

The Ekaterinburg seminar “Algebraic Systems”: 40 years of activities

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Abstract

The aim of the present article is to give a characterization of distinctive features of a scientific seminar founded and led by the author as well as to show the main sides of its activities during four decades.

1. Origin of the seminar

The seminar indicated in the title of the article started its work in 1966. By that time several younger researchers were grouped around the present writer at the Ural State University. Naturally, I discussed with each of them different problems belonged to the area of his/her investigations. However, besides these individual meetings, a usual need in such situations had arisen – to gather regularly for discussing results obtained and, in general, for diverse discussions concerning our investigations in algebra.

It should be noted that Ekaterinburg (Sverdlovsk from 1924 to 1991) is a city with considerable scientific algebraic traditions. In a great degree their beginning is due to activities of Professor P. G. Kontorovich (1905–1968) who worked for several decades at the Ural State University and was one of the leading Soviet algebraists. The scientific school created by P. G. Kontorovich gained a notable recognition in the mathematical community by the 1960s, and, in particular, it was not accidental that, after the first two All-Union Algebraic Conferences held in Moscow in 1958 and 1959, the third one was organized just in Sverdlovsk in 1960, and Prof. Kontorovich was the Chairman of its Organizing Committee¹. My scientific rise was going on under Kontorovich’s supervision; I defended a dissertation for Candidate Degree in 1961 and a dissertation for Doctor Degree in 1966².

The seminar having afterwards received the name “Algebraic Systems” had at first about 10 members. Since the 1970s the quantity of its regular participants stays at the level 20–25, in the 1980s at some meetings this quantity achieved up to 30 persons. Since the middle of the eighties, side by side with students of the leader of the seminar, students of his students were becoming regular participants of the seminar. The number of these my “scientific grandchildren” is steadily increasing.

¹ In the paper [1] I have written rather minutely about the formation of the Sverdlovsk algebraic school for the period from the end of the 1930s till the beginning of the 1960s; some key figures were presented there and some essential events and facts were mentioned. The articles [2] and [3] are devoted personally to P. G. Kontorovich. They are published in a special issue of the “Proceedings of the Ural State University” dedicated to the centenary of his birthday; the second of them is reprinted from an issue of “Mathematical Transactions” of the Ural State University (1970) dedicated to the memory of Kontorovich.

² For the reader who is not familiar with the system of Soviet (and now Russian) scientific degrees, I note that Candidate Degree approximately corresponds to the degree Ph.D. in the Western World, while Doctor Degree has no exact analogues in the western system. The latter is of a considerably higher level than the former; usually only about 10% candidates of sciences become later doctors of sciences.

Besides discussion of problems and results, it became traditional for the seminar to discuss also abstracts of talks being prepared for various conferences. It also became customary that members of the seminar attending some conferences give reports at the seminar about these conferences. The leader of the seminar pays much attention to development of skill of his disciples to perform scientific talks.

2. Topics and some peculiarities in research

The objects of investigations carried out at the seminar are a number of the main types of algebraic systems: semigroups, groups, rings and algebras (both associative and non-associative, in particular, Lie algebras), lattices and some others. These types of systems are subjects of largely developed theories, which continue to develop intensively. Members of the seminar succeeded in fundamental contributions to several fields of these theories; this will be briefly characterized below. Since the 1990s, the area of our interests was extended and includes now some topics which are referred as belonging to discrete mathematics. I mention among them, first of all, certain problems of theories of graphs and clones, in particular, problems of discrete optimization. Since the end of last century we give considerable attention to applied aspects of algebra, see item (x) below.

One may distinguish the following main directions of our investigations (with a different degree of intensity in different periods of our work).

- (i) Structure of systems and finiteness conditions³⁾.
- (ii) Lattices properties, i.e. properties related to considering lattices of subsystems for systems of a given class.
- (iii) Varieties and similar classes: quasivarieties, pseudovarieties, and the like.
- (iv) Algorithmic problems.
- (v) Congruences.
- (vi) Embeddings.
- (vii) Transformations.
- (viii) Independence of related structures: automorphism group, congruence lattice, subsystem lattice, etc.
- (ix) Combinatorics and discrete optimization.
- (x) Applications of an algebraic approach to some branches of computer science: computation complexity, synchronizability of finite automata, algorithmic problems for formal languages, etc.

In each of these directions many essential results have been obtained by members of the seminar. The most notable achievements concern directions (i)–(iv), where we accomplished quite a number of large series of works. They have received considerable recognition, which is reflected, in particular, in some summarizing publications at an international level, see Section 5 below.

I would like to give some comments for direction (iii). The central concept here is a variety. A class of algebraic systems is called a *variety* if there is a set of identities such that this class consists of all systems that satisfy all the identities from this set⁴⁾. The origin of development of the theory of varieties was given in 1935 by a basic paper by G. Birkhoff. At the second half of the 20th century the theory of varieties became one of the main trends in general algebra. Plenty of

³⁾ Here it is, of course, impossible to give definitions for the main notions being mentioned. However, in some exclusive cases one may formulate definitions that can be understandable even for the reader who is not a mathematician. For instance, it concerns the notion “finiteness condition”. Given a class of algebraic systems, by a *finiteness condition* is meant any property which is possessed by all finite systems of this class. Many infinite systems satisfy certain finiteness conditions, and examination of systems with such conditions provides a possibility to obtain diverse results in much more general situations than for finite systems. Imposing finiteness conditions is a classical approach (within the 20th century) in investigations of algebraic systems of different kinds.

For the reader who would like to consult some source with other algebraic notions mentioned in this article, I may recommend the recent handbook [4].

⁴⁾ I shall not formulate a general definition of an identity and only give the simplest examples of identities which are familiar to everybody since school time: $x + y = y + x$, $(xy)z = x(yz)$, $x(y + z) = xy + xz$.

investigations were devoted to this theory in many countries. In our seminar such investigations were begun since the end of the 1960s. They may be (conditionally) divided into five directions: identities, structural aspects, lattices of varieties, free systems, algorithmic problems. In each of them certain concrete parts may be distinguished. For instance, for the direction “identities” one of the central problems, called *the finite basis problem*, is to determine which varieties can be given by a finite set of identities. Some fundamental results obtained by members of the seminar were devoted just to this problem for different classes of algebraic systems, to the problem of classification of varieties with certain restrictions on the lattice of their subvarieties, to the description of varieties whose elementary theory is decidable as well as to quite a number of other important problems.

