

CONTEMPORARY MATHEMATICS

629

Riemann and Klein Surfaces, Automorphisms, Symmetries and Moduli Spaces

Conference in Honor of Emilio Bujalance
Riemann and Klein Surfaces, Symmetries
and Moduli Spaces
June 24–28, 2013
Linköping University, Linköping, Sweden

Milagros Izquierdo
S. Allen Broughton
Antonio F. Costa
Rubí E. Rodríguez
Editors



Riemann and Klein Surfaces, Automorphisms, Symmetries and Moduli Spaces

CONTEMPORARY MATHEMATICS

629

Riemann and Klein Surfaces, Automorphisms, Symmetries and Moduli Spaces

Conference in Honor of Emilio Bujalance
Riemann and Klein Surfaces, Symmetries
and Moduli Spaces

June 24–28, 2013

Linköping University, Linköping, Sweden

Milagros Izquierdo
S. Allen Broughton
Antonio F. Costa
Rubí E. Rodríguez
Editors



American Mathematical Society
Providence, Rhode Island

EDITORIAL COMMITTEE

Dennis DeTurck, Managing Editor

Michael Loss Kailash Misra Martin J. Strauss

2010 *Mathematics Subject Classification*. Primary 30Fxx, 14Hxx, 20Hxx, 57Mxx, 14Gxx, 14Kxx, 14Jxx.

Library of Congress Cataloging-in-Publication Data

Riemann and Klein surfaces, automorphisms, symmetries and moduli spaces : conference in honor of Emilio Bujalance on Riemann and Klein surfaces, symmetries and moduli spaces, June 24–28, 2013, Linköping University, Linköping, Sweden / Milagros Izquierdo, S. Allen Broughton, Antonio F. Costa, Rubi E. Rodriguez, editors.

pages cm. — (Contemporary mathematics ; volume 629)

Includes bibliographical references.

ISBN 978-1-4704-1093-3 (alk. paper)

1. Riemann surfaces—Congresses. 2. Geometry, Algebraic—Congresses. 3. Automorphisms—Congresses. 4. Moduli theory—Congresses. I. Izquierdo, Milagros, 1963– editor of compilation. II. Broughton, S. Allen, 1951– editor of compilation. III. Costa, A. F., 1960– editor of compilation. IV. Rodriguez, Rubi E., 1953– editor of compilation.

QA333.R54 2014
515'.93—dc23

2014012547

Contemporary Mathematics ISSN: 0271-4132 (print); ISSN: 1098-3627 (online)

DOI: <http://dx.doi.org/10.1090/conm/629>

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 select pages for use in teaching or research. Permission is granted to quote brief passages from this publication in reviews, provided the customary acknowledgment of the source is given.

Republication, systematic copying, or multiple reproduction of any material in this publication is permitted only under license from the American Mathematical Society. Permissions to reuse portions of AMS publication content are handled by Copyright Clearance Center's RightsLink[®] service. For more information, please visit: <http://www.ams.org/rightslink>.

Send requests for translation rights and licensed reprints to reprint-permission@ams.org.

Excluded from these provisions is material for which the author holds copyright. In such cases, requests for permission to reuse or reprint material should be addressed directly to the author(s). Copyright ownership is indicated on the copyright page, or on the lower right-hand corner of the first page of each article within proceedings volumes.

© 2014 by the American Mathematical Society. All rights reserved.

The American Mathematical Society retains all rights
except those granted to the United States Government.
Printed in the United States of America.

⊗ The paper used in this book is acid-free and falls within the guidelines
established to ensure permanence and durability.
Visit the AMS home page at <http://www.ams.org/>

10 9 8 7 6 5 4 3 2 1 19 18 17 16 15 14

To our master and colleague Prof. Bujalance
and specially to our great friend Emilio who united us all in mathematics

