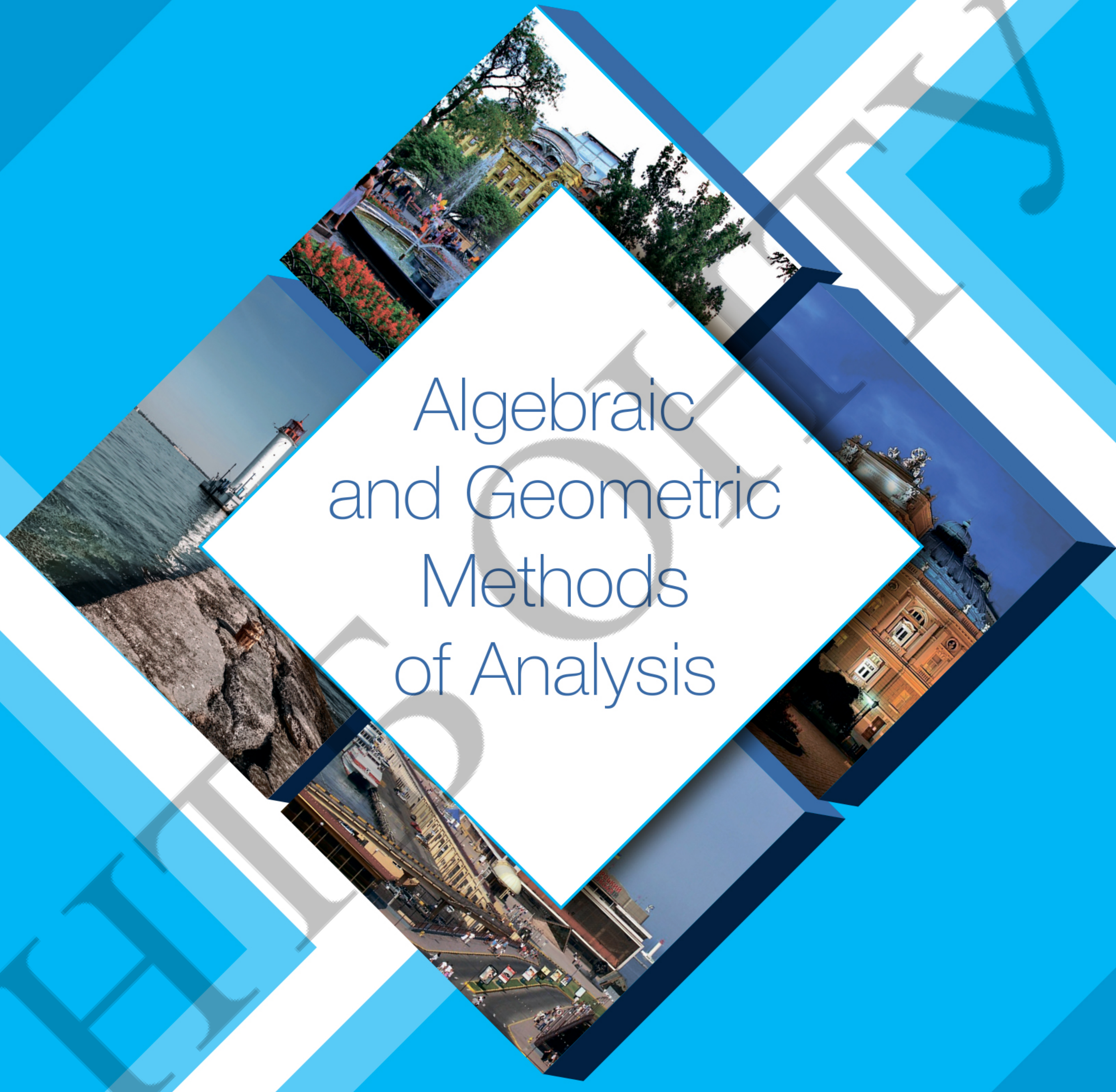
International
Scientific Conference



Algebraic and Geometric Methods of Analysis

27-30 May 2024
Odesa, Ukraine

The purpose of this conference is to bring together researchers in geometry, topology, algebra, analysis and dynamical systems and to provide for them a forum to present their recent work to colleagues from different nationalities. This way we aim to stimulate discussion about the latest findings in geometrical and topological methods in analysis and to increase international collaboration.

The conference continues the traditional annual conference «Geometry in Odesa» holding from 2004, and hosted by Odesa National University of Technology (Odesa National Academy of Food Technologies till 2021). From 2017 the conference was renamed to «Algebraic and geometric methods of analysis» (AGMA).

The Conference languages: Ukrainian and English.

