CONTEMPORARY MATHEMATICS

Combinatorial Methods in Topology and Algebraic Geometry

AMERICAN MATHEMATICAL SOCIETY

VOLUME 44

http://dx.doi.org/10.1090/conm/044

CONTEMPORARY MATHEMATICS

Titles in this Series

Volume

1 **Markov random fields and their applications**, Ross Kindermann and J. Laurie Snell

2 **Proceedings of the conference on integration, topology, and geometry in linear spaces**, William H. Graves, Editor

3 **The closed graph and P-closed graph properties in general topology**, T. R. Hamlett and L. L. Herrington

4 **Problems of elastic stability and vibrations**, Vadim Komkov, Editor

5 **Rational constructions of modules for simple Lie algebras**, George B. Seligman

6 **Umbral calculus and Hopf algebras**, Robert Morris, Editor

7 **Complex contour integral representation of cardinal spline functions**, Walter Schempp

8 **Ordered fields and real algebraic geometry**, D. W. Dubois and T. Recio, Editors

9 **Papers in algebra, analysis and statistics**, R. Lidl, Editor

10 **Operator algebras and K-theory**, Ronald G. Douglas and Claude Schochet, Editors

11 **Plane ellipticity and related problems**, Robert P. Gilbert, Editor

12 **Symposium on algebraic topology in honor of José Adem**, Samuel Gitler, Editor

13 **Algebraists' homage: Papers in ring theory and related topics**, S. A. Amitsur, D. J. Saltman and G. B. Seligman, Editors

14 **Lectures on Nielsen fixed point theory**, Boju Jiang

15 **Advanced analytic number theory. Part I: Ramification theoretic methods**, Carlos J. Moreno

16 **Complex representations of GL(2, K) for finite fields K**, Ilya Piatetski-Shapiro

17 **Nonlinear partial differential equations**, Joel A. Smoller, Editor

18 **Fixed points and nonexpansive mappings**, Robert C. Sine, Editor

19 **Proceedings of the Northwestern homotopy theory conference**, Haynes R. Miller and Stewart B. Priddy, Editors

20 **Low dimensional topology**, Samuel J. Lomonaco, Jr., Editor

21 **Topological methods in nonlinear functional analysis**, S. P. Singh, S. Thomeier, and B. Watson, Editors

22 **Factorizations of $b^n \pm 1$, $b = 2, 3, 5, 6, 7, 10, 11, 12$ up to high powers**, John Brillhart, D. H. Lehmer, J. L. Selfridge, Bryant Tuckerman, and S. S. Wagstaff, Jr.

23 **Chapter 9 of Ramanujan's second notebook—Infinite series identities, transformations, and evaluations**, Bruce C. Berndt and Padmini T. Joshi

24 **Central extensions, Galois groups, and ideal class groups of number fields**, A. Fröhlich

25 **Value distribution theory and its applications**, Chung-Chun Yang, Editor

26 **Conference in modern analysis and probability**, Richard Beals, Anatole Beck, Alexandra Bellow and Arshag Hajian, Editors

27 **Microlocal analysis**, M. Salah Baouendi, Richard Beals and Linda Preiss Rothschild, Editors

Titles in this Series

Volume

28 **Fluids and plasmas: geometry and dynamics**, Jerrold E. Marsden, Editor

29 **Automated theorem proving**, W. W. Bledsoe and Donald Loveland, Editors

30 **Mathematical applications of category theory**, J. W. Gray, Editor

31 **Axiomatic set theory**, James E. Baumgartner, Donald A. Martin and Saharon Shelah, Editors

32 **Proceedings of the conference on Banach algebras and several complex variables**, F. Greenleaf and D. Gulick, Editors

33 **Contributions to group theory**, Kenneth I. Appel, John G. Ratcliffe and Paul E. Schupp, Editors

