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Part 2

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Proceedings of the International Conference on Algebra

Dedicated to the Memory of A. I. Mal'cev

Part 2

L. A. Bokut'
Yu L. Ershov
A. I. Kostrikin
Editors

American Mathematical Society
Providence, Rhode Island

The International Conference on Algebra dedicated to the memory of A. I. Mal'cev took place on August 21–26, 1989, in Novosibirsk, USSR. This conference was supported by the International Mathematical Union, the Soviet Academy of Sciences, the Siberian Mathematical Society, and the Novosibirsk Systems Institute.

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Foreword

In memory of the eminent mathematician A. I. Mal'cev, 1909–1967, and near to his 80th birthday, an International Conference on Algebra and Related Areas took place, 21–26 August 1989, at Akademgorodok, Novosibirsk, USSR, organized by Novosibirsk State University and the Institute of Mathematics of the USSR, Academy of Sciences, Siberian Branch. This conference had the moral and financial support of the International Mathematical Union, the Soviet Academy of Sciences, the Siberian Mathematical Society, and the Novosibirsk Systems Institute.

There were more than 800 participants of whom 195 arrived from abroad. This huge number of participants put the local organization under considerable strain... This conference consisted of invited main lectures and longer and shorter communications in many sections; there also was a cultural program. Most importantly, however, this conference gave a beautiful occasion for scientific and personal exchange on a larger scale than had been possible before. Intensive informal contacts on a personal level should be seen as a major contribution to furthering progress of scientific ideas and collaboration and to international understanding.

A good part of the scientific communications to this conference are gathered in these volumes. They are a testimony to the memory of A. I. Mal'cev, the width of his mathematical interest and ideas, and the stimulus which his work still provides.

Introduction

The International Conference on Algebra dedicated to the memory of A. I. Mal'cev (1909–1967) took place in Novosibirsk, August 21–26, 1989. This conference became a significant event in Soviet mathematics. It was the first time since the International Congress of Mathematicians in Moscow, 1966, that Soviet algebraists could meet a large number of their foreign colleagues. More than 700 Soviet algebraists and more than 200 foreign mathematicians (1000 in all, counting family members) participated in the conference. There were fifty-six people from the United States, thirty-five from Germany, fourteen each from Canada and Great Britain, eleven from Bulgaria, ten from Poland, nine from Japan, and eight from Italy. Participants also included mathematicians from Australia, Austria, Belgium, China, Czechoslovakia, Denmark, Egypt, Hong Kong, Holland, Hungary, India, Iran, Israel, Mongolia, Norway, Singapore, Sweden, Switzerland, Vietnam, and Yugoslavia. As for the USSR, there were more than 500 participants from Russia, ninety-two from the Ukraine, thirty-eight from Belorussia, twenty-three from Kazakhstan, and sixteen from Georgia, as well as representatives from Uzbekistan, Estonia, Latvia, Azerbaidzhan, Armenia, Kirgizia, Lithuania, and Tadzhikistan. Together with specialists in the various branches of algebra, mathematicians interested in applications of algebraic methods in logic, number theory, geometry, analysis, theoretical physics, and computer science also participated in the conference. Traditional sessions on the theory of groups (finite, infinite), ring theory (including Lie algebras, associative and nonassociative rings, modules, and abelian groups), universal algebra (including semigroups and lattices), logic, and model theory were supplemented by the following sessions: algebraic geometry, algebraic topology, algebraic K-theory, category theory, representations of algebras, group rings and group representations, division algebras, linear groups over rings, topological algebra, ordered systems, rings and geometries, algorithmic problems in algebra, nonstandard and Boolean analysis, functional analysis and mathematical physics, computational analysis and computational topology, symmetric spaces and Jordan algebras, computer algebra, and applied algebra. Sessions started at

9:00 and went on until 19:00 (one day of afternoon sessions was cancelled for an excursion). Typically, there were four plenary talks (one hour each) in the morning (9:00 to 13:00), then five topical talks on five sessions (15:00 to 16:00), and finally (16:00 to 19:00) five to six half-hour talks in smaller sessions. Extensive personal contacts in a nonofficial atmosphere (including those during the excursion over the river Ob on two passenger ships and the subsequent picnic) complete the picture, showing that the participants worked hard indeed. Although the living conditions could not be called excellent, the general high scientific level of the conference helped many participants to form the very best feeling about it.

