

# Cyclic Homology of Algebras with One Generator\*

## THE BUENOS AIRES CYCLIC HOMOLOGY GROUP\*\*

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**Abstract.** We compute the cyclic homology of  $A = k[X]/\langle X^n \rangle$  for an arbitrary commutative ring  $k$ , and we apply this result to compute the cyclic homology of  $k[X]/\langle f \rangle$ , when  $k$  is a field and  $f$  is an arbitrary polynomial.

**Key words.** Cyclic homology, Hochschild homology.

## 0. Introduction

The aim of this paper is the computation of the cyclic homology of the algebra  $A = k[X]/\langle f \rangle$ , where  $k$  is a commutative ring with unit and  $f$  is a monic polynomial, under suitable hypothesis. In [8], Masuda and Natsume calculate the cyclic homology of this kind of algebra when the characteristic of  $k$  is 0. This has also been done by Kassel in [5]. In this work, we generalize these results. The special case  $f = X^n - 1$  has been treated in [2] and [3].

We divide the article into three sections. In the first, we build up a simplified resolution using the Taylor series developed in [7] to compute the Hochschild homology of  $A$  over  $k$ . Both the Hochschild resolution and the simplified resolution are homotopically equivalent, so we compute the maps which give this equivalence. This study was started while one of the authors was at the University of Paris VII working with M. Karoubi [4].

In the second section, we compute the cyclic homology of  $A = k[X]/\langle X^n \rangle$  starting with  $k = \mathbb{Z}$  and then applying the Künneth formula [1].

We obtain the following results:

$$(a) \quad HC_{2r+1}(A) = \bigoplus_{j=0}^r \left( \left( \bigoplus_{a=1}^{n-1} \frac{k}{(a+jn)k} \right) \oplus \frac{k}{nk} \right) \quad (r \geq 0),$$

$$(b) \quad HC_{2r}(A) = (\text{Ann}(n)^{(r)}) \oplus k^{(n)} \oplus \left( \bigoplus_{j=0}^{r-1} \left( \bigoplus_{a=1}^{n-1} \text{Ann}(a+nj) \right) \right) \quad (r \geq 0),$$

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\*\* The following people participated in this research: Jorge A. Guccione, Juan José Guccione, María Julia Redondo, Andrea Solotar, and Orlando E. Villamayor.

# Cyclic Homology Of Algebras

**Alain Connes, Joachim Cuntz, Erik G.  
Guentner, Nigel Higson, Jerome  
Kaminker, John E. Roberts**



## Cyclic Homology Of Algebras:

**Cyclic Homology Of Algebras** Peter Seibt, 1987-12-01 This book is purely algebraic and concentrates on cyclic homology rather than on cohomology. It attempts to single out the basic algebraic facts and techniques of the theory. The book is organized in two chapters. The first chapter deals with the intimate relation of cyclic theory to ordinary Hochschild theory. The second chapter deals with cyclic homology as a typical characteristic zero theory. *Cyclic Homology in Non-Commutative Geometry* Joachim Cuntz, Georges Skandalis, Boris Tsygan, 2013-03-14 Cyclic homology was introduced in the early eighties independently by Connes and Tsygan. They came from different directions. Connes wanted to associate homological invariants to K homology classes and to describe the index pairing with K theory in that way while Tsygan was motivated by algebraic K theory and Lie algebra cohomology. At the same time Karoubi had done work on characteristic classes that led him to study related structures without however arriving at cyclic homology properly speaking. Many of the principal properties of cyclic homology were already developed in the fundamental article of Connes and in the long paper by Feigin Tsygan. In the sequel cyclic homology was recognized quickly by many specialists as a new intriguing structure in homological algebra with unusual features. In a first phase it was tried to treat this structure as well as possible within the traditional framework of homological algebra. The cyclic homology groups were computed in many examples and new important properties such as product structures, excision for H-unital ideals or connections with cyclic objects and simplicial topology were established. An excellent account of the state of the theory after that phase is given in the book of Loday.

**Cyclic Homology** Jean-Louis Loday, 2013-06-29 This book is a comprehensive study of cyclic homology theory together with its relationship with Hochschild homology, de Rham cohomology,  $S^1$  equivariant homology, the Chern character, Lie algebra homology, algebraic K theory and non commutative differential geometry. Though conceived as a basic reference on the subject, many parts of this book are accessible to graduate students. Local and Analytic Cyclic Homology Ralf Meyer, 2007 Periodic cyclic homology is a homology theory for non commutative algebras that plays a similar role in non commutative geometry as de Rham cohomology for smooth manifolds. While it produces good results for algebras of smooth or polynomial functions, it fails for bigger algebras such as most Banach algebras or C algebras. Analytic and local cyclic homology are variants of periodic cyclic homology that work better for such algebras. In this book the author develops and compares these theories emphasizing their homological properties. This includes the excision theorem, invariance under passage to certain dense subalgebras, a Universal Coefficient Theorem that relates them to K theory and the Chern Connes character for K theory and K homology. The cyclic homology theories studied in this text require a good deal of functional analysis in bornological vector spaces which is supplied in the first chapters. The focal points here are the relationship with inductive systems and the functional calculus in non commutative bornological algebras. Some chapters are more elementary and independent of the rest of the book and will be of interest to researchers and students working on functional analysis and