Contents

Preface	ix
On Jacobians of curves with superelliptic components LUBJANA BESHAI, TONY SHASKA, and CALEB SHOR	1
Superelliptic surfaces as p -gonal surfaces S. ALLEN BROUGHTON	15
Exceptional automorphisms of (generalized) super elliptic surfaces S. ALLEN BROUGHTON and AARON WOOTTON	29
Symmetric group actions on Jacobian varieties ANGEL CAROCCA, RUBÍ E. RODRÍGUEZ, and ANITA M. ROJAS	43
Normal coverings of hyperelliptic real Riemann surfaces FRANCISCO-JAVIER CIRRE and RUBÉN A. HIDALGO	59
Large group actions on surfaces MARSTON D. E. CONDER	77
Maximal bordered surface groups versus maximal handlebody groups MARSTON D. E. CONDER and BRUNO P. ZIMMERMANN	99
Maximal and non-maximal NEC and Fuchsian groups uniformizing Klein and Riemann surfaces ANTONIO F. COSTA, MILAGROS IZQUIERDO, and ANA M. PORTO	107
On the minimum genus problem on bordered Klein surfaces for automorphisms of even order JOSÉ JAVIER ETAYO and ERNESTO MARTÍNEZ	119
Computing adapted bases for conformal automorphism groups of Riemann surfaces JANE GILMAN	137
Fields of definition of uniform dessins on quasiplatonic surfaces ERNESTO GIRONDO, DAVID TORRES-TEIGELL, and JÜRGEN WOLFART	155
Surfaces as complete intersections VINICIO GÓMEZ GUTIÉRREZ and SANTIAGO LÓPEZ DE MEDRANO	171
Conjugacy classes of symmetries of compact Kleinian 3-manifolds GRZEGORZ GROMADZKI and RUBÉN A. HIDALGO	181

Connectivity and dimension of the p -locus in moduli space GRZEGORZ GROMADZKI, ANTHONY WEAVER, and AARON WOOTTON	189
Free degree of periodic self-homeomorphisms of compact bordered orientable surfaces GRZEGORZ GROMADZKI and XUEZHI ZHAO	203
p -adic origamis FRANK HERRLICH	225
Regular dessins with a given automorphism group GARETH A. JONES	245
Growth in Hecke groups MARTIN KREUZER and GERHARD ROSENBERGER	261
Some results on abelian groups of automorphisms of compact Riemann surfaces JESÚS RODRÍGUEZ	283
Abelian varieties and group actions RUBÍ E. RODRÍGUEZ	299
The remarkable Accola-Maclachlan surfaces DAVID SINGERMAN	315
Patterns in semigroups associated with combinatorial configurations KLARA STOKES and MARIA BRAS-AMORÓS	323
Computing equations, automorphisms and symmetries of Riemann surfaces PETER TURBEK	335

Preface

Group actions on Riemann surfaces, Klein surfaces, and related structures such as hyperbolic manifolds, complex surfaces, and Teichmüller spaces constitute an important nexus for group theory, combinatorics, geometry, topology, Galois theory and complex analysis. Compact Riemann surfaces are complex projective curves and have been studied for well over one hundred years. These surfaces have spawned a rich, interconnected theory in algebraic geometry, complex analysis, hyperbolic geometry, topology, and combinatorial/geometric group theory using tools such as uniformizing Fuchsian groups, Jacobian varieties, and moduli spaces. The use of combinatorial/geometric group theory for studying Riemann surfaces goes all the way back to Klein, Hurwitz and others; has continued through topological methods such as mapping class groups, Teichmüller and moduli spaces; and is a key part of the more recent developments in cryptographic applications, the Grothendieck theory of dessins d'enfants, and the use of powerful computer algebra systems such as Magma and GAP.

This volume is based on the conference, Riemann and Klein Surfaces, Symmetries, and Moduli Spaces, that took place at Linköping University 24–28 June 2013, in honor of Professor Emilio Bujalance. The conference and this volume are devoted to the mathematics that Professor Bujalance and his many colleagues have worked on, with special focus on Riemann and Klein surfaces, i.e., complex curves, automorphisms of surfaces (real and complex), group actions on surfaces, Grothendieck theory of dessins d'enfants, topological properties of moduli spaces of complex curves, and Abelian varieties. The conference had a computational/combinatorial flavour; the presence of a group action—geometric, combinatorial, or topological—was felt in almost every paper presented.

There is considerable current activity in these fields. As noted, these topics range from classical problems of classifying Riemann and Klein surfaces and their automorphism groups to the discovery of the topological structure of moduli spaces and the Grothendieck theory of dessins d'enfants. This volume should be a very useful source for anyone working in the area since the conference covered such a wide spectrum of topics. To guide mathematicians new to the area, several articles of an expository nature have been included. The volume will also serve as a tool in communicating the interplay among the different areas.

