BEAUVILLE SURFACES AND FINITE SIMPLE GROUPS

SHELLY GARION, MICHAEL LARSEN, AND ALEXANDER LUBOTZKY

In memory of Fritz Grunewald, an inspiring mathematician and a dear friend

ABSTRACT. A Beauville surface is a rigid complex surface of the form $(C_1 \times C_2)/G$, where C_1 and C_2 are non-singular, projective, higher genus curves, and G is a finite group acting freely on the product. Bauer, Catanese, and Grunewald conjectured that every finite simple group G, with the exception of A_5, gives rise to such a surface. We prove that this is so for almost all finite simple groups (i.e., with at most finitely many exceptions). The proof makes use of the structure theory of finite simple groups, probability theory, and character estimates.

Catanese [Cat] defined a *Beauville surface* to be an infinitesimally rigid complex surface of the form $X := (C_1 \times C_2)/G$, where C_1 and C_2 are non-singular projective curves of genus ≥ 2, and G is a finite group acting freely on the product. Every $g \in G$ respects the product decomposition $C_1 \times C_2$. Let G^0 denote the subgroup of G (of index ≤ 2) which preserves the ordered pair (C_1, C_2). Any Beauville surface can be presented in such a way that G^0 acts effectively on each factor. Catanese called such a presentation *minimal* and proved that it is unique [Cat, Proposition 3.13]. A Beauville surface is *mixed* (resp. *unmixed*) if $[G : G^0] = 2$ (resp. $G = G^0$).

There has been an effort to classify finite groups G appearing in minimal presentations of unmixed Beauville surfaces. A finite group G appears in this way if and only if it admits an *unmixed Beauville structure*. This consists of an ordered quadruple $(x_1, y_1, x_2, y_2) \in G$

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   Beauville Surfaces and Groups Ingrid Bauer,Shelly Garion,Alina Vdovina,2015-04-14 This collection of surveys and research articles explores a fascinating class of varieties Beauville surfaces It is the first time that these objects are discussed from the points of view of algebraic geometry as well as group theory The book also includes various open problems and conjectures related to these surfaces Beauville surfaces are a class of rigid regular surfaces of general type which can be described in a purely algebraic combinatoric way They play an important role in different fields of mathematics like algebraic geometry group theory and number theory The notion of Beauville surface was introduced by Fabrizio Catanese in 2000 and after the first systematic study of these surfaces by Ingrid Bauer Fabrizio Catanese and Fritz Grunewald there has been an increasing interest in the subject These proceedings reflect the topics of the lectures presented during the workshop Beauville surfaces and groups 2012 held at Newcastle University UK in June 2012 This conference brought together for the first time experts of different fields of mathematics interested in Beauville surfaces **Symmetries in Graphs, Maps, and Polytopes** Jozef Širáň,Robert Jajcay,2016-03-26 This volume contains seventeen of the best papers delivered at the SIGMAP Workshop 2014 representing the most recent advances in the field of symmetries of discrete objects and structures with a particular emphasis on connections between maps Riemann surfaces and dessins d enfant Providing the global community of researchers in the field with the opportunity to gather converse and present their newest findings and advances the Symmetries In Graphs Maps and Polytopes Workshop 2014 was the fifth in a series of workshops The initial workshop organized by Steve Wilson in Flagstaff Arizona in 1998 was followed in 2002 and 2006 by two meetings held in Aveiro Portugal organized by Antonio Breda d Azevedo and a fourth workshop held in Oaxaca Mexico organized by Isabel Hubard in 2010 This book should appeal to both specialists and those seeking a broad overview of what is happening in the area of symmetries of discrete objects and structures iv **Groups St Andrews 2013** C. M. Campbell,M. R. Quick,E. F. Robertson,C. M. Roney-Dougal,2015-10-22 Leading researchers survey the latest developments in group theory and many related areas *Groups St Andrews 2017 in Birmingham* C. M. Campbell,C. W. Parker,M. R. Quick,E. F. Robertson,C. M. Roney-Dougal,2019-04-11 These proceedings of Groups St Andrews 2017 provide a snapshot of the state of the art in contemporary group theory Quasiconformal Mappings, Riemann Surfaces, and Teichmuller Spaces Yunping Jiang,Sudeb Mitra,2012 This volume contains the proceedings of the AMS Special Session on Quasiconformal Mappings Riemann Surfaces and Teichmuller Spaces held in honor of Clifford J Earle from October 2 3 2010 in Syracuse New York This volume includes a wide range of papers on Teichmuller theory and related areas It provides a broad survey of the present state of research and the applications of quasiconformal mappings Riemann surfaces complex dynamical systems Teichmuller theory and geometric function theory The papers in this volume reflect the directions of research in different aspects of these fields and also give the reader an idea of how Teichmuller theory intersects with other areas of mathematics **Beauville**