34 **Combinatorics and algebra**, Curtis Greene, Editor

35 **Four-manifold theory**, Cameron Gordon and Robion Kirby, Editors

36 **Group actions on manifolds**, Reinhard Schultz, Editor

37 **Conference on algebraic topology in honor of Peter Hilton**, Renzo Piccinini and Denis Sjerve, Editors

38 **Topics in complex analysis**, Dorothy Brown Shaffer, Editor

39 **Errett Bishop: Reflections on him and his research**, Murray Rosenblatt, Editor

40 **Integral bases for affine Lie algebras and their universal enveloping algebras**, David Mitzman

41 **Particle systems, random media and large deviations**, Richard Durrett, Editor

42 **Classical real analysis**, Daniel Waterman, Editor

43 **Group actions on rings**, Susan Montgomery, Editor

44 **Combinatorial methods in topology and algebraic geometry**, John R. Harper and Richard Mandelbaum, Editors

Combinatorial Methods in Topology and Algebraic Geometry

CONTEMPORARY MATHEMATICS

Volume 44

Combinatorial Methods in Topology and Algebraic Geometry

John R. Harper and
Richard Mandelbaum, Editors

AMERICAN MATHEMATICAL SOCIETY
Providence • Rhode Island

EDITORIAL BOARD

R. O. Wells, Jr., managing editor
Adriano M. Garsia
James I. Lepowsky
Jan Mycielski
Johannes C. C. Nitsche
Carl M. Pearcy
Irving Reiner
Alan D. Weinstein

Proceedings of a conference in honor of Arthur M. Stone held at the University of Rochester, Rochester, New York, June 29–July 2, 1982, and partially supported by the National Science Foundation Grant MCS-8116754.

This volume was prepared by the authors using the TEX typesetting system and was transmitted to the AMS via magnetic tape. Final copy was produced on an Alphatype CRS at the AMS office. The paper used in this book is acid-free and falls within the guidelines established to ensure permanence and durability. The American Mathematical Society retains all rights except those granted to the United States Government. Copying and reprinting information can be found at the back of this volume.

1980 *Mathematics Subject Classification.* Primary 14J, 20F, 55P, 55S, 57M, 47Q, 57R, 57S.

Library of Congress Cataloging-in-Publication Data
Main entry under title:

Combinatorial methods in topology and algebraic geometry.

(Contemporary mathematics, ISSN 0271-4132; v. 44)
Bibliography: p.
1. Combinatorial topology—Addresses, essays, lectures. 2. Geometry, Algebraic—Addresses, essays, lectures. 3. Combinatorial analysis—Addresses, essays, lectures. I. Harper, John R., 1941– . II. Mandelbaum, Richard, 1946– . III. Series.
QA612.C585 1985 514'.22 85-11244
ISBN 0-8218-5039-3 (alk.paper)

Copyright © 1985 by the American Mathematical Society. All rights reserved.
Printed in the United States of America.

Reprinted 1988

The paper used in this book is acid-free and falls within the guidelines established to ensure permanence and durability.

To Dorothy Maharam Stone and Arthur Harold Stone
in appreciation for their contribution and
service to Mathematics.