its applications *Lectures on Cyclic Homology* Dale Husemöller, 1991 The Homology of Banach and Topological Algebras A.Y. Helemskii, 1989-10-31 Et moi si j'avait su comment en revenir One service mathematics has rendered the human race It has put common sense back je n'y serais point aUe it belongs on the topmost shelf next Jules Verne where to the dusty canister labelled discarded non The series is divergent therefore we may be sense Eric T Bell able to do something with it o Heaviside Mathematics is a tool for thought A highly necessary tool in a world where both feedback and non linearities abound Similarly all kinds of parts of mathematics serve as tools for other parts and for other sciences Applying a simple rewriting rule to the quote on the right above one finds such statements as One service topology has rendered mathematical physics One service logic has rendered computer science One service category theory has rendered mathematics All arguably true And all statements obtainable this way form part of the raison d'être of this series

*Bivariant Periodic Cyclic Homology* Christian Groenbaek, 1999-04-30 Recent work by Cuntz and Quillen on bivariant periodic cyclic homology has caused quite a revolution in the subject In this self contained exposition the author's purpose is to understand the functorial properties of the Cuntz Quillen theory which motivates his explorations of what he calls cyclic pro homology Simply stated the cyclic pro homology of an associative algebra  $A$  is short for the  $\mathbb{Z} \times \mathbb{Z}$  graded inverse system of cyclic homology groups of  $A$  considered as a pro vector space The author finds that this functor taking algebras over a field  $k$  of characteristic zero into the category of pro  $k$  vector spaces is remarkable He presents a proof that it is excisive and that it satisfies a Kunneth isomorphism for the tensor product of algebras He explains the relation to the Cuntz Quillen groups in a Universal Coefficient Theorem and in a Milnor  $\lim^1$  sequence This enables the lifting to some extent of the nice properties of cyclic pro homology properties to the Cuntz Quillen theory itself It is interesting to note that for the excision result this lifting procedure goes through without constraints For those new to cyclic homology Dr Groenbaek takes care to provide an introduction to the subject including the motivation for the theory definitions and fundamental results and establishes the homological machinery needed for application to the Cuntz Quillen theory Mathematicians interested in cyclic homology especially ring theorists using homological methods will find this work original enlightening and thought provoking The author leaves the door open for deeper study into excision for the Cuntz Quillen theory for a class of topological algebras such as the category of  $m$  algebras considered by Cuntz Cyclic Cohomology at 40: Achievements and Future Prospects A. Connes, C. Consani, B. I. Dundas, M. Khalkhali, H. Moscovici, 2023-02-23 This volume contains the proceedings of the virtual conference on Cyclic Cohomology at 40 Achievements and Future Prospects held from September 27 October 1 2021 and hosted by the Fields Institute for Research in Mathematical Sciences Toronto ON Canada Cyclic cohomology since its discovery forty years ago in noncommutative differential geometry has become a fundamental mathematical tool with applications in domains as diverse as analysis algebraic K theory algebraic geometry arithmetic geometry solid state physics and quantum field theory The reader will find survey articles providing a user friendly introduction to applications of cyclic

cohomology in such areas as higher categorical algebra Hopf algebra symmetries de Rham Witt complex quantum physics etc in which cyclic homology plays the role of a unifying theme The researcher will find frontier research articles in which the cyclic theory provides a computational tool of great relevance In particular in analysis cyclic cohomology index formulas capture the higher invariants of manifolds where the group symmetries are extended to Hopf algebra actions and where Lie algebra cohomology is greatly extended to the cyclic cohomology of Hopf algebras which becomes the natural receptacle for characteristic classes In algebraic topology the cyclotomic structure obtained using the cyclic subgroups of the circle action on topological Hochschild homology gives rise to remarkably significant arithmetic structures intimately related to crystalline cohomology through the de Rham Witt complex Fontaine's theory and the Fargues Fontaine curve

**Cyclic Homology and de Rham Homology of Affine Algebras** Ioannis Emmanouil,1994 Cyclic Homology of Extension Algebras with Application to Matrix Algebras, Algebraic K-theory, and Nest Algebras of Operators Lars David Kadison,1989

*An Introduction to Homological Algebra* Charles A. Weibel,1995-10-27 The landscape of homological algebra has evolved over the last half century into a fundamental tool for the working mathematician This book provides a unified account of homological algebra as it exists today The historical connection with topology regular local rings and semi simple Lie algebras are also described This book is suitable for second or third year graduate students The first half of the book takes as its subject the canonical topics in homological algebra derived functors Tor and Ext projective dimensions and spectral sequences Homology of group and Lie algebras illustrate these topics Intermingled are less canonical topics such as the derived inverse limit functor  $\lim^1$  local cohomology Galois cohomology and affine Lie algebras The last part of the book covers less traditional topics that are a vital part of the modern homological toolkit simplicial methods Hochschild and cyclic homology derived categories and total derived functors By making these tools more accessible the book helps to break down the technological barrier between experts and casual users of homological algebra

