

The rational function analogue of a question of Schur and exceptionality of permutation representations

Robert M. Guralnick ^{*} Peter Müller [†] Jan Saxl [‡]

February 5, 1999

Abstract

In 1923 Schur considered the following problem. Let $f \in \mathbb{Z}[X]$ be a polynomial that induces a bijection on the residue fields $\mathbb{Z}/p\mathbb{Z}$ for infinitely many primes p . His conjecture, that such polynomials are compositions of linear and Dickson polynomials, was proved by M. Fried in 1970. Here we investigate the analogous question for rational functions, also we allow the base field to be any number field. As a result, there are many more rational functions for which the analogous property holds. Some infinite series come from rational isogenies of elliptic curves and deformations. There are several sporadic examples which do not fit in any of the series we obtain.

First we translate the arithmetic property to a question about finite permutation groups, and classify those groups which fulfill the necessary conditions. The proofs depend on the classification of the finite simple groups. Then we use arithmetic arguments to either rule out many cases, or to prove that the remaining cases indeed give rise to examples. This part is based on Mazur's classical results about rational points on the modular curves $X_0(p)$ and $X_1(p)$, results about Galois images in $\mathrm{GL}_2(p)$ coming from action of the absolute Galois group of \mathbb{Q} on p -torsion points of elliptic curves, the theory of complex multiplication, and the techniques used in the inverse regular Galois problem.

1 Introduction

In 1923 Schur [Sch23] posed the following question. Let $f(X) \in \mathbb{Z}[X]$ be a polynomial which induces a bijection on $\mathbb{Z}/p\mathbb{Z}$ for infinitely many primes p . He proved that if f has prime degree, then f is, up to linear changes

^{*}Partially supported by the NSF and NATO.

[†]Supported by the DFG.

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Rational Function Analogue Of A Question Of Schur And Exceptionality Of Permutation Representations

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Rational Function Analogue Of A Question Of Schur And Exceptionality Of Permutation Representations:

The Rational Function Analogue of a Question of Schur and Exceptionality of Permutation Representations Robert M. Guralnick, Peter Müller, Jan Saxl, 2003 Investigates the analogous question for rational functions This book describes the Galois theoretic translation based on Chebotarev's density theorem leads to a certain property of permutation groups called exceptionality

The Rational Function Analogue of a Question of Schur and Exceptionality of Permutation Representations Ricardo Donato Salvatore, Robert M. Guralnick, 2014-09-11 Investigates the analogous question for rational functions This book describes the Galois theoretic translation based on Chebotarev's density theorem leads to a certain property of permutation groups called exceptionality

Algebraic Groups and their Representations R.W. Carter, J. Saxl, 2012-12-06 This volume contains 19 articles written by speakers at the Advanced Study Institute on Modular representations and subgroup structure of algebraic groups and related finite groups held at the Isaac Newton Institute Cambridge from 23rd June to 4th July 1997 We acknowledge with gratitude the financial support given by the NATO Science Committee to enable this ASI to take place Generous financial support was also provided by the European Union We are also pleased to acknowledge funds given by EPSRC to the Newton Institute which were used to support the meeting It is a pleasure to thank the Director of the Isaac Newton Institute Professor Keith Moffatt and the staff of the Institute for their dedicated work which did so much to further the success of the meeting The editors wish to thank Dr Ross Lawther and Dr Nick Inglis most warmly for their help in the production of this volume Dr Lawther in particular made an invaluable contribution in preparing the volume for submission to the publishers Finally we wish to thank the distinguished speakers at the ASI who agreed to write articles for this volume based on their lectures at the meeting We hope that the volume will stimulate further significant advances in the theory of algebraic groups

Equivariant, Almost-Arborescent Representations of Open Simply-Connected 3-Manifolds; A Finiteness Result Valentin Poenaru, C. Tanasi, 2004 Shows that at the cost of replacing V DEGREES3 by V_h DEGREES3 V DEGREES3 with very many holes we can always find representations X DEGREES2 $\text{stackrel{rel f}{\rightarrow}} V$ DEGREES3 with X DEGREES2 locally finite and almost arborescent with $\Psi f \Phi f$ and with the open *Representation Theory and Numerical AF-Invariants* Ola Bratteli, Palle E. T. Jørgensen, Vasyli' Ostrovs'kyi, 2004 Part A Representation theory Part B Numerical AF invariants Bibliography List of figures List of tables List of terms and symbols

Classification and Probabilistic Representation of the Positive Solutions of a Semilinear Elliptic Equation Benoît Mselati, 2004 Concerned with the nonnegative solutions of $\Delta u = u^2$ in a bounded and smooth domain in \mathbb{R}^d this title intends to prove that they are uniquely determined by their fine trace on the boundary as defined in DK98a answering a major open question of Dy02

Algebra, Arithmetic and Geometry with Applications Chris Christensen, Ganesh Sundaram, Avinash Sathaye, Chandrajit Bajaj, 2011-06-27 Proceedings of the Conference on Algebra and Algebraic Geometry with Applications July 19-26 2000 at Purdue University to honor Professor Shreeram S Abhyankar on the occasion of his seventieth birthday Eighty five of

Professor Abhyankar's students, collaborators, and colleagues were invited participants. Sixty participants presented papers related to Professor Abhyankar's broad areas of mathematical interest. Sessions were held on algebraic geometry, singularities, group theory, Galois theory, combinatorics, Drinfeld modules, affine geometry, and the Jacobian problem. This volume offers an outstanding collection of papers by expert authors.