The First International Conference on Algebra[1] was in fact the Twentieth All-Union Conference on Algebra. The first such conference was organized in 1958 by A. G. Kurosh and A. I. Mal'cev (even earlier, in 1950, O. Yu. Schmidt (1892–1954) directed the All-Union Algebraic Meeting in Moscow, which can be considered a prototype of future conferences). At the Nineteenth Conference in Lvov in 1987, it was decided that the next conference would be international. Therefore, the years of "perestroika" in the USSR coincided with the birth of a new tradition in Soviet (Russian) algebra, and with a new era in the history of algebraic conferences.

The conference was dedicated to the memory of the outstanding Russian mathematician, specialist in algebra and mathematical logic, Anatoliĭ Ivanovich Mal'cev. His contribution to the development of mathematics was quite noticeable. One can recall his local theorem in logic, results in the theory of Lie groups and Lie algebras, and results in group theory, ring theory, and universal algebra. A. I. Mal'cev was one of the founders of model theory and of constructive model theory (theory of numerations). As a mathematician, he was brought up by the Moscow mathematical school, of which he was later a noticeable representative. The great Russian mathematician, A. N. Kolmogorov, one of the leaders of this school, was his thesis advisor. Works of A. I. Mal'cev were closely related to the development of world mathematics. Mal'cev himself often indicated the influence of David Hilbert. Together with Alfred Tarski, Mal'cev started the development of modern model theory. At the end of his life, Mal'cev was connected to Tarski by warm personal friendship. Abraham Robinson wrote that it was Mal'cev who showed the way from logic to algebra. The conference proved that Mal'cev and his papers are not forgotten.

Concluding this introduction, we want to thank a number of people, both in our country and abroad, who actively participated in the organization of the conference and helped make it successful. We want to especially mention the contribution of D. K. Faddeev (1907–1989), who was one of the key members of the Organizing Committee, and whose contribution was decisive

[1]By the time this introduction was written, the Second International Conference, dedicated to the memory of A. I. Shirshov, had taken place in Barnaul on August 20–25, 1991.

in consolidating the Organizing Committee around the idea of a wide, large conference. Unfortunately, this was the last conference in which D. K. Faddeev participated. During the conference, a tragic incident occurred, and D. K. Faddeev died on October 20, 1989. M. M. Lavrent'ev, the director of the Institute of Mathematics in Novosibirsk, contributed to the success of the conference, if only by the fact that he was not afraid to invite a large (even huge, by Novosibirsk standards) number of foreigners. Nathan Jacobson was the first western mathematician who enthusiastically supported (at the very beginning of 1988) the idea of the conference, therefore helping it become successful. The contribution of O. Kegel was diverse, starting from the first version of the list of plenary speakers composed during his visit to Novosibirsk one year before the conference, continuing as an acting treasurer of the conference, and finally, actively participating in the preparation of these Proceedings. In a large part due to the activity of S. Mac Lane, the American delegation was the biggest among all foreign delegations. To all these people, and to a much larger number of people whom we did not mention here (especially to those from Novosibirsk and Moscow), who actively helped to organize the conference, we want to express our deep gratitude. We want to also thank the American Mathematical Society for publishing the proceedings of the conference.

L. A. Bokut'
Yu. L. Ershov
A. I. Kostrikin

Brief Scientific Contents of the Plenary Reports at the International Conference on Algebra Dedicated to the Memory of A. I. Mal'cev

An * indicates that the plenary report was delivered at the conference, but does not appear in this volume.

A. R. Kemer (Barnaul), *Identities of associative algebras**

Kemer's report dealt with a positive solution to the famous problem of Specht on the existence of a finite basis of identities in an arbitrary associative algebra over a field of zero characteristic. In the process of the proof, the author solved another well-known problem on representability of matrix algebras: he proved that every reduced free finitely generated associative algebra over a field of zero characteristic and satisfying a nontrivial polynomial identity can be imbedded in the matrix algebra over a commutative ring. The proof is based on the structure theory worked out by the author for varieties of associative algebras, which makes essential use of the apparatus of superalgebras.

