

## Stable modules and Wall's D(2)-problem

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**Abstract.** The D(2)-problem is to determine whether for a three-dimensional complex  $X$ , the vanishing of 3-dimensional cohomology, in all coefficients, is enough to guarantee that  $X$  is homotopically two-dimensional. We show that for finite complexes with finite fundamental group, a positive solution to the D(2)-problem is obtained precisely when all stably free algebraic 2-complexes are geometrically realizable.

The proof makes very strong use of techniques which apply to finite fundamental groups but not more generally; in particular, Yoneda's Theorem that, for finite groups, group cohomology is representable by stable modules of finite type, and also the Swan-Jacobinski Cancellation Theorem for such stable modules.

**Mathematics Subject Classification (2000).** Primary: 57M20, 57M05; Secondary: 20C05, 18C10, 18E25, 14E20.

**Keywords.** Cohomologically 2-dimensional 3-complex, algebraic 2-complex, stable module,  $k$ -invariant, geometrical realization.

### 1. Introduction

In Wall's fundamental study of Poincaré Duality [30], a finite Poincaré complex of dimension  $n$  is envisaged as a cell complex of the following *standard form*

$$(*) \quad M(\alpha) = X \cup_{\alpha} e^n$$

where  $X$  is a finite complex of dimension  $\leq n-1$  and  $\alpha : S^{n-1} \rightarrow X$  is a continuous map. This approach encounters a difficulty in dimension three, where it is unclear whether we can take  $X$  to be of geometrical, rather than merely cohomological, dimension two (see also [29]). This prompts the celebrated

**D(2) problem.** Suppose that  $X$  is a finite three dimensional cell complex such that  $H^3(X; B) = 0$  for all local coefficient systems  $B$  on  $X$ . Is  $X$  homotopy equivalent to a finite 2-dimensional complex?

The D(2)-problem is naturally parametrized by the fundamental group of the complex involved; we say that a finitely presented group  $G$  possesses the D(2)-

# Stable Modules And The D2 Problem

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Patterns, Knowledge Maps, and Domain Analysis Mohamed E. Fayad, Huascar A. Sanchez, Srikanth G.K. Hegde, Anshu Basia, Ashka Vakil, 2014-12-04 Software design patterns are known to play a vital role in enhancing the quality of software systems while reducing development time and cost However the use of these design patterns has also been known to introduce problems that can significantly reduce the stability robustness and reusability of software This book introduces a new process for **Abstracts of Papers Presented to the American Mathematical Society** American Mathematical Society, 2005

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renowned academics and practitioners from major industrial users of neurocontrol Nonlinear Analysis and Variational Problems Panos M. Pardalos, Themistocles M. Rassias, Akhtar A. Khan, 2009-10-20 The chapters in this volume written by international experts from different fields of mathematics are devoted to honoring George Isac a renowned mathematician These contributions focus on recent developments in complementarity theory variational principles stability theory of functional equations nonsmooth optimization and several other important topics at the forefront of nonlinear analysis and optimization **Probabilistic Machine Learning** Kevin P. Murphy, 2022-03-01 A detailed and up to date introduction to

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a detailed and up to date introduction to machine learning including deep learning through the unifying lens of probabilistic modeling and Bayesian decision theory The book covers mathematical background including linear algebra and optimization basic supervised learning including linear and logistic regression and deep neural networks as well as more advanced topics including transfer learning and unsupervised learning End of chapter exercises allow students to apply what they have learned and an appendix covers notation Probabilistic Machine Learning grew out of the author s 2012 book Machine Learning A Probabilistic Perspective More than just a simple update this is a completely new book that reflects the dramatic developments in the field since 2012 most notably deep learning In addition the new book is accompanied by online Python code using libraries such as scikit learn JAX PyTorch and Tensorflow which can be used to reproduce nearly all the figures this code can be run inside a web browser using cloud based notebooks and provides a practical complement to the theoretical topics discussed in the book This introductory text will be followed by a sequel that covers more advanced topics taking the same probabilistic approach

**Nonlinear and Adaptive Control** Alan S.I. Zinober, David H. Owens, 2003-07-01 The objective of the EU Nonlinear Control Network Workshop was to bring together scientists who are already active in nonlinear control and young researchers working in this field This book presents selectively invited contributions from the workshop some describing state of the art subjects that already have a status of maturity while others propose promising future directions in nonlinear control Amongst others following topics of nonlinear and adaptive control are included adaptive and robust control applications in physical systems distributed parameter systems disturbance attenuation dynamic feedback optimal control sliding mode control and tracking and motion planning