The concept of a quasivariety is a certain generalization of the concept of a variety, the concept of a pseudovariety is an analogue of the concept of variety applied to finite systems. Both these concepts also serve as objects of fruitful investigations. A motivation for the study of pseudovarieties is caused in a great degree by deep connections between pseudovarieties and formal languages. A key impulse for development in this direction was given by S. Eilenberg (1976) in the volume B of his well-known monograph «Automata, Languages and Machines».

The classification (i)–(x) is rather conditional: there are no clear-cut borders between these directions. Moreover, for the themes of many works accomplished at the seminar it is just typical to combine idea motifs pertained to two or more directions. Examples of such an interlacing are numerous, and there is no reason to try to characterize all corresponding situations within this article. I shall touch only one of the subject lines – imposing finiteness conditions. This classical approach was applied in our research in diverse situations: in the study of lattice properties of semigroups and groups; in considerations of congruences (for instance, in studying residually finite semigroups and rings, in particular, from the view of the theory of varieties); in a combination with problems of embeddings (a typical example is a search of conditions for embeddability in finitely generated systems with certain restrictions) as well as in investigations on algorithmic problems (for instance, in those cases when principal objects of examination are finitely presented systems).

One may note several specific features of research at the seminar.

a) *Predominance of semigroups*, especially during the first three decades of the seminar work. It is worth noticing in this connection that the theory of semigroups is one of the youngest fields of modern algebra. It was formed by the 1960s, just at that time the first monographs appeared which were entirely devoted to semigroups: a book by E. S. Ljapin “Semigroups” in the Soviet Union (1960) and a two-volume monograph by A. H. Clifford and G. B. Preston “The Algebraic Theory of Semigroups” in the USA (1961, 1967). As it can be seen from relevant information in the last paragraph of this section and in Sections 3–7, diverse manifestations of our activities in semigroup theory are numerous.

b) At the same time, *dissemination of our interests and research as applied to other types of algebraic systems*. See, in particular, comments given in item c) and especially in item f) containing a more concrete assertion which will be illustrated in the subsequent lines. This illustration together with information given in Sections 3–5 allow to show in more details various subjects of research accomplished at the seminar.

c) *Permanent attention to lattices*, both as an independent type of systems and (mostly) as related structures: the lattices of subsystems, of congruences, of ideals, of clones, of subvarieties, of subquasivarieties, of subpseudovarieties, and the like.

d) In general, *attention to related structures of different kinds*: automorphism groups, endomorphism monoids, elementary theories and the like.

e) *Permanent attention to algorithmic problems*.

f) *Investigations of the same problem for different types of algebraic systems*, both owing to research activities of different authors and in works of one and the same author.

Here is a list of such “polysystem” series of works (enumerated approximately in chronological order), each due to one author:

- on densely embedded ideals of semigroups, associative algebras (as well as some generalizations), and Lie algebras, by *L. N. Shevrin*, the end of the 1960s – the beginning of the 1970s;
- on decidability of elementary theories of varieties of groups, semigroups, associative rings, by *A. P. Zamyatin*, the 1970s;
- on independence of related structures for semigroups and lattices, by *V. A. Baranskii*, the 1970s–1980s;
- on attainability and solvability for classes of algebras applied to arbitrary universal algebras, semigroups, groups, modules, associative and Lie algebras, unars, by *L. M. Martynov*, the 1970s–1980s;
- on bases of identities and lattices of varieties applied to associative rings and semigroups, by *M. V. Volkov*, the end of the 1970s – the beginning of the 1990s;
- on critical theories of certain classes of semigroups and rings of different kinds, by *Yu. M. Vazhenin*, the 1980s – the beginning of the 1990s;
- on the word problem for varieties of groups and Lie algebras, by *O. G. Kharlampovich*, the 1980s;
- on algorithmic problems for semigroups and associative algebras, by *M. V. Sapir*, the 1980s;
- on radicals and bands of semigroups and associative rings, by *A. V. Kelarev*, the 1980s;
- on lattices of varieties of associative rings and semigroups, by *B. M. Vernikov*, the 1980s;
- on representation of lattices by subsystem lattices for semigroups, groups, rings and lattices, by *V. B. Repritskii*, the end of the 1980s – the 1990s;
- on algorithmic problems for varieties of semigroups, monoids, groups and rings, by *V. Yu. Popov*, the 1990s – the beginning of the 2000s.

3. Dissertations

The results of our investigations have found a natural reflection in dissertations defended by members of the seminar. During four decades of our work there were in all 60 such dissertations, among them 50 for Candidate Degree and 10 for Doctor Degree. I give below the list of all these dissertations.

Dissertations for Candidate Degree

Supervisor L. N. Shevrin:

1. *N. D. Filippov*. Partially ordered sets and certain algebraic systems connected with them, 1969.
2. *E. A. Golubov*. Finitely separable and residually finite semigroups, 1970.
3. *V. A. Baranskii*. Lattice isomorphisms of semigroups and certain semigroup-theoretic constructions, 1971.
4. *Yu. M. Vazhenin*. Semigroups of transformations of graphs and the first order language, 1972.
5. *L. M. Martynov*. Verbal chains in universal algebras, 1972.
6. *A. N. Trakhtman*. On the system of proper subsemigroups of a semigroup, 1973.
7. *T. I. Ershova*. On lattice properties of inverse semigroups, 1974.
8. *A. S. Prosvirov*. Idealizers of subsemigroups and the structure of a semigroup, 1977.
9. *V. B. Lender*. The operation of multiplication on classes of lattices and related topics, 1977.
10. *A. M. Gasanov*. Ternary semigroups of continuous and homeomorphic mappings, 1978.