Conformal and Harmonic Measures on Laminations Associated with Rational Maps Vadim A. Kaimanovich, Mikhail Lyubich, 2005. This book is dedicated to Dennis Sullivan on the occasion of his 60th birthday. The framework of affine and hyperbolic laminations provides a unifying foundation for many aspects of conformal dynamics and hyperbolic geometry. The central objects of this approach are an affine Riemann surface lamination \mathcal{A} and the associated hyperbolic 3 lamination \mathcal{H} endowed with an action of a discrete group of isomorphisms. This action is properly discontinuous on \mathcal{H} which allows one to pass to the quotient hyperbolic lamination \mathcal{M} . Our work explores natural geometric measures on these laminations. We begin with a brief self-contained introduction to the measure theory on laminations by discussing the relationship between leafwise transverse and global measures. The central themes of our study are leafwise and transverse conformal streams on an affine lamination \mathcal{A} , analogues of the Patterson-Sullivan conformal measures for Kleinian groups, harmonic and invariant measures on the corresponding hyperbolic lamination \mathcal{H} , the Anosov-Sinai cocycle, the corresponding basic cohomology class on \mathcal{A} which provides an obstruction to flatness, and the Busemann cocycle on \mathcal{H} . A number of related geometric objects on laminations, in particular the backward and forward Poincaré series and the associated critical exponents, the curvature forms, and the Euler class, currents, and transverse invariant measures, λ -harmonic functions, and the leafwise Brownian motion, are discussed along the lines. The main examples are provided by the laminations arising from the Kleinian and the rational dynamics. In the former case \mathcal{M} is a sublamination of the unit tangent bundle of a hyperbolic 3-manifold; its transversals can be identified with the limit set of the Kleinian group, and we show how the classical theory of Patterson-Sullivan measures can be recast in terms of our general approach. In the latter case the laminations were recently constructed by Lyubich and Minsky in LM97. Assuming that they are locally compact, we construct a transverse δ -conformal stream on \mathcal{A} and the corresponding λ -harmonic measure on \mathcal{M} where $\lambda \delta \delta^2$. We prove that the exponent δ of the stream does not exceed 2 and that the affine laminations are never flat except for several explicit special cases: rational functions with parabolic Thurston orbifold.

An Analogue of a Reductive Algebraic Monoid Whose Unit Group Is a Kac-Moody Group Claus Mokler, 2005. By an easy generalization of the Tannaka-Krein reconstruction, we associate to the category of admissible representations of the category \mathcal{O} of a Kac-Moody algebra and its category of admissible duals a monoid with a coordinate ring. The Kac-Moody group is the Zariski open dense unit group of this monoid. The restriction of the coordinate ring to the Kac-Moody group is the algebra of strongly regular functions introduced by V. Kac and D. Peterson. This monoid has similar structural properties as a reductive algebraic

monoid In particular it is unit regular its idempotents related to the faces of the Tits cone It has Bruhat and Birkhoff decompositions The Kac Moody algebra is isomorphic to the Lie algebra of this monoid

On Central Critical Values of the Degree Four L -functions for $\mathrm{GSp}(4)$: The Fundamental Lemma Masaaki Furusawa, Joseph A. Shalika, 2003 Proves two equalities of local Kloosterman integrals on $\mathrm{GSp}(4)$ the group of 4 by 4 symplectic similitude matrices This book conjectures that both of Jacquet's relative trace formulas for the central critical values of the L functions for $\mathrm{GSp}(4)$ in J_1 and J_2

Rational Number Theory in the 20th Century Władysław Narkiewicz, 2011-09-02 The last one hundred years have seen many important achievements in the classical part of number theory After the proof of the Prime Number Theorem in 1896 a quick development of analytical tools led to the invention of various new methods like Brun's sieve method and the circle method of Hardy Littlewood and Ramanujan developments in topics such as prime and additive number theory and the solution of Fermat's problem Rational Number Theory in the 20th Century From PNT to FLT offers a short survey of 20th century developments in classical number theory documenting between the proof of the Prime Number Theorem and the proof of Fermat's Last Theorem The focus lays upon the part of number theory that deals with properties of integers and rational numbers Chapters are divided into five time periods which are then further divided into subject areas With the introduction of each new topic developments are followed through to the present day This book will appeal to graduate researchers and student in number theory however the presentation of main results without technicalities will make this accessible to anyone with an interest in the area

