

Research group on *Topology*

IMAR Participants: B. Berceanu, S. Papadima, F. Panaite, A. Nenciu, M. Staic.

Romanian Cooperations: Bucharest University and SNS-Bucharest. Several junior Romanian mathematicians (post-doctoral researchers and PhD and master students) have been joined to the group either for direct research activity or for training in research.

International Cooperations:

Belgium: Antwerp University

Czech Republic: Institute of Mathematics of the Czech Academy of Sciences, Prague

France: Universities of Bordeaux, Grenoble, Mulhouse and Nice; invited talks in CIRM-Luminy (Marseille)

Workpackages involved: A1, B1, B2, C3.

Ph. D. students and post-doctoral fellows at IMAR:

1. S. Poirier spent 5 months at IMAR, in 2001, with a post-doctoral fellowship. Before his arrival here, he wrote a thesis at University of Grenoble, under the supervision of Prof. C. Lescop, on topics in low-dimensional topology. At the beginning of his stay in Bucharest, he wrote a paper:

<http://spoirier.lautre.net/anom.ps>

where he proved three results announced in his Ph.D. thesis. After that, his mathematical interest shifted from topology to pedagogical aspects of mathematical physics.

2. Corina Calinescu (IMAR) continued the work on his PhD thesis *the classification of Hopf algebras of a given dimension over an algebraically closed field of characteristic zero* and participated at the doctoral program of the department of mathematics of the Antwerp University and attended the weekly Algebra Seminar.
3. P. Bellingeri had a one month Ph.D. fellowship, in 2001. In this period, he continued to work on his Ph.D. thesis, while attending our Topology seminar. He wrote the paper "*On the solvability of the word problem for the singular braid monoid*". Later on, he finished his thesis, under the supervision of prof. V. Sergiescu (Universite de Grenoble).
4. E. Remm visited IMAR twice. During her first stay here (with one month Ph.D. fellowship, in 2001), she continued to work on her Ph.D. thesis, and wrote the paper "*Affine structures on non characteristically Lie algebras*" (math.RA/0109071). After that, she completed her thesis, with Prof. M. Goze (Universite de Mulhouse). During her second stay in Bucharest, in 2002, she wrote the paper "*Valued deformations of algebras*" (with M. Goze, submitted to Journal of Algebra and its Applications). She attended regularly our Friday Topology seminar. Here, she met Prof. M. Markl (Mathematical Institute of the Czech Academy, Prague), with whom she begun a scientific project, related to the theory of operads, which she is currently continuing in Prague.
5. Before his arrival at IMAR (with an EURROMMAT post-doctoral fellowship), G. Massuyeau has obtained a Ph.D. degree from Universite de Nantes, by writing a thesis on topics in low-dimensional topology, under the supervision of Prof. C. Blanchet. During his stay in Bucharest, he pursued his investigations on the topology of 3-manifolds. Using results from his thesis, he was able to reformulate Y_2 -equivalence of closed oriented 3-manifolds in algebraic terms, thus extending a result on Y_1 -equivalence, due to S. Matveev; see paper. He was one of the most active members in our Topology seminar. Here, he met young IMAR researcher F. Nichita. Together, they wrote a paper which establishes an interesting connection between associative algebras and the Alexander polynomial of knots. Recently, he was invited by the Hebrew University of Jerusalem, where he gave a talk on "*Cohomology rings, Rochlin function, linking pairing and the Goussarov-Habiro theory of 3-manifolds*".

Scientific Objectives:

1. low-dimensional topology (papers [1, 2, 3, 5] from the Selected Papers below)
2. topology of algebraic varieties (papers [4, 6, 7, 8, 9, 10] from the Selected Papers below);
3. quantum groups (papers [11--17] from the Selected Papers below).

Main Results:

1. B. Berceanu and S. Papadima (with M. Markl): *Multiplicative models for configuration spaces of algebraic varieties*, submitted; preprint arXiv:math.AT/0308243.
2. F. Panaite: *Hopf bimodules are modules over a diagonal crossed product algebra*, Comm. Algebra 30 (8), 4049-4058 (2002).
3. F. Panaite (with D. Bulacu and S. Caenepeel): *Yetter-Drinfeld categories for quasi-Hopf algebras*, preprint 2003.
4. F. Panaite (with D. Bulacu and S. Caenepeel) *Some results on Yetter-Drinfeld modules for quasi-Hopf algebras*, preprint 2003.
5. G. Massuyeau: *Cohomology rings, Rochlin function, linking pairing and the Goussarov--Habiro theory of 3-manifolds*, Algebraic and Geometric Topology, 3 (2003), 1139--1166.
6. G. Massuyeau and F. Nichita: *Yang-Baxter operators arising from algebra structures and the Alexander polynomial of knots*, preprint 2003.

