

# SEMI-STABILITY OF AMALGAMATED PRODUCTS, HNN-EXTENSIONS, AND ALL ONE-RELATOR GROUPS

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## 1. INTRODUCTION

Semistability at infinity is a geometric property used in the study of ends of finitely presented groups. If a finitely presented group  $G$  is semistable at infinity, then sophisticated invariants for  $G$ , such as the fundamental group at an end of  $G$ , can be defined (see [10]). It is unknown whether or not all finitely presented groups are semistable at infinity, although by [16] it suffices to know whether all 1-ended finitely presented groups are semistable at infinity. There are a number of results showing many 1-ended groups have this property, e.g., if  $G$  is finitely presented and contains a finitely generated, infinite, normal subgroup of infinite index, then  $G$  is semistable at infinity (see [12] and for other such results [13-15]).

Semistability at infinity is of interest in the study of cohomology of groups; if a finitely presented group  $G$  is semistable at infinity, then  $H^2(G; \mathbb{Z}G)$  is free abelian (see [6, 7]). This is conjectured to be true for all finitely presented groups, but at present it is not even known for 2-dimensional duality groups (where one is discussing the dualizing module, see [2]).

For negatively curved groups (i.e., hyperbolic groups in the sense of Gromov, see [8]), semistability at infinity has additional interesting consequences. If a negatively curved group  $G$  is given the word metric with respect to some finite generating set, then there is a compactification  $\overline{G}$  of  $G$  where a point of  $\partial G = \overline{G} - G$  is a certain equivalence class of proper sequences of points in  $G$ . The boundary of  $G$  is a compact, metrizable, finite-dimensional space, which determines the cohomology of  $G$ . Bestvina and Mess have shown that if  $G$  is a negatively curved group, then for every ring  $R$ , there is an isomorphism of  $RG$ -modules  $H^*(G; RG) \cong H^{*-1}(\partial G; R)$  (Čech reduced). Geoghegan has observed that results in [1] imply that a negatively curved group  $G$  is semistable at infinity iff  $\partial G$  has the shape of a locally connected continuum (see [6]). Furthermore, in [1], ideas closely related to semistability at infinity are used to analyze closed irreducible 3-manifolds with negatively curved fundamental group.

A continuous map is *proper* if inverse images of compact sets are compact. Proper rays  $r, s: [0, \infty) \rightarrow K$  in a locally finite CW-complex  $K$  are said to *converge to the same end* of  $K$  if for every compact  $C \subseteq K$  there exists an  $N$  such that  $r([N, \infty))$  and  $s([N, \infty))$  are contained in the same path component of  $K - C$ . A locally finite

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# Semistability Of Amalgamated Products And Hnn Extensions

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## **Semistability Of Amalgamated Products And Hnn Extensions:**

**Semistability of Amalgamated Products and HNN-Extensions** Michael L. Mihalik, Steven Thomas Tschantz, 1992 In the study of the proper homotopy theory of finitely presented groups semistability at infinity is an end invariant of central importance A finitely presented group that is semistable at infinity has a well defined fundamental group at infinity independent of base ray If  $G$  is semistable at infinity then  $G$  has free abelian second cohomology with  $\mathbb{Z}G$  coefficients In this work the authors show that amalgamated products and HNN extensions of finitely presented semistable at infinity groups are also semistable at infinity A major step toward determining whether all finitely presented groups are semistable at infinity this result easily generalizes to finite graphs of groups In an early application this result was used in showing that all one relator groups are semistable at infinity The theory of group actions on trees and techniques derived from the proof of Dunwoody's accessibility theorem are key ingredients in this work

**Analytic and Algebraic Geometry** Anil Atmaja Aryasomayajula, Indranil Biswas, Archana S. Morye, A. J. Parameswaran, 2017-09-08 This volume is an outcome of the International conference held in Tata Institute of Fundamental Research and the University of Hyderabad There are fifteen articles in this volume The main purpose of the articles is to introduce recent and advanced techniques in the area of analytic and algebraic geometry This volume attempts to give recent developments in the area to target mainly young researchers who are new to this area Also some research articles have been added to give examples of how to use these techniques to prove new results