TABLE OF CONTENTS

Introduction xi

Plenary lectures xiii

List of participants xv

TOPOLOGY AND COMBINATORIAL GROUP THEORY

M. COHEN, W. METZLER, K. SAUERMANN
Collapses of $K \times I$ and Group Presentations 3

W. METZLER
On the Andrews-Curtis-Conjecture and related problems 35

M. LUSTIG and W. METZLER
Integral representations of $\mathrm{Aut}\, F^n$ and presentation classes of groups 51

R. GOLDSTEIN and E. C. TURNER
A note on commutators and squares in free products 69

K. B. LEE and F. RAYMOND
Rigidity of almost crystallographic groups 73

J. R. STALLINGS
Finite graphs and free groups 79

C. TRETKOFF and M. TRETKOFF
A topological proof of a theorem of Brunner and Burns about M. Hall groups 85

KNOT THEORY

D. GABAI
The Murasugi sum is a natural geometric operation II 93

L. H. KAUFFMAN
The Arf Invariant of classical knots 101

W. B. R. LICKORISH
The unknotting number of a classical knot 117

B. TRACE
A general position theorem for surfaces in Euclidean 4-space 123

3-MANIFOLDS

A. L. EDMONDS
On the equivariant Dehn lemma 141
J. HEMPEL
Virtually Haken manifolds 149
J. M. MONTESINOS
Lectures on 3-fold simple coverings and 3-manifolds 157
H. S. OH
The Witt classes of Seifert manifolds 179
M. SCHARLEMANN
Outermost forks and a theorem of Jaco 189
J. R. STALLINGS
Surfaces in 3-manifolds 195

HOMOTOPY THEORY AND INFINITE DIMENSIONAL TOPOLOGY

M. G. BARRATT
Taming Hopf invariants 201
F. R. COHEN
Artin's braid groups and classical homotopy theory 207
L. R. RUBIN
More compacta of infinite cohomological dimension 221
A. ZABRODSKY
Endomorphisms in the homotopy category 227

FOUR MANIFOLDS AND ALGEBRAIC SURFACES

S. AKBULUT
On fake $S^3\tilde{\times}S'\#S^2\times S^2$ 281
N. GOLDSTEIN
Manifolds having non-ample Norman bundles in quadrices 287
R. MANDELBAUM
Lefschetz fibrations of Riemann surfaces and decompositions of complex elliptic surfaces 291
B. MOISHEZON
Algebraic surfaces and the arithmetic of braids, II 311
J. MONTESINOS
A note on moves and on irregular coverings of S^4 345

INTRODUCTION

In recent years, combinatorial methods have re-appeared in deep and diverse ways, both in topology and algebraic geometry. In honor of Prof. Arthur H. Stone, the Department of Mathematics of the University of Rochester held a conference June 20–July 2, 1982. The purpose was to present a series of lectures surveying recent accomplishments and indicating further directions for research. These proceedings contain reports from most of the lectures that were given.

On behalf of the organizers, it is a pleasure to acknowledge the support of many people and institutions. Financial support was provided by the National Science Foundation and the Mathematics Department of the University of Rochester. We are grateful to help received from Dr. Alvin Thaler in preparing our proposal. During the conference we were assisted by Prof. A. Libgober and M. Scharlemann who organized seminars. Sally Allison, of the University of Rochester, provided us with logistical support. The departmental staff, Roberta Colon and Joan Robinson looked after myriads of details. We would especially like to thank Joan Robinson for an outstanding job of typing all the manuscripts in TEX and Prof. A. Pizer for making sure that everything connected with TEX worked out as expected.

PLENARY LECTURES

M. COHEN/W. METZLER: Combinatorial group theory and simple homotopy theory

W. TUTTE: Map coloring and differential equations

F. COHEN: Braids and homotopy theory

R. MANDELBAUM: Combinatorial group theory and Lefschetz fibrations

F. RAYMOND: Mapping class groups of Seifert manifolds

M. BARRATT: Taming Hopf invariants

B. MOISHEZON: The braid group and algebraic surfaces

M. E. RUDIN: Paracompactness

S. CAPPELL: The topology of group representations

R. KIRBY: An overview of new results in 4-dimensional topology

R. EDWARDS: Freedman's work and its consequences

J. STALLINGS: Finite graphs and free groups

J. MONTESINOS: Representing 3-manifolds as branched covers

LIST OF PARTICIPANTS

Dr. Selman Akbulut
Mathematical Institute at Berkeley
2223 Fulton St., Room 602
Berkeley, CA 94720

Dr. M. G. Barratt
Northwestern University
Evanston, IL 60201

Dr. Winfried Becker
Johann Wolfgang Goethe-Universität
Fachbereich Mathematik
6000 Frankfurt/Main
Robert-Mayer-Strasse 6-10
Germany