Surfaces and Finite Simple Groups Shelly Garion,Michael Larsen,Alexander Lubotzky,2010　**Rigidity and Symmetry** Robert Connelly,Asia Ivić Weiss,Walter Whiteley,2014-06-11 This book contains recent contributions to the fields of rigidity and symmetry with two primary focuses to present the mathematically rigorous treatment of rigidity of structures and to explore the interaction of geometry algebra and combinatorics Contributions present recent trends and advances in discrete geometry particularly in the theory of polytopes The rapid development of abstract polytope theory has resulted in a rich theory featuring an attractive interplay of methods and tools from discrete geometry group theory classical geometry hyperbolic geometry and topology Overall the book shows how researchers from diverse backgrounds explore connections among the various discrete structures with symmetry as the unifying theme The volume will be a valuable source as an introduction to the ideas of both combinatorial and geometric rigidity theory and its applications incorporating the surprising impact of symmetry It will appeal to students at both the advanced undergraduate and graduate levels as well as post docs structural engineers and chemists　**Geometry, Groups and Dynamics** C. S. Aravinda,William M. Goldman, Krishnendu Gongopadhyay, Alexander Lubotzky, Mahan Mj,Anthony Weaver,2015-05-01 This volume contains the proceedings of the ICTS Program Groups Geometry and Dynamics held December 3 16 2012 at CEMS Almora India The activity was an academic tribute to Ravi S Kulkarni on his turning seventy Articles included in this volume both introductory and advanced surveys represent the broad area of geometry that encompasses a large portion of group theory finite or otherwise and dynamics in its proximity These areas have been influenced by Kulkarni s ideas and are closely related to his work and contribution　**Galois Covers, Grothendieck-Teichmüller Theory and Dessins d'Enfants** Frank Neumann,Sibylle Schroll,2020-09-26 This book presents original peer reviewed contributions from the London Mathematical Society LMS Midlands Regional Meeting and Workshop on Galois Covers Grothendieck Teichm ller Theory and Dessinsd Enfants which took place at the University of Leicester UK from 4 to 7 June 2018 Within the theme of the workshop the collected articles cover a broad range of topics and explore exciting new links between algebraic geometry representation theory group theory number theory and algebraic topology The book combines research and overview articles by prominent international researchers and provides a valuable resource for researchers and students alike　**Geometric Methods in Algebra and Number Theory** Fedor Bogomolov,Yuri Tschinkel,2006-06-22 Contains a selection of articles exploring geometric approaches to problems in algebra algebraic geometry and number theory The collection gives a representative sample of problems and most recent results in algebraic and arithmetic geometry Text can serve as an intense introduction for graduate students and those wishing to pursue research in algebraic and arithmetic geometry　*Dessins d'Enfants on Riemann Surfaces* Gareth A. Jones,Jürgen Wolfart,2016-03-23 This volume provides an introduction to dessins d enfants and embeddings of bipartite graphs in compact Riemann surfaces The first part of the book presents basic material guiding the reader through the current field of research A key point of the second part is the interplay between the automorphism groups

of dessins and their Riemann surfaces and the action of the absolute Galois group on dessins and their algebraic curves It concludes by showing the links between the theory of dessins and other areas of arithmetic and geometry such as the abc conjecture complex multiplication and Beauville surfaces Dessins d Enfants on Riemann Surfaces will appeal to graduate students and all mathematicians interested in maps hypermaps Riemann surfaces geometric group actions and arithmetic