An Introduction to Homological Algebra Charles A. Weibel,1994 A portrait of the subject of homological algebra as it exists today

**Idempotent Matrices over Complex Group Algebras** Ioannis Emmanouil,2005-12-19 The theory of idempotent matrices with entries in complex group algebras has recently experienced a revival in view of its close relationship with deep geometric problems and conjectures The relevant questions studied in this book for general groups are motivated by specific examples A variety of techniques is employed from commutative algebra homological algebra and functional analysis The book can serve as an introduction to this lively research area The pace is suitable for independent study and the level of the presentation not very demanding The exercises at the end of each chapter form an essential part of the book

**Some Aspects of Cyclic Homology and Quantum Quasi-shuffle Algebras** Jiao Zhang,2010

**Hochschild and Cyclic Homology of Finite Type Algebras** David A. Kazhdan,Victor Nistor,Peter Schneider,Eberly College of Science. Department of Mathematics,1997 We study Hochschild and cyclic homology of finite type algebras using abelian stratifications of their primitive ideal spectrum

Hochschild homology turns out to have a quite complicated behavior but cyclic homology can be related directly to the singular cohomology of the strata We also briefly discuss some connections with the representation theory of reductive  $p$ -adic groups

Algebraic K-Theory and Its Applications Jonathan Rosenberg, 2012-12-06 Algebraic K Theory plays an important role in many areas of modern mathematics most notably algebraic topology number theory and algebraic geometry but even including operator theory The broad range of these topics has tended to give the subject an aura of inapproachability This book based on a course at the University of Maryland in the fall of 1990 is intended to enable graduate students or mathematicians working in other areas not only to learn the basics of algebraic K Theory but also to get a feel for its many applications The required prerequisites are only the standard one year graduate algebra course and the standard introductory graduate course on algebraic and geometric topology Many topics from algebraic topology homological algebra and algebraic number theory are developed as needed The final chapter gives a concise introduction to cyclic homology and its interrelationship with K Theory

### **Singularities, Algebraic Geometry, Commutative Algebra, and Related Topics**

Gert-Martin Greuel, Luis Narváez Macarro, Sebastià Xambó-Descamps, 2018-09-18 This volume brings together recent original research and survey articles by leading experts in several fields that include singularity theory algebraic geometry and commutative algebra The motivation for this collection comes from the wide ranging research of the distinguished mathematician Antonio Campillo in these and related fields Besides his influence in the mathematical community stemming from his research Campillo has also endeavored to promote mathematics and mathematicians networking everywhere especially in Spain Latin America and Europe Because of his impressive achievements throughout his career we dedicate this book to Campillo in honor of his 65th birthday Researchers and students from the world wide and in particular Latin American and European communities in singularities algebraic geometry commutative algebra coding theory and other fields covered in the volume will have interest in this book

**Handbook of Algebra** M. Hazewinkel, 2000-04-06 Handbook of Algebra

Graphs and Patterns in Mathematics and Theoretical Physics Mikhail Lyubich, Leon Armenovich

Takhtadzhidze, 2005 The Stony Brook Conference Graphs and Patterns in Mathematics and Theoretical Physics was dedicated to Dennis Sullivan in honor of his sixtieth birthday The event's scientific content which was suggested by Sullivan was largely based on mini courses and survey lectures The main idea was to help researchers and graduate students in mathematics and theoretical physics who encounter graphs in their research to overcome conceptual barriers The collection begins with Sullivan's paper Sigma models and string topology which describes a background algebraic structure for the sigma model based on algebraic topology and transversality Other contributions to the volume were organized into five sections Feynman Diagrams Algebraic Structures Manifolds Invariants and Mirror Symmetry Combinatorial Aspects of Dynamics and Physics These sections along with more research oriented articles contain the following surveys Feynman diagrams for pedestrians and mathematicians by M Polyak Notes on universal algebra by A Voronov Unimodal maps and

hierarchical models by M Yampolsky and Quantum geometry in action big bang and black holes by A Ashtekar This comprehensive volume is suitable for graduate students and research mathematicians interested in graph theory and its applications in mathematics and physics      **Noncommutative Geometry** Alain Connes, Joachim Cuntz, Erik G. Guentner, Nigel Higson, Jerome Kaminker, John E. Roberts, 2003-12-08 Noncommutative Geometry is one of the most deep and vital research subjects of present day Mathematics Its development mainly due to Alain Connes is providing an increasing number of applications and deeper insights for instance in Foliations K Theory Index Theory Number Theory but also in Quantum Physics of elementary particles The purpose of the Summer School in Martina Franca was to offer a fresh invitation to the subject and closely related topics the contributions in this volume include the four main lectures cover advanced developments and are delivered by prominent specialists

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