**Topology at Infinity of Discrete Groups** Ross Geoghegan, Craig R. Guilbault, Kim Ruane, 2025-02-07 This volume contains the proceedings of the AMS Special Session on Ends and Boundaries of Groups held in honor of Michael Mihalik's 70th birthday on April 15-16, 2023 at the University of Cincinnati Ohio The papers cover current topics in geometric group theory and related topology Four survey papers discuss hyperbolic actions CAT(0) groups Thompson type groups and Z-set boundaries Other papers cover new material related to hyperbolic groups Poincaré Duality groups outer automorphism groups right angled Artin groups and mapping class groups Several papers present new results on ends of spaces and related group theory A notable addition intended for readers interested in the interplay of topology and group theory is a self-contained detailed exposition of Z-sets and their role in geometric group theory

**Topology and Geometric Group Theory** Michael W. Davis, James Fowler, Jean-François Lafont, Ian J. Leary, 2016-09-14 This book presents articles at the interface of two active areas of research classical topology and the relatively new field of geometric group theory It includes two long survey articles one on proofs of the Farrell-Jones conjectures and the other on ends of spaces and groups In 2010-2011 Ohio State University OSU hosted a special year in topology and geometric group theory Over the course of the year there were seminars workshops short weekend conferences and a major conference out of which this book resulted Four other research articles complement these surveys making this book ideal for graduate students and established mathematicians interested in entering this area of research

**Topological Methods in Group Theory** Ross

Geoghegan, 2007-12-27 This book is about the interplay between algebraic topology and the theory of infinite discrete groups. It is a hugely important contribution to the field of topological and geometric group theory and is bound to become a standard reference in the field. To keep the length reasonable and the focus clear, the author assumes the reader knows or can easily learn the necessary algebra but wants to see the topology done in detail. The central subject of the book is the theory of ends. Here the author adopts a new algebraic approach which is geometric in spirit. **Extension of Positive-Definite Distributions and Maximum Entropy** Jean-Pierre Gabardo, 1993 In this work the maximum entropy method is used to solve the extension problem associated with a positive definite function or distribution defined on an interval of the real line. Gabardo computes explicitly the entropy maximizers corresponding to various logarithmic integrals depending on a complex parameter and investigates the relation to the problem of uniqueness of the extension. These results are based on a generalization in both the discrete and continuous cases of Burg's maximum entropy theorem. **An Extension of the Galois Theory of Grothendieck** André Joyal, Myles Tierney, 1984 In this paper we compare in a precise way the concept of Grothendieck topos to the classical notion of topological space. The comparison takes the form of a two fold extension of the idea of space. **Extensions of the Jacobi Identity for Vertex Operators, and Standard  $\mathbb{A}^1$ -Modules** Cristiano Hsu, 1993 The main axiom for a vertex operator algebra over a field of characteristic zero is the Jacobi identity. This identity is extended to multi operator identities. Then relative to  $\mathbb{Z}_2$  twisted vertex operators are introduced and a Jacobi identity for these operators is established. Then these ideas are used to interpret and recover the twisted  $\mathbb{Z}$  operators and corresponding generating function identities developed by Lepowsky and R. L. Wilson. This work is closely related to the twisted parafermion algebra constructed by Zamolodchikov, Fateev. Loop Groups, Discrete Versions of Some Classical Integrable Systems, and Rank 2 Extensions Percy Deift, Luen-Chau Li, Carlos Tomei, 1992 The authors show how to interpret recent results of Moser and Veselov on discrete versions of a class of classical integrable systems in terms of a loop group framework. In this framework the discrete systems appear as time one maps of integrable Hamiltonian flows. Earlier results of Moser on isospectral deformations of rank 2 extensions of a fixed matrix can also be incorporated into their scheme. Symplectic Cobordism and the Computation of Stable Stems Stanley O. Kochman, 1993 This memoir consists of two independent papers. In the first The symplectic cobordism ring  $III$  the classical Adams spectral sequence is used to study the symplectic cobordism ring  $\text{capital Greek Omega}^{\text{superscript}}_{\text{subscript italic capital S}}$ . In the second The symplectic Adams-Novikov spectral sequence for spheres we analyze the symplectic Adams-Novikov spectral sequence converging to the stable homotopy groups of spheres. Continuous Images of Arcs and Inverse Limit Methods Jacek Nikiel, H. M. Tuncali, E. D. Tymchatyn, 1993 Continuous images of ordered continua are investigated. The paper gives various properties of their monotone images and inverse limits of their inverse systems or sequences with monotone bonding surjections. Some factorization theorems are provided. Special attention is given to one