11. *A. P. Zamyatin*. Decidability of elementary theories of varieties of groups, semigroups and associative rings, 1979.
12. *V. N. Klimov*. Congruences of semigroups, 1979.
13. *A. J. Ovsyannikov*. Lattice isomorphisms of semigroups, and varieties of semigroups, 1980.
14. *M. V. Volkov*. Lattices of varieties of rings, 1980.
15. *B. P. Tanana*. On lattice properties of topological semigroups, 1980.
16. *E. V. Sukhanov*. Varieties and bands of semigroups, 1980.
17. *E. I. Kleiman*. Varieties of inverse semigroups, 1981.
18. *O. M. Mamedov*. Equational compactness in general algebras and algebras with an order relation, 1982.
19. *V. V. Rasin*. Varieties of Clifford semigroups, 1982.
20. *M. V. Sapir*. Quasivarieties of semigroups, 1983.
21. *S. I. Katsman*. Semigroups with certain types of subsemigroup lattices, 1983.
22. *T. A. Martynova*. The groupoid of varieties of semigroups with zero, 1983.
23. *O. G. Kharlampovich*. Algorithmic and other combinatorial problems for groups and Lie algebras, 1984.
24. *V. B. Reprnitskii*. Varieties of lattice-ordered semigroups, 1985.
25. *I. O. Koryakov*. Periodic linear semigroups, 1985.
26. *E. A. Perminov*. Rigid graphs and lattices, 1985.
27. *B. V. Rozenblat*. On elementary and positive theories of relatively free semigroups, 1985.
28. *A. N. Petrov*. Embeddings of semigroups, and varieties, 1987.
29. *A. V. Kelarev*. Radicals and bands of semigroups and associative rings, 1989.
30. *B. M. Vernikov*. Varieties of associative rings and semigroups with restrictions on the subvariety lattice, 1989.
31. *O. V. Knyazev*. On the theory of varieties of Clifford semigroups, 1991.

Supervisor V. A. Baranskii:

1. *P. V. Shumyatsky*. Periodic groups with regular 2-groups of automorphisms, 1989.
2. *A. P. Zolotarev*. Helly, Radon, Carathéodory and Goldie numbers in lattices, 1993.
3. *M. I. Naumik*. Congruences and stable orders of the semigroup of linear relations, 1995.
4. *V. A. Shcherbakova*. The Steiner problem on a graduated directed graph, 1998.
5. *O. V. Rasin*. Polynomial algorithms of recognition of isomorphism in some classes of graphs, 2005.

Supervisor Yu. M. Vazhenin:

1. *S. V. Siziyy*. Quasivarieties of endomodels and algorithmic problems, 1990.
2. *B. Bayasgalan*. Decidable theories of related structures of semigroups, 1991.
3. *V. Yu. Popov*. Critical theories of varieties of rings, 1995.
4. *Yu. V. Nagrebetskaya*. Decidability of theories of the first order of matrix algebras and transformation groups, 2000.

Supervisor E. V. Sukhanov:

1. *A. A. Bulatov*. Algebraic properties of the lattice of clones, 1995.
2. *A. M. Shur*. Algebraic and combinatorial properties of equational languages, 1998.
3. *A. A. Krokhin*. Intervals in lattices of clones, 1998.
4. *K. L. Safin*. Ideals of iterative algebras, 2000.
5. *A. P. Semigrodskikh*. Lattices of closed classes of functions on an infinite set, 2003.
6. *A. V. Klepinin*. On algebraic and applied aspects of the problem of search of information, 2005.

Supervisor M. V. Volkov:

1. *D. S. Ananichev*. Identities in the lattices of varieties of solvable Lie rings, 1997.
2. *O. B. Finogenova (Paison)*. Indicatorial characterizations of certain properties of varieties of associative rings, 1998.
3. *I. A. Goldberg*. The finite basis problem for transformation semigroups, 2006.

Supervisor I. O. Koryakov:

1. *I. Yu. Zhil'tsov*. Pseudo-operations and pseudo-free semigroups, 1999.

Dissertations for Doctor Degree

For such dissertations, a person whose role is similar to that of a supervisor is called a scientific consultant. In cases 2–8 and 10, functions of the scientific consultant were effected by L. N. Shevrin, in case 9 they were effected by Yu. M. Vazhenin.

1. *L. N. Shevrin*. Lattice properties of semigroups, 1966.
2. *V. A. Baranskii*. Independence of related structures in classes of algebraic systems, 1987.
3. *O. G. Kharlampovich*. Word problem for groups and Lie algebras, 1990.
4. *Yu. M. Vazhenin*. Critical theories of the first order, 1992.
5. *L. M. Martynov*. Spectra of solvability for varieties of algebras, 1992.
6. *M. V. Volkov*. Identities in lattices of varieties of semigroups, 1994.
7. *D. A. Bredihin*. Identities and quasi-identities of relation algebras, 1997.
8. *V. B. Repritskii*. Representations of lattices by subalgebra lattices, 1997.
9. *V. Yu. Popov*. Algorithmic problems for varieties of semigroups, monoids, groups and rings, 2002.
10. *B. M. Vernikov*. Identities and quasi-identities in lattices of varieties of semigroups and congruences related to them, 2004.

Dissertations prepared under supervision of former members of the seminar

Several former members of the seminar now work in other towns, mostly abroad. Some of them trained their own students who defended dissertations. Here are the corresponding names:

L. M. Martynov (Omsk, Russia) was the supervisor of A. I. Kornev, 2001, D. V. Solomatin, 2006, T. Yu. Fink, 2006;

M. V. Sapir (Nashville, USA) was the supervisor of T. Jajcayova, 1997;

O. G. Kharlampovich (Montreal, Canada) was the supervisor of J. Bridson, 1998, S. Lioutikov, 1999, E. Lioutikova, 1999, and D. Chung, 2004;

A. V. Kelarev (Hobart, Australia) was the supervisor of J. Gazaran, 1998, and S. Quinn, 2002.

P. V. Shumyatsky (Brazilia, Brazil) was the supervisor of A. Tamarozzi, 2003, and S. Brazil, 2004.

Thus by 2007 there are in all 63 disciples in the “scientific tree” of the leader of the seminar; Tamarozzi and Brazil are the first of my scientific great-grandchildren. The number of members of this tree will definitely increase for the near months and years: there are fairly many post-graduated students at the Ural State University who are doing research under supervision of some older members of the seminar.