Symplectic 4-Manifolds and Algebraic Surfaces Fabrizio Catanese,Denis Auroux,Gang Tian,Marco Manetti,Paul Seidel,Bernd Siebert,Ivan Smith,2008-04-17 Modern approaches to the study of symplectic 4 manifolds and algebraic surfaces combine a wide range of techniques and sources of inspiration Gauge theory symplectic geometry pseudoholomorphic curves singularity theory moduli spaces braid groups monodromy in addition to classical topology and algebraic geometry combine to make this one of the most vibrant and active areas of research in mathematics It is our hope that the five lectures of the present volume given at the C I M E Summer School held in Cetraro Italy September 2 10 2003 will be useful to people working in related areas of mathematics and will become standard references on these topics The volume is a coherent exposition of an active field of current research focusing on the introduction of new methods for the study of moduli spaces of complex structures on algebraic surfaces and for the investigation of symplectic topology in dimension 4 and higher   Global Aspects of Complex Geometry Fabrizio Catanese,Hélène Esnault,Alan Huckleberry,Klaus Hulek,Thomas Peternell,2006-09-29 This collection of surveys present an overview of recent developments in Complex Geometry Topics range from curve and surface theory through special varieties in higher dimensions moduli theory K hler geometry and group actions to Hodge theory and characteristic p geometry Written by established experts this book will be a must for mathematicians working in Complex Geometry   *Automorphisms of Riemann Surfaces, Subgroups of Mapping Class Groups and Related Topics* Aaron Wootton,S. Allen Broughton,Jennifer Paulhus,2022-02-03 Automorphism groups of Riemann surfaces have been widely studied for almost 150 years This area has persisted in part because it has close ties to many other topics of interest such as number theory graph theory mapping class groups and geometric and computational group theory In recent years there has been a major revival in this area due in part to great advances in computer algebra systems and progress in finite group theory This volume provides a concise but thorough introduction for newcomers to the area while at the same time highlighting new developments for established researchers The volume starts with two expository articles The first of these articles gives a historical perspective of the field with an emphasis on highly symmetric surfaces such as Hurwitz surfaces The second expository article focuses on the future of the field outlining some of the more popular topics in recent years and providing 78 open research problems across all topics The remaining articles showcase new developments in the area and have specifically been chosen to cover a variety of topics to illustrate the range of diversity within the field   **Riemann and Klein Surfaces, Automorphisms, Symmetries and Moduli Spaces** Milagros Izquierdo, S. Allen Broughton, Antonio F. Costa,Rubí E. Rodríguez,2014-11-21 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 Link ping 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

Groups and Symmetries John P. Harnad,Pavel Winternitz, The Cremona Group and Its Subgroups Julie Déserti,2021-04-13 The goal of this book is to present a portrait of the n n dimensional Cremona group with an emphasis on the 2 dimensional case After recalling some crucial tools the book describes a naturally defined infinite dimensional hyperbolic space on which the Cremona group acts This space plays a fundamental role in the study of Cremona groups as it allows one to apply tools from geometric group theory to explore properties of the subgroups of the Cremona group as well as the degree growth and dynamical behavior of birational transformations The book describes natural topologies on the Cremona group codifies the notion of algebraic subgroups of the Cremona groups and finishes with a chapter on the dynamics of their actions This book is aimed at graduate students and researchers in algebraic geometry who are interested in birational geometry and its interactions with geometric group theory and dynamical systems New Beauville Surfaces, Moduli Spaces and Finite Groups Shelly Garion,Matteo Penegini,2010 The Character Theory of Finite Groups of Lie Type Meinolf Geck,Gunter Malle,2020-02-27 A comprehensive guide to the vast literature and range of results around Lusztig s character theory of finite groups of Lie type **Algebra, Arithmetic, and Geometry** Yuri Tschinkel,Yuri Zarhin,2010-08-05 EMAlgebra Arithmetic and Geometry In Honor of Yu I ManinEM consists of invited expository and research articles on new developments arising from Manin s outstanding contributions to mathematics

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