 9 8 7 6 5 4 3 2 1

All rights reserved

No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording, or otherwise, without written permission from the Publisher

LIST OF SPEAKERS OF THE WORKSHOP CARGESE-93

I. Antoniadis
C. Bachas
M. Bellon
D. Bernard
M. Bershadsky
D. Boulatov
P. Bouwknegt
E. Brezin
S. Dalley
J. -M. Daul
R. Dijkgraaf
M. Douglas
G. Felder
J. -L. Gervais
D. Gross
G. Harris
P. Horava

C. Itzykson
V. Kazakov
A. Kirillov
I. Kostov
E. Martinec
A. Migdal
T. Miva
S. Mukhi
H. Nicolai
E. Rabinovici
F. Ravanini
V. Ogievetski
H. Ooguri
A. Schwimmer
N. Warner
P. Wiegmann
Al. Zamolodchikov

PREFACE

The Cargèse Workshop "Quantum Field Theory and String Theory" was held from May 10 to May 21, 1993.

The broad spectrum of the work presented at the Workshop was the reflection of a time of intensive search for new ways of solving some of the most fundamental problems in string theory, quantum gravity and non-perturbative field theory. A number of talks indicated the emergence of new promising domains of investigation. It is this very diversity of topics which, in our opinion, represents one of the most attractive features of the present volume which we hope will provide a good orientation in the abundant flow of ideas and publications in modern quantum field theory.

Many contributions to the present proceedings are concerned with two dimensional quantum field theory. The continuous advances in the domain of two dimensional integrable theories on the lattice as well as in the continuum, including conformal field theories, Liouville field theory and matrix models of two dimensional quantum gravity are very well represented. Other papers address physically realistic (and therefore very complicated) problems like developed turbulence, the Hofstadter problem, higher dimensional gravity and phenomenological strings. A new elegant class of topological field theories is presented. New ideas in the string representation of multicolor quantum chromodynamics were widely discussed at the Workshop, more particularly the example of the exactly solvable two dimensional case.

We would like to point out that some of the papers included in this volume contain, along with original developments, an extensive review of a particular topic and can serve as a convenient source of information even for the non-specialist or for students.

We would like to thank the many people who contributed to the successful organization of the conference and in particular Marie-France Hanseler for her constant attention to the well being of all the participants. She was once again one of the pillars of the Cargèse Institute.

We are greatly indebted to NATO Division for Scientific Affairs and to *Département de la Formation Permanente* of the Centre National de la Recherche Scientifique for their generous financial support. Partial support was also provided by the Science grant SCI*0394 from the European Commission.

Last, but not least, we would like to thank all the participants for helping create an excellent working atmosphere and especially the contributors to this volume for the quality of their presentation and also for significantly simplifying our task in editing this volume.

Laurent Baulieu
Vladimir Dotsenko
Vladimir Kazakov
Paul Windey

CONTENTS

Fractal Structure in 4d Gravity	1
I. Antoniadis	
A One Dimensional Ideal Gas of Spinons, or Some Exact Results on the XXX Spin Chain with Long Range Interaction	11
D. Bernard, V. Pasquier and D. Serban	
Kodaira-Spencer Theory of Gravity	23
M. Bershadsky	
3d Gravity and Gauge Theories	39
D. Boulatov	
On the W-Gravity Spectrum and its G-Structure	59
P. Bouwknegt, J. McCarthy and K. Pilch	
Light-Cone Quantization of Matrix Models at $c>1$	71
S. Dalley	
Multicritical Points of 2-Matrix Models	81
J.-M. Daul	
The Super Self-Dual Matreoshka	87
Ch. Devchand and V. Ogievetsky	
The Phenomenology of Strings and Clusters in the 3-d Ising Model	99
V.S. Dotsenko, M. Picco, P. Windey, G. Harris, E. Marinari and E. Martinec	
Conformal Field Theory Techniques in Large N Yang-Mills Theory	119
Michael R. Douglas	
Introduction to Differential W-Geometry	137
J.-L. Gervais	
Topological Strings and QCD in Two Dimensions	151
P. Horava	

Continuum QCD₂ in Terms of Discrete Random Surfaces with Local Weights	165
I. Kostov	
Strings and Causality	185
E. Martinec	
Loop Equation and Area Law in Turbulence	193
A.A. Migdal	
The Two-Dimensional String as a Topological Field Theory	233
S. Mukhi	
Linear Systems for 2d Poincaré Supergravities	249
H. Nicolai	
Quantization of Mirror Symmetry	261
H. Ooguri	
Integrable Qft₂ Encoded on Products of Dynkin Diagrams	273
E. Quattrini, F. Ravanini and R. Tateo	
Remarks on Topological String Theories	285
E. Rabinovici	
Hamiltonian Reduction of the BRST Complex and N=2 SUSY	305
V. Sadov	
Lattice Models and N=2 Supersymmetry	335
H. Saleur and N.P. Warner	
Canonical Construction of Liouville Field Operators with Arbitrary Spin	379
J. Schnittger	
Bethe Ansatz for the Bloch Particle in Magnetic Field	399
P. B. Wiegmann and A.V. Zabrodin	
Index	417