Dr. Richard E. Bedient
Department of Mathematics
Hamilton College
Clinton, NY 13323

Dr. Terrence P. Bisson
Canisius College
Department of Mathematics
Buffalo, NY 14208

Dr. Sylvain E. Cappell
NYU-Courant
251 Mercer St.
New York, NY 10012

Dr. Frederick R. Cohen
University of Kentucky
Department of Mathematics
Lexington, KY 40506

Dr. Marshall M. Cohen
Cornell University
Department of Mathematics
Ithaca, NY 14853

Dr. Alan H. Durfee
Holyoke Community College
Department of Mathematics
Holyoke, MA 01040

Dr. Allan L. Edmonds
Indiana University
Department of Mathematics
Bloomington, IN 47405

Dr. Robert D. Edwards
University of California at Los Angeles
Department of Mathematics
Los Angeles, CA 90024

Dr. Steven C. Ferry
University of Kentucky
Department of Mathematics
Lexington, KY 40506

Dr. Jonathan Fine
Southern Illinois University
Department of Mathematics
Carbondale, IL 62901

Dr. David Gabai
University of Pennsylvania
Department of Mathematics
Philadelphia, PA 19104

Dr. Ross Geoghegan
SUNY at Binghamton
Department of Mathematics
Binghamton, NY 13901

Dr. Charles Giffen
University of Virginia
Department of Mathematics
Charlottesville, VA 22903

Dr. Patrick M. Gilmer
Louisiana State University
Department of Mathematics
Baton Rouge, LA 70803

Dr. Norman Goldstein
University of British Columbia
Department of Mathematics
121-1984 Mathematics Rd.
Vancouver (V6T 1Y4)
British Columbia, Canada

Dr. Richard Z. Goldstein
State University of New York
Department of Mathematics
Albany, NY 12222

Dr. John Hempel
Rice University
Department of Mathematics
Houston, TX 77251

Dr. Cynthia Hog
Johann Wolfgang Goethe-Universität
Fachbereich Mathematik
6000 Frankfurt/Main
Robert-Mayer-Strasse 6-10
Germany

Dr. John E. Kalliongis
Southwest Texas State University
Department of Mathematics
San Marcos, TX 78666

Dr. Richard Kane
University of Western Ontario
Department of Mathematics
London, Ontario
Canada

Dr. Louis Kaufman
University of Illinois at Chicago Circle
Department of Mathematics,
Statistics & Computer Science
Chicago, IL 60680

Dr. Robion C. Kirby
University of California at Berkeley
Department of Mathematics
Berkeley, CA 94720

Dr. Kyung Bai Lee
Purdue University
Department of Mathematics
W. Lafayette, IN 47907

Dr. Anatoly S. Libgober
University of Illinois at Chicago
Department of Mathematics
Box 4348
Chicago, IL 60680

Dr. W. B. Raymond Lickorish
University of Cambridge
Department of Pure Mathematics
and Mathematical Statistics
16 Mill Lane
Cambridge (CB2 1SB), England

Dr. S. J. Lomonaco, Jr.
Inst. for Defense Analyses, STD
1801 N. Beauregard St.
Alexandria, VA 22311

Dr. Martin Lustig
Johann Wolfgang Goethe-Universität
Fachbereich Mathematik
6000 Frankfurt/Main
Robert-Mayer-Strasse 6-10
Germany

Dr. Darryl McCullough
University of Oklahoma
Department of Mathematics
Norman, OK 73019

Dr. Wolfgang Metzler
Johann Wolfgang Goethe-Universität
Fachbereich Mathematik
6000 Frankfurt/Main
Robert-Mayer-Strasse 6-10
Germany

Dr. Michael Mihalik
Vanderbilt University
Department of Mathematics
Nashville, TN 37240