S. S. Goncharov (Novosibirsk), *The development of ideas of Mal'cev in the contemporary theory of constructive algebras and models**

This was a discussion of the mathematical and methodological ideas of Mal'cev in his papers on the constructive theory of models, along with an analysis of their development in the work of contemporary authors connected with the problem of characterizing nonequivalent representations and self-stability, numerical invariants as a means of characterizing the existence of effective representations for groups, fields, and other systems, algebraic conditions for the constructibility of positive algebras, properties of recursive automorphisms of lattices of a subsystem, and so on.

R. McKenzie (U.S.A), *Families of equivalence classes: classification, structure, and Mal'cev families**

The report gave a brief survey of the contemporary state of universal algebra, including the theory of commutators and the theory of finite algebras. The courses of further development were sketched.

Yu. L. Ershov (Novosibirsk), *Elementary theory of fields**

This report gave a survey of the problems of Mal'cev on decidability of elementary theories for fields of rational functions and fields of formal power series. Basic results were formulated on the decidability problem for the most interesting classes of fields.

S. I. Adian and I. G. Lysionok (Moscow), *A method for classifying periodic words and the Burnside problem*

A comparison was made of the methods for investigating the Burnside problem developed on the one hand by Novikov and Adian and on the other hand by Ol'shanskiĭ. The estimate of the exponent for which the Burnside group is infinite was reduced from 665 to 115.

Shigefumi Mori, *Birational classification on three-dimensional algebraic manifolds**

The report was an exposition of recent results worked out according to the so-called Mori program in the theory of birational transformations and classification of three-dimensional algebraic manifolds.

A. Yu. Ol'shanskiĭ (Moscow), *Diagrams of group homomorphisms*

The concept of the diagram of a group homomorphism was introduced. It was applied to the study of homomorphisms of surface groups and to the solution of quadratic equations in hyperbolic groups.

B. I. Zil'ber (Kemerovo), *Theory of models of algebraically closed fields*

The report dealt with questions at the boundary between the theory of models and algebraic geometry and having their roots in the theory of uncountable categoricity. In particular, it was shown that an algebraically closed field can be defined in sufficiently rich algebro-geometric structures.

M. Liebeck and J. Saxl (Great Britain), *Maximal subgroups of finite simple groups of Lie type*

The report reflected the impressive progress in the study of large subgroups of finite simple groups based on the classification of the simple groups and on successes in the theory of algebraic groups. An appreciable contribution here has been made by Soviet experts: A. V. Borovik, A. S. Kondrat'ev, and others.

Yu. A. Medvedev (Novosibirsk), *Sandwiches and absolute divisors of zero in Jordan algebras and Lie algebras**

Sandwiches and absolute divisors of zero have played a key role in the solution of many important problems in various classes of rings. Here it suffices to mention the restricted Burnside problem and classification problems in Jordan and Lie algebras. There is a close connection between the results obtained for Lie algebras and for Jordan systems. The basic result of the speaker asserts that if there is a nontrivial sandwich in a Lie algebra of characteristic p, then there is a sandwich of thickness p-4 in it. This result was reported earlier by A. I. Kostrikin under the additional assumption of the Engel condition, and played a key role in the solution of the restricted Burnside problem for groups of prime exponent. The ideas of Kostrikin lie at the basis of the speaker's proof.

Yu. P. Razmyslov (Moscow), *Identities of algebras and their representations*

The report dealt with basic concepts and constructions in the theory of characters on two words. A survey was given of results obtained in the theory of identities of algebras and their representations with the help of the solution of a basic problem in the theory of characters—the problem of describing the spectra of α- functions (multiplicative characters). Open problems of the theory of α-functions were formulated that are important for the description of identities of representations of simple Lie algebras and Grassmann envelopes of Lie superalgebras.