4. Grants

Subjects of our research are reflected also in grants we got from sources both national and international. Note that in Russia a system of scientific grants was established only since the beginning of the 1990s. I give below a list of grants got by some, as a rule, small groups of

investigators belonging to the seminar (approximately in chronological order within a one-type group of grants) and point out i) the structures that apportion grants, ii) the research subjects of grants, iii) the leaders, and iv) the years of supporting.

State Committee of Higher Education (later – Ministry of Education)

- Pseudovarieties of algebras: combinatorial-algebraic aspects, *the leader L. N. Shevrin*, 1994–1995.
- Pseudovarieties: algorithmic and structural-topological aspects, *the leader L. N. Shevrin*, 1996–1997.
- Combinatorial-algebraic properties of logical functions and formal languages, *the leader E. V. Sukhanov*, 1996–1997.
- Combinatorial-algebraic aspects of the theory of logical functions and formal languages, *the leader E. V. Sukhanov*, 1998–2000.
- New approaches in the theory of pseudovarieties of semigroups, *the leader L. N. Shevrin*, 1998–2000.
- Pseudovarieties of semigroups and their applications in computer science, *the leader L. N. Shevrin*, 2001–2002.
- Profinite methods in the theory of pseudovarieties and symbolic dynamics, *the leader L. N. Shevrin*, 2003–2004.
- Computational complexity of algorithmic problems, *the investigator V. Yu. Popov*, 2006.

International Science Foundation

- Semigroup varieties: their lattices and free objects, *the leader L. N. Shevrin*, 1994–1995.

INTAS⁵⁾

- Algebraic and logic models for computer science, *one of the investigators M. V. Volkov*, 1995–1996.
- Combinatorial and geometric theory of groups and semigroups and its applications to computer science, *the coordinator of the Russian part of the project M. V. Volkov*, 2000–2003.
- Universal algebra and lattice theory, *one of the investigators V. B. Repnitskii*, 2004–2006.

Ministry of Culture and Education of Hungary

- Semigroups and their classes, *one of the investigators M. V. Volkov*, 1997–2000.

Russian Foundation for Basic Research

- Idea of variety applied to finite and regular semigroups, *the leader L. N. Shevrin*, 1997–1999.
- Lattices of varieties of classical algebras, *the leader M. V. Volkov*, 2001–2003.
- Access control of information in computer systems, *the leader V. A. Baranskii*, 2003.
- Combinatorics of words and automata and its applications in computer science and bioinformatics, *the leader M. V. Volkov*, 2005–2007.
- Epigroups: structural and equational aspects, *the leader L. N. Shevrin*, 2006–2008.

The scientific program “Universities of Russia”

- Subsystems and congruences of algebraic systems, *the leader L. N. Shevrin*, 1994–1995.
- Lattices as related structures, *the leader L. N. Shevrin*, 1998–2000.
- Structural and combinatorial properties of algebraic systems, *the leader L. N. Shevrin*, 2002–2003.

⁵⁾ The International Association for the promotion of cooperation with scientists from the New Independent States of the former Soviet Union.

- Structural and combinatorial theory of algebraic systems and its applications, *the leader L. N. Shevrin*, 2004.

The Ministry program of a support of post-graduate students

- The isomorphism problem for graphs, and *dist*-decompositions, *O. V. Rasin (the supervisor V. A. Baranskii)*, 2003–2004.

- The finite basis problem for some semigroups of transformations, *I. A. Goldberg (the supervisor M. V. Volkov)*, 2004–2005.

Other projects of the Ministry of Education

- Combinatorial theory of varieties and pseudovarieties of semigroups, languages and automata and its applications in computer science and information security, *the leader L. N. Shevrin*, 2003–2005.

- A new generation of a scientific school on algebra and discrete mathematics, *the leader L. N. Shevrin*, 2005.

The President program of a support of leading scientific schools of the Russian Federation

- Investigations of classical algebraic systems and algebraic methods in computer science, *the leader L. N. Shevrin*, 2003–2005.

This grant, crowning the sequence of our grants, has marked activities of the whole collective joined by the seminar “Algebraic Systems”.

5. Publications

There are in all over 1500 publications by members of the seminar including more than 750 papers and more that 650 abstracts at various conferences⁶⁾. The number of abstracts shows that we were (and are) highly active participants of many conferences, see some information on this subject in section 6. As to the number of papers, here are some main summands of it: over 320 papers were published in principal Russian mathematical journals, over 200 in international journals or proceedings of international conferences, over 110 in “Mathematical Transactions” of the Ural State University (which were issued annually in the 1960s–1980s), over 60 in several encyclopedias as well as in a handbook.

It is reasonable to point out first of all our summarizing works. These are the survey articles [5]–[17] and the monographs [18], [19]. They are devoted to topics which particular attention was given to at the seminar, and where we made an appreciable (or, in some points, even a crucial) contribution. The works mentioned, except the papers [13], [14], are comprehensive and present in a systematical form achievements in these areas belonging not only to members of the seminar but also to many other authors from different countries⁷⁾. Two papers just mentioned give a survey of results in the theory of clones obtained by their authors (E. V. Sukhanov and his students) in the 1990s.

It may be added here that the first works on the theory of pseudovarieties accomplished in the seminar were presented in a special issue of the mentioned journal “Izvestiya VUZ. Matematika” entirely devoted to pseudovarieties, see its English version: Russian Mathematics. Iz. VUZ, 39, № 1, 1995. This issue contains papers by the following members of the seminar: M. V.

⁶⁾ These numbers are related to publications which appeared when their authors were regular participants of the seminar. As was already noted, some members of the seminar left Ekaterinburg in their time, so their further works are not taken into account in reviews of our publications that we do at the seminar from time to time and, respectively, these data are not reflected in the present article.