dimensional spaces which are continuous images of arcs and among them various classes of rim finite continua The methods of proofs include cyclic element theory T set approximations and null family decompositions The paper brings also new properties of cyclic elements and T sets in locally connected continua in general *Filtrations on the Homology of Algebraic Varieties* Eric M. Friedlander, Barry Mazur, 1994 This work provides a detailed exposition of a classical topic from a very recent viewpoint Friedlander and Mazur describe some foundational aspects of Lawson homology for complex projective algebraic varieties a homology theory defined in terms of homotopy groups of spaces of algebraic cycles Attention is paid to methods of group completing abelian topological monoids The authors study properties of Chow varieties especially in connection with algebraic correspondences relating algebraic varieties Operations on Lawson homology are introduced and analysed These operations lead to a filtration on the singular homology of algebraic varieties which is identified in terms of correspondences and related to classical filtrations of Hodge and Grothendieck **Phantom Homology** Melvin Hochster, Craig Huneke, 1993 This book uses a powerful new technique tight closure to provide insight into many different problems that were previously not recognized as related The authors develop the notion of weakly Cohen Macaulay rings or modules and prove some very general acyclicity theorems These theorems are applied to the new theory of phantom homology which uses tight closure techniques to show that certain elements in the homology of complexes must vanish when mapped to well behaved rings These ideas are used to strengthen various local homological conjectures Initially the authors develop the theory in positive characteristic but it can be extended to characteristic 0 by the method of reduction to characteristic p The book would be suitable for use in an advanced graduate course in commutative algebra **The Cohen-Macaulay and Gorenstein Rees Algebras Associated to Filtrations** Shirō Gotō, Kōji Nishida, 1994 At first this volume was intended to be an investigation of symbolic blow up rings for prime ideals defining curve singularities The motivation for that has come from the recent 3 dimensional counterexamples to Cowsik's question given by the authors and Watanabe it has to be helpful for further researches on Cowsik's question and a related problem of Kronecker to generalize their methods to those of a higher dimension However while the study was progressing it proved apparent that the framework of Part I still works not only for the rather special symbolic blow up rings but also in the study of Rees algebras  $R_F$  associated to general filtrations  $F = \bigcup_{n \geq 0} F_n$  of ideals This observation is closely explained in Part II of this volume as a general ring theory of Rees algebras  $R_F$  We are glad if this volume will be a new starting point for the further researchers on Rees algebras  $R_F$  and their associated graded rings  $G_F$  **Markov Cell Structures near a Hyperbolic Set** F. Thomas Farrell, Lowell Jones, 1993 The authors argument is a spiritual descendent of earlier work of Adler and Weiss Sina and Bowen and involves a close study of triangulations The discussion is long and technical but the outline of the proof is sketched clearly in Section 1 for the special case of *F* an expanding immersion A concluding section lists problems on hyperbolic sets Markov partitions and related matters remarks

on topological invariants including the conjectured vanishing of Pontryagin classes for manifolds supporting Anosov diffeomorphisms may be of particular interest

**Rankin-Selberg Convolutions for  $\mathrm{SO}_{2\ell+1} \times \mathrm{GL}_n$  : Local Theory** David Soudry, 1993 On the product and on the subproduct

**Deformation Theory of Pseudogroup Structures** Victor Guillemin, Shlomo Sternberg, 1966

*Abelian Coverings of the Complex Projective Plane Branched along Configurations of Real Lines* Eriko Hironaka, 1993 This work studies abelian branched coverings of smooth complex projective surfaces from the topological viewpoint Geometric information about the coverings such as the first Betti numbers of a smooth model or intersections of embedded curves is related to topological and combinatorial information about the base space and branch locus Special attention is given to examples in which the base space is the complex projective plane and the branch locus is a configuration of lines

**Theory and Applications of Holomorphic Functions on Algebraic Varieties over Arbitrary Ground Fields** Oscar Zariski, 1951

**Higher Spinor Classes** J. F. Jardine, 1994 This work defines the higher spinor classes of an orthogonal representation of a Galois group These classes are higher degree analogues of the Frobenius spinor class which quantify the difference between the Stiefel Whitney classes of an orthogonal representation and the Hasse Witt classes of the associated form Jardine establishes various basic properties including vanishing in odd degrees and an induction formula for quadratic field extensions The methods used include the homotopy theory of simplicial presheaves and the action of the Steenrod algebra on mod 2 stable cohomology

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