E. I. Zel'manov (Novosibirsk), *The restricted Burnside problem**

Zel'manov discussed the solution of the restricted Burnside problem for groups of prime-power exponent. As in the case of groups of prime exponent, the problem was first reduced to the problem of local nilpotence of Lie algebras with the Engel condition, and this problem was then solved positively by the author. The solution of Zel'manov included ideas from work of Kostrikin and Shirshov dealing with problems of Burnside type in Lie and Jordan algebras. With the use of the announced classification of simple finite groups, the results of Zel'manov yield a positive solution of the restricted Burnside problem for all exponents.

L. Van den Dries (U.S.A), *Analytic Ax-Kochen-Ershov theory*

The report communicates the author's extension of the Ax-Kochen-Ershov principle from the theory of local fields to a more general language—that of the theory of fields enriched by operations defined by convergent multiple power series.

A. N. Rudakov (Moscow), *Exceptional bundles on algebraic manifolds**

The report discussed ways of constructing exceptional bundles and their roles in the description of the set of stable vector bundles on algebraic surfaces.

V. P. Platonov (Minsk), *Local-global methods in algebra and number theory*

A survey was given of new results obtained by the speaker and his students in the area of the theory of algebraic and arithmetic groups defined over global fields. The methods of proof led to the results as a consequence of corresponding local considerations.

R. Gabriel (France) **and A. V. Roĭter** (Kiev), *Representations of finite-dimensional algebras**

The report gave a survey of new results of the speaker and other authors in the theory of representations of finite-dimensional algebras.

G. A. Margulis (Moscow), *Flows on homogeneous spaces and number theory**

Applications of methods from ergodic theory and the theory of algebraic groups to certain questions in number theory were discussed. A number of problems connected with this circle of questions were formulated on the dynamical properties of flows on homogeneous spaces.

A. A. Suslin (Leningrad), *SK_1 for division algebras and Galois cohomology**

The speaker gave a survey of known and new results on the connections between the groups $SK \diamond K_1 K_1$ for finite-dimensional division algebras and suitable Galois cohomology groups. In particular, connections were also established with the group.

I. V. Kuznetsov (Khabarovsk), *Problems in analytic number theory from the point of view of automorphic forms**

The report gave estimates of the Fourier coefficients of the eigenfunctions of the discrete spectrum of the Laplace operator on the Lobachevsky plane that are automorphic with respect to the modular group.

R. Freese (U.S.A.), *Free and finitely defined lattices*

The report gave a survey of results on free and finitely defined lattices. The evolution of these areas was considered, beginning with the work of Whitman and including many recent yet unpublished results. Some unsolved problems were formulated. Applications to varieties of lattices were also considered.

Yu. I. Manin (Moscow), *On the number of roots of Diophantine equations**

In the hypothetical asymptotics of the number of integer points of a projective variety, the numbers depending on the geometric properties of the variety and the numbers depending on the arithmetic properties of the variety are distinguished.

W. Strassen (West Germany), *Asymptotics of the spectrum of a product of matrices**

The report gave a survey of contemporary work on a problem connected with the development of algorithms optimal with respect to the number of multiplications for solving linear algebraic systems.

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Proceedings of the International Conference on Algebra Dedicated to the Memory of A. I. Mal′cev

L. A. Bokut′, Yu. L. Ershov, A. I. Kostrikin, Editors

In August 1989, more than 700 Soviet algebraists and more than 200 foreign mathematicians convened in Novosibirsk in the former Soviet Union for the International Conference on Algebra. Dedicated to the memory of A. I. Mal′cev, the great Russian algebraist and logician, the conference marked the first time since the International Congress of Mathematicians was held in Moscow in 1966 that Soviet algebraists could meet with a large number of their foreign colleagues. This volume contains the proceedings from this historic conference. Some of the Soviet contributions to this volume are not easily available from other sources.

Some of the major figures in the field, including P. M. Cohn, P. Gabriel, N. Jacobson, E. R. Kolchin, and V. Platonov, contributed to this volume. The papers span a broad range of areas including groups, Lie algebras, associative and nonassociative rings, fields and skew fields, differential algebra, universal algebra, categories, combinatorics, logic, algebraic geometry, geometry, topology, and mathematical physics.

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