⁷⁾ Remark that the original versions of the articles [7] and [9] were written in Russian. Since the journal “Izvestiya VUZ. Matematika” where they were published is translated into English, I decided that it is worth to give here the coordinates of their English versions (although, as it may be noted, in those texts there are some mistakes made by the translators).

Volkov (two papers in co-authorship), I. Yu. Zhil'tsov, A. P. Zamyatin, I. O. Koryakov, O. B. Paison. The other papers were written by some foreign specialists invited (by the present writer as a member of the Editorial Board who was compiling this issue) to be contributors: J. Almeida and P. Weil (a joint paper), A. Azevedo, S. Margolis, J.-E. Pin.

Returning to reviewing survey works, I would like to note that my students A. V. Kelarev, O. G. Kharlampovich and M. V. Sapir, having left Ekaterinburg at the beginning of the 1990s, not only continue their active and successful research work but also have written several survey articles and books (partially in co-authorship) devoted to certain topical algebraic subjects. I mentioned here only those of their survey works which were written or begun in Ekaterinburg.

As to some topical trends concerning applications of an algebraic approach to computer science, which entered into a sphere of our interests at the very end of the 1990s, I would like to point out the recent survey [20], the first two authors of which (my scientific grandchildren) are former members of the seminar, and the second of them left Ekaterinburg only recently.

The next portion of publications being described is a good deal of works of encyclopedic character. This line was begun with the paper [21]. Later the present writer prepared a series of (41) papers on semigroups for the "Mathematical Encyclopedia" [22]. Note that this encyclopedia, published originally in Russian, received later a rather wide spreading, since English, Spanish and Chinese translations of it have appeared. A root paper "Semigroup" from the series mentioned was reprinted later in the "Mathematical Encyclopedic Dictionary" [23]. A large book chapter [24] of a reference monograph on general algebra gives a comprehensive and detailed picture of semigroup theory (including applications to the theories of formal languages, automata and codes) existed by the beginning of the 1990s.

Later I made a contribution to the handbook [4] by preparing 9 sections for Chapter "Semigroups" and 2 sections for Chapter "Universal Algebra". These are the following sections: *Ideals and Green's Relations*, *Bands of Semigroups*, *Free Semigroups*, *Simple Semigroups*, *Epigroups*, *Periodic Semigroups*, *Subsemigroup Lattices* (with A. J. Ovsyannikov), *Varieties of Semigroups* (with M. V. Volkov), *Applications of Semigroups* (with G. F. Pilz and P. G. Trotter), *Free Algebras* (with E. V. Sukhanov), *Varieties and Quasivarieties* (with M. V. Volkov).

For the encyclopedia [25] we prepared 11 papers: *Code*, *Finite Automaton*, *Pushdown Automaton*, *Variety of Rational Languages*, *Rational Language*, *Syntactic Monoid* (all by I. O. Koryakov), *Formal Grammar* (by I. O. Koryakov and A. P. Zamyatin), *Formal Language* (by I. O. Koryakov and L. N. Shevrin), *Pseudovariety of Universal Algebras* (by M. V. Volkov and L. N. Shevrin), *Asynchronous Automaton*, and *Trace Theory* (by M. V. Volkov).

Certain attention was given also to scientific-popular papers devoted to some interesting algebraic topics. The first experience in this direction was my paper "*On periodic and locally finite groups and semigroups*" (1979) published in a pamphlet "Methodical Recommendations and Instructions on Specialization" addressed to students-mathematicians of the Ural State University. Later I published three papers in the "Soros Educational Journal": *Identities in algebra* (1996), *What a semigroup is* (1997), *How groups appear when examining semigroups* (1997). The first of them has been reprinted in volume 3 of the encyclopedia [26] prepared by the International Soros Science Education Program. M. V. Volkov has written a paper "*The finite basis problem for identities*" (1997) published in a journal for schoolchildren "MIF" (an abbreviation derived from Russian "Matematika i Fizika" – Mathematics and Physics) issued by a special school attached to the Ural State University; I mentioned this important problem in Section 2.

All senior members of the seminar are university teachers, so some of them succeeded in writing teaching books for students. The most activity in this affair was displayed by V. A. Baranskii, A. J. Ovsyannikov, S. V. Siziyy, Yu. M. Vazhenin, B. M. Vernikov, A. P. Zamyatin. There are over 50 teaching books and methodical brochures for students written by members of the seminar. They concern diverse subjects pertaining to both general and special courses: linear

algebra, general algebra, geometry, theory of numbers, mathematical logic, theory of algorithms, theory of graphs, theory of varieties, etc. I shall not give a list of such books and mention only four notable samples of them. The book [27] gives a good contemporary exposition of basic topics in the theory of graphs as well as presents a detailed discussion of combinatorial algorithms solving optimization problems that arise frequently in applications. The book [28] (having joined especially many contributors from the seminar) covers all the basic subjects of the corresponding courses and provides a rich choice of problems of different levels. The books [29] and [30] giving fundamentals of the corresponding mathematical disciplines are characterized by a number of interesting peculiarities, in particular, by a lively style of presentation.

Another line of our activities concerns school mathematics. There are over 20 books and brochures for schoolchildren written by members of the seminar. Apparently the most notable work in this field is a book “*Mathematics 5–6. Textbook-Interlocutor*” by L. N. Shevrin, A. G. Gein, I. O. Koryakov, M. V. Volkov. It was published in 1989 (its manuscript was awarded at the All-Union Competition in 1987), subsequently separate editions of “*Mathematics 5*” and “*Mathematics 6*”, that is, textbooks for the 5th and the 6th class, respectively, appeared in 1992–2004: four editions in Russian, one edition in Belorussian, further, two editions of the “*Working Copy-Books*” attached to these textbooks as well as one edition of a book of methodical recommendations “*Mathematics 5. Book for Teacher*”. So there is, as it is customary to speak, a teaching-methodical complete set consisting of the books mentioned; the work on further modifications of this set is currently continuing⁸⁾.

