International Conference
"Geometry, Topology, and Applications"

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The International Conference on "Geometry, Topology, and Applications", dedicated to the upcoming 70th birthday of Nikolai Dolbilin, was organized by the International Delaunay Laboratory on Discrete and Computational Geometry and took place in September 23–27, 2013, at the P.G. Demidov Yaroslavl State University. This note highlights the main results presented at the conference and underlines the role of such meetings in the development of the field of Discrete and Computational Geometry in Russia.

The article is published in the author's wording.

Discrete Geometry in Russia

The Russian schools of geometry and topology are recognized worldwide for their academic leadership and the wealth and significance of their results in the fields. In spite of this leadership role, the gap between pure mathematical investigations and their commercial exploitation has remained. Closing this gap was among the goals of the Government of the Russian Federation, when it decided to support the creation of a laboratory of a new Discrete and Computational Geometry. This field is a fast developing branch of modern mathematics, with applications in many areas, ranging from entertainment to

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manufacturing, and from medicine to facility planning. It becomes even more important in the new century, which is centered around innovation and technology. The laboratory was conceived as a world-class center, and was headed by Herbert Edelsbrunner, one of the foremost experts in the area, who combines scientific leadership with experience in commercial applications. In 2011, the International Delaunay Laboratory on Discrete and Computational Geometry was established at the Demidov State University in Yaroslavl.

One of the fundamental principles of the Laboratory is the development of interactions between mathematics, computation, and applications. To mention an example, the Laboratory promotes and develops persistent homology, a branch of Computational Topology that originates in a paper by H. Edelsbrunner, D. Letscher and A. Zomorodian [1]. Being based on ideas of Morse Theory (a classic field in Mathematics), persistent homology addresses the question of topological significance of data, and provides a method to separate noise from features. While the method is primarily algebraic, it has fast algorithms with effective implementations which give detailed mathematical analysis of large datasets in a matter of seconds or minutes. The results of these analysis are used in disciplines that include astrophysics, medicine, cartography, and data visualization.

At the Laboratory, a group of well-known specialists from Russia (Lomonosov Moscow State University, Steklov Mathematical Institute, Moscow Institute of Physics and Technology, Yaroslavl State University), Austria (Institute of Science and Technology Austria in Vienna), and the USA (University of Texas in Brownsville), join forces to pursue common research and to popularize Discrete and Computational Geometry. The organization of international conferences on theoretical and practical topics related to the research program is an important element of their activities. The first Yaroslavl International Conference on Discrete Geometry, held in August 2012, was dedicated to a student of B. N. Delaunay, the academician A. D. Alexandrov, one of the originators of modern Discrete Geometry, whose centenary was celebrated in 2012. In 2013, the Laboratory organized the International Conference on "Geometry, Topology, and Applications" dedicated to the upcoming 70th birthday of Nikolai Dolbilin, another outstanding student of B. N. Delaunay.

A Few Words About Nikolai Dolbilin

Nikolai Petrovich Dolbilin was born on December 19, 1943, in Simferopol, Crimea, USSR. Both parents, his father Petr Andrianovich and his mother Raisa Petrovna, worked in civil engineering. Later, the Dolbilin family moved to the Irkutsk region in the Far East.

In 1960, Nikolai finished high school in Angarsk, Irkutsk region, and joined the Faculty of Mechanics and Mathematics of Moscow State University. In 1965, he graduated from the University, and in March 1966, he became a Ph.D. student at the Steklov Mathematical Institute. Dolbilin's adviser was the head of the Geometry Department of Steklov Institute, the outstanding mathematician Boris Delaunay, who invited him to the magnificent world of Discrete Geometry. Nikolai Dolbilin defended his Candidate of Sciences dissertation "On regular Dirichlet tilings of a sphere" in June, 1972. A few years earlier, in March 1969, he became a fellow of the Geometry Department at the Steklov Mathematical Institute.

The early work of Nikolai Dolbilin was dedicated to geometric properties of lattices. His very first paper – "A new construction in the theory of lattice coverings of an n-dimensional space by equal spheres" – jointly written with Boris Delaunay, Sergey Ryshkov, and Mikhail Shtogrin, gave deep insights in the geometric theory of positive quadratic forms. During the second half of the 70s, Dolbilin started to develop new topics in his research: the theory of tilings, and the theory of periodic structures. Starting from "A local test for the regularity of a system of points", written jointly with Boris Delaunay, Ravil Galiulin and Mikhail Shtogrin in 1976, and "Combinatorial and metric theory of planigons", written with Boris Delaunay and Mikhail Shtogrin, this work resulted in the famous Local Theorem, which establishes local conditions that are necessary and sufficient for a tiling to be crystallographic. This theorem allows us to recognize the periodicity of a tiling knowing its local structure only.

A recent photo of Nikolai Petrovich Dolbilin

Based on a long and deep study of periodic and non-periodic sets and tilings, Nikolai Dolbilin defended his Doctorate Dissertation on "Regular and aperiodic structures in space of a constant curvature" in April 2001. It includes many important mathematical achievements, including Dolbilin's Local Theorem and Dolbilin's Extension Theorem.