Web Reasoning and Rule Systems Axel Polleres, Terrance Swift, 2009-10-14 The promise of the Semantic Web at its most expansive is to allow knowledge to be freely accessed and exchanged by software It is now recognized that if the Semantic Web is to contain deep knowledge the need for new representation and reasoning techniques is going to be critical These techniques need to find the right trade off between expressiveness scalability and robustness to deal with the inherently incomplete contradictory and uncertain nature of knowledge on the Web The International Conference on Web Reasoning and Rule Systems RR was founded to address these needs and has grown into a major international forum in this area The third RR conference was held during October 25-26 2009 in Chantilly Virginia co-located with the International Semantic Web Conference ISWC 2009 This year 41 papers were submitted from authors in 21 countries The Program Committee performed outstandingly to ensure that each paper submitted to RR 2009 was thoroughly reviewed by at least three referees in a short period of time The resulting conference presented papers of high quality on many of the key issues for reasoning on the Semantic Web RR 2009 was fortunate to have two distinguished invited speakers Robert Kowalski in his talk integrating Logic Programming and Production Systems with Abductive Logic Programming Agents addressed some of the fundamental considerations hindering reasoning about evolving systems Benjamin Grosz's talk SILK Higher Level Rules with Defaults and Semantic Scalability described the design of a

major next generation rule system The invited tutorial Uncertainty Reasoning for the Semantic Web by Thomas Lukasiewicz provided perspectives on a central issue in this area *Proceedings of the Fourteenth Annual Conference of the Cognitive Science Society* Cognitive Science Society (US) Conference, 2014-05-12 This volume features the complete text of all regular papers posters and summaries of symposia presented at the 14th annual meeting of the Cognitive Science Society

**Functions on Manifolds: Algebraic and Topological Aspects** Vladimir Vasil'evich Sharko, 1993 This monograph covers in a unified manner new results on smooth functions on manifolds A major topic is Morse and Bott functions with a minimal number of singularities on manifolds of dimension greater than five Sharko computes obstructions to deformation of one Morse function into another on a simply connected manifold In addition a method is developed for constructing minimal chain complexes and homotopical systems in the sense of Whitehead This leads to conditions under which Morse functions on non simply connected manifolds exist Sharko also describes new homotopical invariants of manifolds which are used to substantially improve the Morse inequalities The conditions guaranteeing the existence of minimal round Morse functions are discussed **Alcohol Consumption and Problems in the General Population**, 2002 Tenth E.C. Photovoltaic Solar Energy Conference A. Luque, G. Sala, Willeke Palz, G. dos Santos, P. Helm, 2012-12-06 I have great pleasure in presenting the Proceedings of the 10th European Photovoltaic Solar Energy Conference held in Lisbon from 8 to 12 April 1991 These Proceedings contain all the scientific papers delivered at the Conference The following is a short summary of the Conference activities The Conference was opened by the Minister of Industry and Energy of Portugal Eng Luis Mira do Amaral At the opening ceremony the Becquerel Prize created by the Commission of the European Communities was awarded to Professor Werner Bloss of the University of Stuttgart and presented by Professor Philippe Bourdeau Director at the Directorate General for Science Research and Development The Becquerel lecture delivered by Professor Bloss constituted the scientific opening to the conference About 760 delegates from 53 countries presented around 350 contributions 50 of them as plenary lectures the contributions were selected among the many papers submitted this time more strictly than ever before Also a selected group of scientists were invited to deliver 15 review lectures to provide an adequate context to the contributions to the Conference A Symposium on Photovoltaics in Developing Countries which was very well attended took place as a parallel event The Symposium provided an opportunity to hear not only experts of the industrialized countries but also speakers from the countries where photovoltaics provides services of paramount value *Representations of Algebras and Related Topics* Ragnar-Olaf Buchweitz, Helmut Lenzing, This proceedings volume resulted from the Tenth International Conference on Representations of Algebras and Related Topics held at The Fields Institute Toronto ON Canada The collection of research and survey articles honoring Vlastimil Dlab's seventieth birthday reflects state of the art research on the topic Leading experts contributed papers demonstrating the interaction between representation theory of finite dimensional algebras and neighboring subjects A wide range of topics are covered including quantum groups the theory of Lie algebras the geometry

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background makes transparent an entire range of properties of wavelets and coherent states. Many concrete examples such as coherent states from semisimple Lie groups, Gazeau Klauder coherent states, coherent states for the relativity groups and several kinds of wavelets are discussed in detail. The book concludes with a palette of potential applications from the quantum physically oriented like the quantum classical transition or the construction of adequate states in quantum information to the most innovative techniques to be used in data processing. Intended as an introduction to current research for graduate students and others entering the field, the mathematical discussion is self contained. With its extensive references to the research literature, the first edition of the book is already a proven compendium for physicists and mathematicians active in the field and with full coverage of the latest theory and results, the revised second edition is even more valuable.

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