One more line of our scientific publications concerns Russian translations of several books by foreign authors. These are the books [31]–[35]. This choice is explained by both our mathematical interests and a role of these books in the corresponding fields of science. The monograph [31], being, as already was mentioned in Section 2, one of the pioneering monographs on semigroup theory, is a classical work in this field of algebra, so it was very important to have this monograph in Russian. Importance of the book [32] (whose English version was published in 1979) is caused by the fact that this was practically the first summarizing work treating applications of semigroups to the theories of automata, formal languages and codes in a consecutive and fundamental manner; by the way, it did not lose its significance up to now. The book [33] (whose first edition in English appeared in 1984) is one of the first teaching books treating diverse applications of general algebra. (Note that monographs [31] and [32] combine traits inherent in both a reference book and a teaching book, and, for instance, at the Ural State University we used them in teaching for lecture courses and special seminars.) The book [34] (appeared in English in 1998) is the first monograph devoted to DNA computing, it opens quite a new trend on a junction of computer science and molecular biology. The book [35] devoted to very actual area is a professional and interactive tutorial.

6. Participation in conferences

As it follows from a remark at the beginning of Section 5, members of the seminar took part in numerous (definitely over 200) conferences, symposia, workshops, schools, etc. It is worth first of all mentioning among them All-Union Algebraic Conferences which were the most considerable meetings of Soviet algebraists. They were held regularly till 1991 in different algebraic centers of the USSR and gathered up to several hundreds participants. I mentioned the first three such conferences in Section 1. Members of the seminar began to take part in All-Union Conferences from the 8th one, which took place in 1967. As to the leader of the seminar, I participated in all the

⁸⁾ I may add that literary activities of the present writer in mathematics included also three teaching-belletristic books (joint with V. G. Zhitomirskii) addressed to little children: *Geometry for Kids*, *Mathematical ABC*, *Travels in Geometry Land*. These books had in all 38 editions in 21 languages.

preceding conferences as well. Perhaps it is not without interest for the reader to learn a list of all these conferences.

Here is such a list: I – 1958, Moscow; II – 1959, Moscow; III – 1960, Sverdlovsk; IV – 1962, Kiev; V – 1963, Novosibirsk; VI – 1964, Minsk; VII – 1965, Kishinev; VIII – 1967, Riga; IX – 1968, Gomel; X – 1969, Novosibirsk; XI – 1971, Kishinev; XII – 1973, Sverdlovsk; XIII – 1975, Gomel; XIV – 1977, Novosibirsk; XV – 1979, Krasnoyarsk; XVI – 1981, Leningrad; XVII – 1983, Minsk; XVIII – 1985, Kishinev; XIX – 1987, Lvov; XX – 1989, Novosibirsk; XXI – 1991, Barnaul. It should be noted that the last two conferences were in fact international; the 20th one was dedicated to the 80th birthday of academician A. I. Mal'cev (1909–1967), the 21st one was dedicated to the 70th birthday of corresponding member of the Academy of Sciences of USSR A. I. Shirshov (1921–1981).

There were very many other international conferences, both in Russia and foreign countries, which members of the seminar participated in. The leader of the seminar began to participate in conferences abroad in 1967. It was 1981 when I for the first time came to such a conference together with several of my students (V. A. Baranskii, L. M. Martynov, E. V. Sukhanov, A. N. Trakhtman, Yu. M. Vazhenin), it happened at the International Conference on Semigroup Theory in Szeged. Since that time my disciples took part with increasing activity in various mathematical meetings abroad, and members of the seminar visited on this occasion the following countries (many of them repeatedly): Australia, Austria, Bulgaria, Canada, Czechoslovakia (since the beginning of the 1990s – separately Czech Republic and Slovakia), Finland, France, Germany, Great Britain, Hong Kong, Hungary, Ireland, Israel, Italy, Japan, Mexico, Poland, Portugal, USA. Such a list can be somewhat extended if one takes into account conferences attended by former members of the seminar who now work abroad.

Obviously it would not be reasonable to give here a list of all conferences with our participation. I remark only that for some time past the seminar was annually represented at least at 9–10 international conferences, and as an illustration I give the corresponding data for 2003. The titles of the majority of these conferences show also some components of the spectrum of our current research.

7th International Conference “Developments in Language Theory”, Szeged, Hungary, – a speaker D. S. Ananichev;

International Conference “Lattices, Universal Algebra and Applications”, Lisbon, Portugal, *18th IEEE Symposium on Logic in Computer Science*, Ottawa, Canada, *18th International Joint Conference on Artificial Intelligence*, Acapulco, Mexico, *International Seminar “Graph Coloring”*, Castle Dagstuhl, Germany, *44th Annual IEEE Symposium on Foundations of Computer Science*, Cambridge, USA, – a speaker A. A. Bulatov;

International Conference “Kolmogorov and Contemporary Mathematics”, Moscow, Russia, – a speaker M. V. Volkov;

International meeting on Semigroups and Related Topics, Braga, Portugal, – a member of the Program Committee M. V. Volkov;

Euresco Conference “Symmetries and Ordered Structures under the Influence of Model Theory and Combinatorics”, Hattingen, Germany, – an invited speaker M. V. Volkov;

IV International Conference on Words, Turku, Finland, – an invited speaker M. V. Volkov, speakers D. S. Ananichev, A. M. Shur;

NATO Advanced Study Institute on Structural Theory of Automata, Semigroups, and Universal Algebra, Montreal, Canada, – invited lecturers L. N. Shevrin, M. V. Volkov and a former member of our seminar A. A. Krokhin, a speaker A. P. Semigrodskii, among the listeners there were I. A. Goldberg, S. V. Pleshcheva, B. M. Vernikov;

International Conference “Mal'cev Readings”, Novosibirsk, Russia, – an invited speaker L. N. Shevrin, speakers E. V. Sukhanov, B. M. Vernikov.

Thus representatives of the seminar “Algebraic Systems” participated in 12 international conferences in 2003. One can give similar indices in this matter for the next three years: 10 international conferences in 2004, 9 international conferences in 2005, 12 international conferences

in 2006. I may note also that besides international conferences almost every year there are conferences of All-Russian or regional status attended by some members of the seminar.

7. Scientific-organizing activities

The subject of this section is divided into two parts: organization of conferences, membership in different editorial boards. In each of these areas there are quite a number examples of our activity.