Dolbilin is a person of many talents. Beside his strong research, Nikolai Dolbilin plays an important role in mathematical education in Russia. Since the 1980s, he is the Secretary of the Mathematical Education Commission of the Russian Academy of Sciences. Several times, he was a member of the Program Committee and an invited speaker of the International Congress on Mathematical Education. In addition, he worked in the famous Kolmogorov school from 1993 to 97. Since 1998, Nikolai Dolbilin works at Faculty of Mechanics and Mathematics of Moscow State University.

Since the middle 1980s, Nikolai Dolbilin is a vice-editor of the "Kvant" ("Quantum") journal, which targets a broad audience, namely everybody interested in mathematics and physics. He wrote several brilliant articles for this journal and also published a related book "Pearls of the polytopes theory". These works popularize science and invite everybody – from high-school student to academician – to the world of Discrete Geometry. With the help of Nikolai, many students found their way into the fantastic world

of Discrete Geometry and now continue Nikolai's research or find their own problems in this rich field of mathematics.

Today, Nikolai Dolbilin is an active mathematician and expert in mathematical education. He still works at the Steklov Institute and advises several Ph.D. students. Since 2011, he works in the Delaunay Laboratory of Discrete and Computational Geometry at the Yaroslavl State University. Indeed, he is among the few who inspired the foundation of the Laboratory at that University. The conference, organized in Yaroslavl and dedicated to his 70th birthday, attracted many his close friends, colleagues and co-authors from all over the world.

The Organization

The Program Committee consisted of members of the Delaunay Laboratory as well as other leading specialists in Discrete and Computational Geometry: H. Edelsbrunner (Chair), V. Buchstaber, V. Dolnikov, S. Glyzin, A. Ivanov, O. Musin, S. Novikov, E. Shchepin, and M. Shtogrin. The Local Organizing Committee took on the responsibility for planning and scheduling the meeting. The Chair, M. Nevskii, and the members, A. Garber, D. Glyzin, A. Maksimenko, E. Nevskaya, A. Nikolaev, P. Parfenov, I. Preobrazhenskii, A. Ukhalov, and O. Yakimova did an excellent job laying the foundations for the success of the conference, which also benefited from the assistance of post graduate students and staff from the Yaroslavl State University. The Conference was funded by the Government of the Russian Federation, under Grant 220, Contract 11.G34.31.0053.

The Program

The international program committee strived to cover topics in pure as well as in applied areas of modern Geometry and Topology, focusing at the activities of the Laboratory and also taking into account scientific interests of Nikolai Dolbilin. As a result, the conference represented contributions from a wide range of areas, which we now categorize and list. The **Theory of Polyhedra** is a classic branch of Discrete Geometry, going back to ancient Greek science. L. Euler, A. Cauchy, H. Minkowski, B. Delaunay, and A. Alexandrov contributed much to this field. Today, the theory of polyhedra attracts the interest of many specialists, not only because of the beauty and the depth of the results, but also because of applications in computer science, biology, and medicine. The talks in this area presented at the conference are:

- Peter Gruber, *Normal Bundles of Convex Bodies*;

- Idzhad Sabitov, *On an Approach to the Calculation of Volumes in Spaces of Constant Curvature*;

- Andrey Vesnin, *From Right-Angled Hyperbolic Polyhedra to Groups and Manifolds*;

- Egon Schulte, *Polyhedral Geometries and Graphs for Crystallographic Groups*;

- Alexander Gaifullin, *Flexible Polyhedra and Places of Fields*;

- Nikolai Erokhovets, *Buchstaber Invariants and Matroids*;

- Arseniy Akopyan, *On the Euler Line in Polytopes*;

- Alexey Tarasov, *Edge Unfoldings of an Acute-Angle Polyhedral Surface*;

- Mikhail Shtogrin, *Flexible Surfaces with Active Handles*;

- Vitalii Makarov and Florin Damian, *Star Complexes over Regular Maps*;

- Nikita Netsvetaev, *Universally Inscribed Polyhedra and Equipartitioning by Convex Fans*;

- Mikhail Nevskii, *On a Longest Segment of Given Direction in a Simplex*.

Questions about **Geometric Arrangements** include problems on packings, tilings, lattices, coverings, and crossings. They belong to classic topics of Discrete Geometry and go back to works of I. Newton and D. Gregory, J. Kepler and C. Gauss. Related questions were investigated in the Russian school by G. Voronoï, B. Delaunay, and A. Alexandrov. Problems of this kind arising naturally and are simple to formulate, but they are often exceedingly difficult and deep while having important applications in coding theory, logistics, design, and other areas. The field attracts the interest of many specialists all over the world. The talks within this area presented at the conference are:

- Andrey Raigorodskii, *Graphs of Diameters*;

- Kàroly Böröczky, *Full Contact Packings of Unit Balls in the Euclidean 3-Space*;

- Marjorie Senechal, *What's New in the Aperiodic Zoo?*;

- Yoshiaki Itoh, *Random Sequential Packing of Cubes*;