List of topics

- Algebraic methods in geometry
- Differential geometry in the large
- Geometry and topology of differentiable manifolds
- General and algebraic topology
- Dynamical systems and their applications
- Geometric and topological methods in natural sciences
- Geometric problems in mathematical analysis

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When we consider the real symmetric matrix model with $\beta = 1$, then $\mathcal{H}$ is the Hamiltonian $\mathcal{H}_{CM}$ for Calogero-Moser model:

$$\mathcal{H}_{CM} := \frac{-\eta}{2N}\left(\sum_{i=1}^{N}\frac{\partial^2}{\partial E_i^2} + \frac{1}{4}\sum_{i\neq j}\frac{1}{(E_i - E_j)^2}\right) + 2\frac{N}{\eta}\sum_{i=1}^{N}E_i^2. \tag{2}$$

It is known that the N-body harmonic oscillator system or the Calogero-Moser model is associated with a Virasoro algebra structure. Using this fact, families of differential equations satisfied by the partition functions are also obtained from the Virasoro(Witt) algebra representations:

$$[\widetilde{L}_n, \widetilde{L}_m] = (n-m)\widetilde{L}_{n+m}. \tag{3}$$

The definitions of symbols and terms are left to the references [1, 2], but the following theorem is obtained

Theorem 2. *The partition function defined by (1) satisfies*

$$\mathcal{L}_{SD}(\widetilde{L}_{-m}Z(E,\eta)) = -\,2m(\widetilde{L}_{-m}Z(E,\eta)). \tag{4}$$

Here $\mathcal{L}_{SD}$ is a differential operator such that some Schwinger-Dyson equation for the partition function given by

$$\mathcal{L}_{SD}Z(E,\eta) = 0. \tag{5}$$

This means that $\widetilde{L}_{-m}Z(E,\eta)$ is an eigenfunction of $\mathcal{L}_{SD}$ with the eigenvalue $-2m$.

This talk is based on [1], in collaboration with H. Grosse, and [2], in collaboration with H. Grosse, N. Kanomata, and R. Wulkenhaar.

References

[1] H. Grosse and A. Sako, "Integrability of Φ^4 Matrix Model as N-body Harmonic Oscillator System," Lett Math Phys 114, 48 (2024). https://doi.org/10.1007/s11005-024-01783-2 [arXiv:2308.11523 [math-ph]].
[2] H. Grosse, N. Kanomata, A. Sako and R. Wulkenhaar, "Real symmetric Φ^4-matrix model as Calogero-Moser model," Lett Math Phys 114, 25 (2024). https://doi.org/10.1007/s11005-024-01772-5 [arXiv:2311.10974[hep-th]].

Partitioning problem and defensive alliances in the context of zero-divisor graphs of rings

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This is joint work with **Driss Bennis**

The partitioning of the vertex set of a graph is a well-studied problem in graph theory. It involves dividing the set of vertices of a graph into disjoint subsets or partitions, based on specific criteria or constraints. In this talk, we are interested in partitioning the zero-divisor graph of a commutative ring into global defensive alliances. This problem has been well investigated in graph theory. Here, we connected it with the ring theoretical context. We characterize various finite commutative rings for which the zero-divisor graph is partitionable into global defensive alliances. We also present several examples to illustrate and delimit the scope of the established results.

References

[1] Bennis D., El Alaoui B., Ouarghi K. (2023). On global defensive k-alliances in zero-divisor graphs of finite commutative rings. *J. Algebra Appl.*, **22(06)**: 2350127.

[2] Bennis D., El Alaoui B. (2024). Partitioning zero-divisor graphs of finite commutative rings into global defensive alliances. (Submitted for publication) https://doi.org/10.48550/arXiv.2305.12942.

[3] Yero I.G., Bermudo S., Rodríguez-Velázquez J.A., Sigarreta J.M. (2010). Partitioning a graph into defensive k-alliances. *Acta Math. Sin. (Engl. Ser.)*, **27**: 73–82.

On the connection between algebraic, geometric, and topological methods in the classification of algebraic surfaces and curves

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The classification of algebraic curves and surfaces in a moduli space is a challenging subject in algebraic geometry. Moduli spaces are spaces that parameterize families of algebraic surfaces. They can be used to study the geometry of algebraic surfaces and to compare different surfaces. Classifying algebraic surfaces and curves is an important task because of the comparison between different objects that we study. The moduli space of curves for example, is a space that parameterizes families of algebraic curves of a fixed genus.

The objects we study and classify can be algebraic curves (via fundamental groups and finding Zariski pairs), algebraic surfaces, and gluing of algebraic surfaces (via deformations and projections).

There are methods that can assist in this classification, for example: topological classification, intersection theory, singularities, cohomology, symmetric groups, etc. There are known algorithmic methods as well, and the choice of a method depends on the specific properties of the surface or curve in question and the desired level of detail in the classification.

From the geometric and topological point of view: we consider planar and non-planar deformations and projections to find branch curves of algebraic surfaces. From the algebraic and computational point of view: researchers in the mathematical community use the computer programs Magma, Singular, Maple, and so on. These are just a few examples of software packages that can be used for classifying algebraic surfaces and curves. In our research we use Magma as well, because we investigate fundamental groups and the Magma is a great tool for this goal. We have built some computer softwares to overcome the complicated algebraic computations in the fundamental groups.

Firstly, in order to understand the complexity of the computations in the classification of algebraic surfaces, let us look at the following figure. We can see a high multiplicity of singularities. It happens especially when we glue two planar deformations or when we consider a non-planar deformation. The following figure shows two planar deformations glued together along four edges, and we get a non-planar deformation with multiplicity 4 in all singularities. In this case, the fundamental group of the Galois cover of the surface that has such a deformation is metabelian of order 2^{23} [1].

Now we explain how classification of algebraic surfaces works. We take an algebraic surface embedded in a projective space and project it with a generic projection onto the projective plane. We get the branch curve and then we are able to calculate G - the fundamental group of its complement. A special software gives as an output all braids relating to the branch curve and also

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