Organization of conferences

The seminar was involved (in full or in part) in organization of several algebraic conferences. For instance, a principal role was played by it in the organization of all three All-Union Symposia on Semigroup Theory held in Sverdlovsk by the Ural State University (1969, 1978, 1988); in particular, the leader of the seminar was the Chairman of the Organizing Committees of these symposia. We also held the Regional Conference of Young Scientists “Algorithms, Automata, and Semigroups” in Sverdlovsk (1982). Further, the enlarged 500th meeting of our seminar (1985) may be regarded as a conference, see details in Section 8.

Some members of the seminar took part in the organization of the XII All-Union Algebraic Conference held in Sverdlovsk (1973) as well as two International Conferences on Semigroups held in St Petersburg (1995, 1999), the Ural State University was a co-organizer of these conferences. The first of the conferences in St Petersburg was dedicated to the 80th birthday of E. S. Ljapin (1914–2005), the latter one was also held in honour of Ljapin.

The most considerable algebraic meeting held in Ekaterinburg was the International Algebraic Conference dedicated to the centenary of the birthday of P. G. Kontorovich and to the 70th birthday of the present writer. This conference was organized by the Ural State University and the Institute of Mathematics and Mechanics of the Ural Branch of the Russian Academy of Sciences and took place from August 29 to September 3, 2005. The Organizing Committee headed by the Rector of the University, V. E. Tretjakov, and the Director of the Institute, V. I. Berdyshev, included among the others several members of the seminar: V. A. Baranskii (Vice-Chairman), V. Yu. Popov, V. B. Repnitskii, E. V. Sukhanov, M. V. Volkov (Secretary). The whole seminar (with the exception of its leader who because of a natural reason was free of any organizing duties that time) was attached to the Organizing Committee for effecting a lot of tasks usually arising in such arrangements. The Program Committee consisted of 20 major algebraists from Russia (9 members), USA (3 members), Germany (2 members), Austria, Belorussia, Canada, Great Britain, Hungary, and Israel (by 1 member each). The seminar was represented in the Program Committee by V. A. Baranskii as one of the Co-Chairmen as well as by two former members of it: O. G. Kharlampovich and M. V. Sapir.

The conference gathered about two hundred participants from 23 countries. There were the following five sections: *Groups, Semigroups, Rings, Universal Algebras and Lattices, Applications*. 21 plenary lectures, 15 section lectures and 93 contributed talks at the sections were given. It is interesting to note that the seminar “Algebraic Systems” celebrated a certain jubilee at the conference: one of the plenary sessions was joint just with the 1000th meeting of our seminar; see the program of this meeting in Section 8.

It should be also noted that some members of the seminar were included in the organizing or program committees of many other conferences, both in Soviet Union (or Russia) and abroad. This concerns first of all the present writer who took part in such committees from the middle of the 1960s. For the last decade this kind of activities is rather typical for M. V. Volkov as well. I mention also V. A. Baranskii who for last years participated in the organization of several conferences, both All-Russian and regional, devoted to topics of information security.

Membership in editorial boards

Since 1972 the leader of the seminar has been on the Editorial Board of the journal “Izvestiya VUZ. Matematika”. This journal, which was mentioned above several times, is one of the principal Russian (before 1992 – All-Union) mathematical journals. It was 1976 when I was invited to enter the Editorial Board of “Semigroup Forum”, which is an international journal on the theory of semigroups printed in USA. In 1979–1988 I was a member of the Editorial Board of “Simon Stevin”, an international journal printed in Belgium. The current Editorial Board of “Semigroup Forum” contains two representatives of Russia, and both of them are members of our seminar (the present writer and M. V. Volkov who was invited in 1998 and became one of the Executive Editors in 2003).

Now I mention periodical editions on mathematics published by the Ural State University. This is first of all “Mathematical Transactions” also mentioned above. After P. G. Kontorovich who was the first Editor-in-Chief since the beginning of the 1960s, the present writer effected the same functions in 1969–1989. Since 1982 the Editorial Board of these “Transactions” was supplemented by M. V. Volkov, since 1987 it was supplemented by I. O. Koryakov. After a ten-year break, printing periodical mathematical editions at our University was resumed with the journal “Proceedings of the Ural State University. Mathematics and Mechanics”. I became the Vice-Editor-in-Chief and M. V. Volkov became the Secretary of the Editorial Board of this series of “Proceedings”. In 2006 a new series of “Proceedings” was founded – “Proceedings of the Ural State University. Computer Science and Computer Technologies”, three (of six) members of its Editorial Board are members of our seminar: V. A. Baranskii, M. V. Volkov and A. M. Shur (Secretary).

There were several single editions that had the editorial boards entirely consisted of members of the seminar. This concerns mainly the materials of three All-Union Symposia on Semigroup Theory mentioned above. For each of these symposia we prepared a collection of abstracts of talks at this symposium. Here are the Editorial Boards for these collections, everywhere with L. N. Shevrin as the Editor-in-Chief: for the 1st Symposium – E. A. Golubov, L. N. Shevrin, Yu. M. Vazhenin; for the 2nd Symposium – V. A. Baranskii, E. A. Golubov, L. N. Shevrin, Yu. M. Vazhenin, A. P. Zamyatin; for the 3rd Symposium – V. A. Baranskii, E. A. Golubov, L. N. Shevrin, E. V. Sukhanov, Yu. M. Vazhenin, M. V. Volkov, A. P. Zamyatin. At the 2nd Symposium it was printed also a separate pamphlet with abstracts of plenary lectures (edited by L. N. Shevrin).