- Masaharu Tanemura, *On the Areal Random Packing*;

- Eiichi Bannai, *On Tight Relative t-Designs*;

- Oleg Musin, *Functionals on Triangulations of Delaunay Sets*;

- Roman Karasev, *Suborbits in Knaster's Problem*;

- Robert Erdahl, *Parity Centers and Commensurate Lattice Polytopes for Parallelohedra*;

- Dirk Frettlöh, *Tilings with Tiles in Infinitely Many Orientations*;

- Alexey Garber, *Voronoï Conjecture on Parallelohedra for New Special Case*;

- Viacheslav Grishukhin, *Some Properties of Standard Faces of a Parallelotope*;

- Ekaterina Kolomeykina, *On the Number of a Lattice Plane Tilings by a Given Area Polyominoes*.

The **Geometry of Differential Equations** is an important branch of modern mathematics, proving its effectivity and significance in the qualitative analysis of dynamical systems. It goes back to works of H. Poincaré, and the list of contributors includes D. Anosov, V. Arnol'd, A. Fomenko, A. Katok, V. Kozlov, V. Maslov, M. Morse, S. Novikov, J. Palis, I. Petrovskii, T. Ratiu, S. Smale, H. Zieschang, and others. The talks within this area presented at the conference are:

- Iskander Taimanov, *Transformations of Surfaces and Their Applications to Spectral Theory*;

- Sergey Glyzin, *Multimode Diffusion Chaos in Reaction-Diffusion Boundary Problem in the Dumbbell Domain*;

- Pavel Bibikov, *Spherization of 2-Jet Space $J^2(\mathbb{R}^n)$ and Contact Classification of Second Order Differential Equations*;

- Evgeniy Timofeev, *Algorithm for Efficient Entropy Estimation,*

- Pavel Nesterov, *Geometry of Parametric Resonances in Adiabatic Oscillations.*

Recently **Computational Topology** has became popular in Russia, in particular through the efforts at the Delaunay Laboratory. We list the talks in this category together with contributions to other **Geometrical Applications**. The talks within these areas presented at the conference are:

- Sergey Krivovichev, *Local Approach and Self-Assembly Modes in Modern Crystallography*;

- Mikhail Machin, *Segmentation of Clinical Endoscopic Images Based on Classification of Geometrical Features*;

- Alexey Ukhalov, *A Topology Preserving Algorithm for Cartographic Generalization*;

- Mikhail Belkin, *Differential Geometric Aspects of Machine Learning and Data Analysis*;

- Brittany Terese Fasy, *Statistical Inference for Persistent Homology*;

- Dmitriy Morozov, *Witnessed k-Distance.*

Combinatorial Methods are of great importance in modern Geometry. Indeed, many natural problems in Geometry lead to extensive enumerations of structures, and geometric and topological approaches to questions often have non-trivial combinatorial interpretations. The talks within this area presented at the conference are:

- Luis Montejano, *When is a Disk Trapped by Four Lines?*;

- Gaiane Panina, *Moduli Space of Planar Polygonal Linkage: a Combinatorial Description*;

- Yaokun Wu, *Combinatorics of the Lit-Only σ-Game*;

- Nikolay Mnëv, *Combinatorics of Circle Bundles*;

- Oleg German, *Oppenheim and Littlewood Conjectures from the Point of View of Multidimensional Continued Fractions*;

- Svetlana Yablokova, *On Homology Groups of One CW-space*;

- Georgy Sharygin, *Characteristic Classes of Combinatorial Bundles and higher Reidemeister Torsion*;

- Andrey Nikolaev, *On Graphs of the Cone Decompositions for the Min-Cut and Max-Cut Problems with Nonnegative Edges*;

- Mikhail Gorsky, *Geometry and Combinatorics of Subword Complexes and Dual Polytopes*.

Concluding Remarks

The five days of the conference featured twenty plenary talks of 35 minutes each, and twenty-five sectional talks of 25 minutes each, with a total of about fifty participants from ten countries. The conference brought together world-leading experts in Geometry, Topology and Applications. They presented results on the state of the art and recent progress in their field. The book of abstracts has been already published [2], and a volume containing a subset of the presented papers is in preparation [3].

This is the the second such representative international conference in Russia in the last two years devoted primarily to Discrete and Combinatorial Geometry and to Computational Topology. Both remarkable scientific events enforce the interest in the subject and attract young mathematicians to the field. We note that both conferences were organized by the International Delaunay Laboratory. We hope that such conferences, in Yaroslavl or in other places within Russia, will become a long-lasting tradition.

References

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Международная конференция "Геометрия, топология и приложения"

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Международная конференция "Геометрия, топология и приложения", посвященная приближающемуся семидесятилетию Николая Петровича Долбилина, была организована Международной лабораторией имени Б. Делоне "Дискретная и вычислительная геометрия" и прошла с 23 по 27 сентября 2013 года в Ярославском государственном университете им. П.Г. Демидова. Цель настоящей заметки — отметить основные результаты, представленные на конференции и подчеркнуть роль подобных мероприятий в развитии дискретной и вычислительной геометрии в России.

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