Arithmetic Differential Equations Alexandru Buium, 2005 For most of the book the only prerequisites are the basic facts of algebraic geometry and number theory

BOOK JACKET

Normal 2-Coverings of the Finite Simple Groups and their Generalizations Daniela Bubboloni, Pablo Spiga, Thomas Stefan Weigel, 2024-07-22 This book provides a complete and comprehensive classification of normal 2 coverings of non abelian simple groups and their generalizations While offering readers a thorough understanding of these structures and of the groups admitting them it delves into the properties of weak normal coverings The focal point is the weak normal covering number of a group G the minimum number of proper subgroups required for every element of G to have a conjugate within one of these subgroups via an element of $\mathrm{Aut}(G)$ This number is shown to be at least 2 for every non abelian simple group and the non abelian simple groups for which this minimum value is attained are classified The discussion then moves to almost simple groups with some insights into their weak normal covering numbers Applications span algebraic number theory combinatorics Galois theory and beyond Compiling existing material and synthesizing it into a cohesive framework the book gives a complete overview of this fundamental aspect of finite group theory It will serve as a valuable resource for researchers and graduate students working on non abelian simple groups

Classical Groups, Derangements and Primes Timothy C. Burness, Michael Giudici, 2016-01-15 A graduate level introduction to finite classical groups featuring a comprehensive account of the conjugacy and geometry of elements of prime order

Anisotropic Hardy

Spaces and Wavelets Marcin Bownik, 2003 Investigates the anisotropic Hardy spaces associated with very general discrete groups of dilations This book includes the classical isotropic Hardy space theory of Fefferman and Stein and parabolic Hardy space theory of Calderon and Torchinsky

Exceptional Vector Bundles, Tilting Sheaves and Tilting Complexes for Weighted Projective Lines Hagen Meltzer, 2004 Deals with weighted projective lines a class of non commutative curves modelled by Geigle and Lenzing on a graded commutative sheaf theory They play an important role in representation theory of finite dimensional algebras the complexity of the classification of coherent sheaves largely depends on the genus of these curves

Infinite Dimensional Complex Symplectic Spaces William Norrie Everitt, Lawrence Markus, 2004 Complex symplectic spaces are non trivial generalizations of the real symplectic spaces of classical analytical dynamics This title presents a self contained investigation of general complex symplectic spaces and their Lagrangian subspaces regardless of the finite or infinite dimensionality

Mutually Catalytic Super Branching Random Walks: Large Finite Systems and Renormalization Analysis J. T. Cox, Jeff Groah, Donald Andrew Dawson, Andreas Greven, 2004 Studies the evolution of the large finite spatial systems in size dependent time scales and compare them with the behavior of the infinite systems which amounts to establishing the so called finite system scheme This title introduces the concept of a continuum limit in the hierarchical mean field limit

Dynamics of Topologically Generic Homeomorphisms Ethan Akin, Mike Hurley, Judy Anita Kennedy, 2003 The goal of this work is to describe the dynamics of generic homeomorphisms of certain compact metric spaces X Here generic is used in the topological sense a property of homeomorphisms on X is generic if the set of homeomorphisms with the property contains a residual subset in the sense of Baire category of the space of all homeomorphisms on X The spaces X we consider are those with enough local homogeneity to allow certain localized perturbations of homeomorphisms for example any compact manifold is such a space We show that the dynamics of a generic homeomorphism is quite complicated with a number of distinct dynamical behaviors coexisting some resemble subshifts of finite type others which we call generalized adding machines appear strictly periodic when viewed to any finite precision but are not actually periodic Such a homeomorphism has infinitely many intricately nested attractors and repellers and uncountably many distinct dynamically connected components of the chain recurrent set We single out several types of these chain components and show that each type occurs densely in an appropriate sense in the chain recurrent set We also identify one type that occurs generically in the chain recurrent set We also show that at least for X a manifold the chain recurrent set of a generic homeomorphism is a Cantor set so its complement is open and dense Somewhat surprisingly there is a residual subset of X consisting of points whose limit sets are chain components of a type other than the type of chain components that are residual in the space of all chain components In fact for each generic homeomorphism on X there is a residual subset of points of X satisfying a stability condition stronger than Lyapunov stability

Quasianalytic Monogenic Solutions of a Cohomological Equation Stefano Marmi, D. Sauzin, 2003 We prove that the solutions of a cohomological equation of

complex dimension one and in the analytic category have a monogenic dependence on the parameter This cohomological equation is the standard linearized conjugacy equation for germs of holomorphic maps in a neighborhood of a fixed point

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