Another our useful edition was closely connected with the symposia mentioned. After each of them we prepared a collection of unsolved problems of semigroup theory. Some of these problems were posed directly at the symposium, mostly at a special session devoted to open problems; some problems were sent by their authors later, among such authors there were not only those ones who attended the symposium. (For the first collection a part of problems was taken also from a notebook started in 1965 by the present writer who proposed personally some semigroupists to write down open problems in this notebook for a subsequent publication somewhere.) This collection was entitled “Sverdlovsk Tetrad” (“tetrad” in Russian means “notebook”) and published as a pamphlet which afterwards was distributed among algebraists interested in semigroup theory. So there were three editions of “Sverdlovsk Tetrad” (1969, 1979, 1989). Here are the Editorial Boards of these editions, with the same Editor-in-Chief as for the collections of abstracts at the symposia: for the 1st edition – L. N. Shevrin, Yu. M. Vazhenin; for the 2nd edition – V. A. Baranskii, E. A. Golubov, L. N. Shevrin, Yu. M. Vazhenin; for the 3rd edition – V. A. Baranskii, E. A. Golubov, L. N. Shevrin, M. V. Volkov. There is English translation of the 1st edition, which was revised by omitting some of the problems (as a rule, those which were solved by that time), see [36]. In each of the subsequent editions there was a special section with comments concerning problems from the previous edition(s) that had been (completely or partially) solved by that time.

The Editorial Board of the collection of abstracts at the International Algebraic Conference held in Ekaterinburg in 2005 consisted of four persons, two of which are members of our seminar: A. J. Ovsyannikov and B. M. Vernikov (Editor-in-Chief).

Lastly, I would like to add that some former members of the seminar working abroad were invited to enter the editorial boards of several journals: O. G. Kharlampovich – in “International Journal of Algebra and Computation”, since 1997; A. A. Krokhin – in “Multiple-Valued Logic”, 1999–2002; M. V. Sapir – in "Algebra Universalis", 1999–2004, "International Journal of Algebra and Computation", since 2000, "Algebra and Discrete Mathematics", since 2003, as well as "Algebra and Combinatorics" (book series), since 2001.

8. Meetings and speakers

The first meeting of the seminar took place on November 2, 1966; so the 40th anniversary of our work was celebrated in November 2006. Usually we hold 25–27 meetings per year, and by this anniversary 1032 meetings of the seminar took place. At each meeting we, as a rule, hear and discuss one talk of duration about 2 hours, sometimes there may be shorter talks or reports. Since the end of 1960s, along with proper members of the seminar, other speakers from our town or from other towns give their talks at the seminar more or less regularly.

There is a diary of the seminar which is kept by the secretary of the seminar. I should mention Yu. M. Vazhenin (1945–2003) who was the permanent secretary from the very beginning of our work up to his last days. The current secretary is V. Yu. Popov. From the diary we can derive statistics we would like to know. In particular, by 2007 at the seminar there were over 1200 talks and reports given by 97 speakers from Ekaterinburg (Sverdlovsk) and over 250 talks given by 155 speakers from other 46 towns of the former Soviet Union and from 22 towns of the following countries: Australia, Austria, Canada, China, Czech Republic, France, Germany, Great Britain, Hungary, Mongolia, Poland, Portugal, Spain, USA. (I remark that several speakers represented different towns in different years.) Each hundredth meeting has a special program: we sum up some statistics, discuss both certain results of the period passed and possible prospects of research for forthcoming years. Four meetings of the seminar were enlarged, information about them is given in the next lines.

The 300th meeting took place on June 30, 1978, just after the 2nd All-Union Symposium on Semigroup Theory, and many participants of that symposium attended this meeting.

The 415th meeting took place on June 30, 1982, and it was joint with a session of the Regional Conference “Algorithms, Automata, and Semigroups” mentioned in section 7.

The 500th meeting was especially considerable: nominally one meeting, in reality it was divided into five long sessions held during three days – from January 31 to February 2, 1985. This meeting in essence turned into a peculiar All-Union conference, it gathered over 90 participants from 20 towns of the Soviet Union and had 38 speakers.

The 1000th meeting took place on September 1, 2005, and was continuing the whole day. As was mentioned in Section 7, it was joint with one of the plenary sessions of the International Algebraic Conference, so it gathered over 150 algebraists from many countries. Here is the program of this jubilee meeting.

L. N. Shevrin (Ekaterinburg), *The seminar «Algebraic Systems» by the 1000th meeting.*

O. G. Kharlampovich (Montreal), *Decidability of the elementary theory of the free group.*

V. Yu. Popov (Ekaterinburg), *Status and diameter of semigroups.*

A. A. Bulatov (Vancouver), *Local methods in CSPs.*

L. Márki (Budapest), *Universal aspects of general radical theory.*

F. Pastijn (Milwaukee), *The lattice of varieties of idempotent semirings.*

A. M. Shur (Ekaterinburg), *On complexity of formal languages.*

R. Pöschel (Dresden), *Completeness and rigidity for operations and relations.*

As the reader can see, among the speakers at this meeting, besides the leader of the seminar, there were two of its current members and two former members who came from Montreal and Vancouver. The other speakers belong to the group of our foreign colleagues who visited us before

and gave their talks at the seminar in different years. For instance, L. Márki was just the first foreign speaker at our seminar and first gave his talk at the seminar in 1989.

9. Concluding remarks

Viability of a scientific collective for a long time and its stability depend on many factors. Not discussing this theme here, I want only to remark that one of such factors is more or less regular replenishment of the corresponding group with younger researches. Applied to the seminar under discussion, it was a matter of my permanent care. And there are reasons to be satisfied that several of my “scientific children” now continue this line and successfully train some representatives of a further generation for research work; a confirmation of this assertion can be seen in Section 3 and in some lines of Section 4. This is promoted, in particular, by means of organization of certain “subseminars”. More than 10 years ago, V. A. Baranskii, Yu. M. Vazhenin and E. V. Sukhanov organized their seminars, respectively, on combinatorics, algorithmic problems of algebra, and discrete mathematics. For the last few years V. A. Baranskii has led the seminar “Algorithms and Structures of Data”. Recently M. V. Volkov and D. S. Ananichev organized the seminar “Computer Science”. Quite recently V. Yu. Popov organized the seminar “Artificial Intelligence”.

Now in the seminar “Algebraic Systems” three generations are represented, and there are some prerequisites for appearance of the next generation in coming years. One may hope that participants of the seminar will successfully continue their investigations both in directions that have become traditional for the seminar and in new directions being assimilated at present.

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