S. Allen Broughton, Antonio F. Costa, Milagros Izquierdo and Rubí E. Rodríguez

Selected Published Titles in This Series

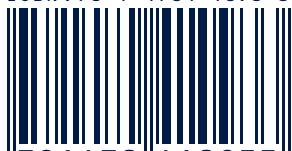
- 629 **Milagros Izquierdo, S. Allen Broughton, Antonio F. Costa, and Rubí E. Rodríguez, Editors**, Riemann and Klein Surfaces, Automorphisms, Symmetries and Moduli Spaces, 2014
- 625 **Alexander Barg and Oleg R. Musin, Editors**, Discrete Geometry and Algebraic Combinatorics, 2014
- 622 **S. Ejaz Ahmed, Editor**, Perspectives on Big Data Analysis, 2014
- 621 **Ludmil Katzarkov, Ernesto Lupercio, and Francisco J. Turrubiates, Editors**, The Influence of Solomon Lefschetz in Geometry and Topology, 2014
- 620 **Ulrike Tillmann, Søren Galatius, and Dev Sinha, Editors**, Algebraic Topology: Applications and New Directions, 2014
- 619 **Gershon Wolansky and Alexander J. Zaslavski, Editors**, Variational and Optimal Control Problems on Unbounded Domains, 2014
- 618 **Abba B. Gumel, Editor**, Mathematics of Continuous and Discrete Dynamical Systems, 2014
- 617 **Christian Ausoni, Kathryn Hess, Brenda Johnson, Wolfgang Lück, and Jérôme Scherer, Editors**, An Alpine Expedition through Algebraic Topology, 2014
- 616 **G. L. Litvinov and S. N. Sergeev, Editors**, Tropical and Idempotent Mathematics and Applications, 2014
- 615 **Plamen Stefanov, András Vasy, and Maciej Zworski, Editors**, Inverse Problems and Applications, 2014
- 614 **James W. Cogdell, Freydoon Shahidi, and David Soudry, Editors**, Automorphic Forms and Related Geometry, 2014
- 613 **Stephan Stolz, Editor**, Topology and Field Theories, 2014
- 612 **Patricio Cifuentes, José García-Cuerva, Gustavo Garrigós, Eugenio Hernández, José María Martell, Javier Parcet, Keith M. Rogers, Alberto Ruiz, Fernando Soria, and Ana Vargas, Editors**, Harmonic Analysis and Partial Differential Equations, 2014
- 611 **Robert Fitzgerald Morse, Daniela Nikolova-Popova, and Sarah Witherspoon, Editors**, Group Theory, Combinatorics, and Computing, 2014
- 610 **Pavel Etingof, Mikhail Khovanov, and Alistair Savage, Editors**, Perspectives in Representation Theory, 2014
- 609 **Dinh Van Huynh, S. K. Jain, Sergio R. López-Permouth, S. Tariq Rizvi, and Cosmin S. Roman, Editors**, Ring Theory and Its Applications, 2014
- 608 **Robert S. Doran, Greg Friedman, and Scott Nollet, Editors**, Hodge Theory, Complex Geometry, and Representation Theory, 2014
- 607 **Kiyoshi Igusa, Alex Martsinkovsky, and Gordana Todorov, Editors**, Expository Lectures on Representation Theory, 2014
- 606 **Chantal David, Matilde Lalín, and Michelle Manes, Editors**, Women in Numbers 2, 2013
- 605 **Omid Amini, Matthew Baker, and Xander Faber, Editors**, Tropical and Non-Archimedean Geometry, 2013
- 604 **José Luis Montaña and Luis M. Pardo, Editors**, Recent Advances in Real Complexity and Computation, 2013
- 603 **Azita Mayeli, Alex Iosevich, Palle E. T. Jorgensen, and Gestur Ólafsson, Editors**, Commutative and Noncommutative Harmonic Analysis and Applications, 2013
- 602 **Vyjayanthi Chari, Jacob Greenstein, Kailash C. Misra, K. N. Raghavan, and Sankaran Viswanath, Editors**, Recent Developments in Algebraic and Combinatorial Aspects of Representation Theory, 2013

For a complete list of titles in this series, visit the
AMS Bookstore at www.ams.org/bookstore/conmseries/.

This volume contains the proceedings of the conference on Riemann and Klein Surfaces, Symmetries and Moduli Spaces, in honor of Emilio Bujalance, held from June 24–28, 2013, at Linköping University.

The conference and this volume are devoted to the mathematics that Emilio Bujalance has worked with in the following areas, all with a computational flavor: Riemann and Klein surfaces, automorphisms of real and complex surfaces, group actions on surfaces and topological properties of moduli spaces of complex curves and Abelian varieties.

ISBN 978-1-4704-1093-3



9 781470 410933

CONM/629

AMS on the Web
www.ams.org