Dr. Kenneth C. Millett
University of California
at Santa Barbara
Department of Mathematics
Santa Barbara, CA 93106

Dr. Boris Moishezon
Columbia University
Department of Mathematics
New York, NY 10027

Dr. José M. Montesinos
University of Zaragoza
Fac de Ciencias
Zaragoza, Spain

Dr. Carlos J. Moreno
University of Illinois
Department of Mathematics
Urbana, IL 61801

Dr. Kazumi Nakano
State University of New York
Department of Mathematics
Brockport, NY 14420

Dr. Joseph Neisendorfer
Ohio State University
Department of Mathematics
Columbus, OH 43210

Dr. Hae Soo Oh
Louisiana State University
Department of Mathematics
Baton Rouge, LA 70803

Dr. Donal O'Shea
Mt. Holyoke College
Clapp Lab
South Hadley, MA 01075

Dr. Richard Randall
University of Iowa
Department of Mathematics
Iowa City, IA 52240

Dr. Frank A. Raymond
University of Michigan
Department of Mathematics
Ann Arbor, MI 48109

Dr. Leonard R. Rubin
University of Oklahoma
Department of Mathematics
Norman, OK 73019

Dr. Martin Scharlemann
University of California
at Santa Barbara
Department of Mathematics
Santa Barbara, CA 93106

Dr. Alan Siegel
Department of Mathematics
Mt. Holyoke College
South Hadley, MA 01075

Dr. Allen Sieradski
University of Oregon
Department of Mathematics
Eugene, OR 97403

Dr. John R. Stallings
University of California at Berkeley
Department of Mathematics
Berkeley, CA 94720

Dr. Mark Steinberger
Northern Illinois University
Department of Mathematics
DeKalb, IL 60115

Dr. Bruce Trace
Department of Mathematics
University of Alabama
Tuscaloosa, AL 35486

Dr. Carol Tretkoff
Brooklyn College
Department of Computer Science
Bedford Avenue and Avenue H
Brooklyn, NY 11210

Dr. Marvin Tretkoff
Stevens Institute of Technology
Department of Mathematics
Castle Point Station
Hoboken, NJ 07030

Dr. Thomas W. Tucker
Colgate University
Department of Mathematics
Hamilton, NY 13346

Dr. Edward C. Turner
State University of New York
Department of Mathematics
Albany, NY 12222

Dr. W. T. Tutte
University of Waterloo
Department of Mathematics
Waterloo (N2L 3G1)
Ontario, Canada

Dr. Samuel A. Weinberger
Princeton University
Department of Mathematics
Princeton, NJ 08544

Dr. James E. West
Cornell University
Department of Mathematics
Ithaca, NY 14853

Dr. George W. Whitehead
Massachusetts Institute of Technology
Department of Mathematics
Cambridge, MA 02139

Dr. John Wood
University of Illinois at Chicago Circle
Department of Mathematics
Chicago, IL 60680

Copying and reprinting. Individual readers of this publication, and nonprofit libraries acting for them, are permitted to make fair use of the material, such as to copy an article for use in teaching or research. Permission is granted to quote brief passages from this publication in reviews provided the customary acknowledgement of the source is given.

Republication, systematic copying, or multiple reproduction of any material in this publication (including abstracts) is permitted only under license from the American Mathematical Society. Requests for such permission should be addressed to the Executive Director, American Mathematical Society, P.O. Box 6248, Providence, Rhode Island 02940.

The appearance of the code on the first page of an article in this volume indicates the copyright owner's consent for copying beyond that permitted by Sections 107 or 108 of the U. S. Copyright Law, provided that the fee of $1.00 plus $.25 per page for each copy be paid directly to Copyright Clearance Center, Inc., 21 Congress Street, Salem, Massachusetts 01970. This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotion purposes, for creating new collective works or for resale.

BCDEFGHIJ-898

ISBN 978-0-8218-5039-8

CONM/44