Research Activity:

- Milnor's μ -invariants of classical links have been intensively studied and used in low-dimensional topology. In [5], they are refined, by lifting them to peripheral invariants with values in unipotent orbit spaces; this point of view enables one to construct similar invariants, for complex hyperplane arrangements. The Kontsevich integral provides a universal invariant of finite type for knots, with rational coefficients. In [3], this is done for Artin braids, with arbitrary coefficients; the methods and results from [3] have been extended to braids on closed oriented surfaces, by Gonzalez-Meneses and Paris [Trans. Amer. Math. Soc. 356, 219--243 (2004)].
- The interplay between topology and geometry, on algebraic varieties, is a classical subject, which goes back to Lefschetz and Zariski. One of the main results from [7] establishes a precise connection between the Jacobian degree of an arbitrary homogeneous polynomial, and cellular structures on the complement of the associated projective hypersurface. Among the corollaries of this fact, one may find in [7] a solution of a conjecture of Dolgachev on polar Cremona transformations, as well as computations of higher homotopy groups (a very difficult task, in general) of complements of hyperplane arrangements, which also use tools from [4, 6]. Another consequence is the existence of minimal cell structures on arrangement complements, further explored in [8]. In an important paper, Fulton-MacPherson [Annals of Math. 139, 183-225 (1994)] described the homotopy type, in characteristic zero, of configuration spaces of smooth compact varieties, in terms of their cohomology rings. This is extended in [10] to (noncompact) punctured varieties. It is worth mentioning that the ideas from [10] emerged during the one month visit of M. Markl at IMAR, supported by EURROMAT.
- The purely algebraic aspects of quantum groups (alias Hopf algebras) were investigated by a group of young IMAR researchers (most of them Ph. D. students in US, since 2001). We should point out an interesting new connection, between algebra and low-dimensional topology, found in the paper by F. Nichita (algebraist, IMAR) and G. Massuyeau (topologist, EURROMAT fellow); they give a simple construction of the Alexander polynomial of knots, starting from an arbitrary associative algebra.

Selected papers:

1. S. Papadima: *Braid commutators and homogenous Campbell- Hausdorff tests*, Pacific Journ. of Math. 197 (2001), 383--416.
2. S. Papadima: *On the indeterminacy and the realization of Milnor's μ -invariants*, Rev. Roumaine Math. Pures Appl. 46 (2001), 471--487.
3. S. Papadima: *The universal finite--type invariant of braids with integer coefficients*, Topology and its Applications 118 (2002), 169--185.

4. S.Papadima (with M. Jambu): *Deformations of hypersolvable arrangements*, Topology and its Applications 118 (2002), 103--111.
5. S.Papadima: *Generalized μ -invariants for links and hyperplane arrangements*, Proc. London Math. Soc. 84 (2002), 492--512.
6. S.Papadima (with A. Suciu): *Higher homotopy groups of complements of complex hyperplane arrangements*, Advances in Math. 165 (2002), 71—100.
7. S.Papadima (with A. Dimca): *Hypersurface complements, Milnor fibers and higher homotopy groups of arrangements*, Annals of Math. 158 (2003), 473--507.
8. S.Papadima (with A. Dimca): *Equivariant chain complexes, twisted homology and relative minimality of arrangements*; math. AT/0305266, to appear in Ann. Scient.Ec. Norm. Sup.
9. S.Papadima (with A. Suciu): *Chen Lie algebras*; math.GR/0307087, to appear in Internat. Math. Res. Notices.
10. B.Berceanu and S. Papadima (with M. Markl): *Multiplicative models for configuration spaces of algebraic varieties* submitted; preprint math.AT/0308243.
11. F.Panaite: *Hopf bimodules are modules over a diagonal crossed product algebra*, Comm. Algebra 30 (2002), no. 8, 4049--4058.
12. F.Panaite (with D. Stefan); *Deformation cohomology for Yetter-Drinfeld modules and Hopf (bi)modules*, Comm. Algebra 30 (2002), no. 1, 331--345.
13. A.Nenciu: *The center construction for weak Hopf algebras*, Tsukuba J. Math. 26 (2002), no. 1, 189--204.
14. A. Nenciu: *Quasitriangular structures for a class of pointed Hopf algebras constructed by Ore extensions*, Comm. Algebra 29 (2001), no. 8, 3419--3432.
15. A. Nenciu: *Cleft extensions for a class of pointed Hopf algebras constructed by Ore extensions*, Comm. Algebra 29 (2001), no. 5, 1959--1981.
16. M. Staic: *Pseudo-quasitriangular subbialgebras of quantum systems*, Comm. Algebra 30 (2002), no. 5, 2133--2141.
17. M. Staic: *On the dimension of the irreducible modules for semisimple Hopf algebras*, Comm. Algebra 30 (2002), no. 1, 437--442.

Communications: The results discussed above were presented on the occasion of various international meetings, such as:

1. S. Papadima: Les groupes d'homotopie superieures des arrangements (Conference on "Arrangements d'hyperplans complexes", Bordeaux, May 2001).
2. S. Papadima: Braid-like groups, loop space homology, and Koszulness ("Journées Tresses", CIRM Luminy, June 2001).
3. S. Papadima: Rescaling formulas ("IMAR Workshop AGAT1", Pitesti and Bucharest, August-September 2001).
4. S. Papadima: Geometry and topology of complements of complex hypersurfaces ("5-th Workshop on differential geometry", Timisoara, September 2001).
5. B. Berceanu: Braid arrangements ("IMAR Workshop AGAT1", Pitesti and Bucharest, August-September 2001).
6. B. Berceanu: Class numbers in B_3 ("IMAR Workshop AGAT1", Pitesti and Bucharest, August-September 2001).
7. B. Berceanu: Braid groups - a combinatorial viewpoint ("5-th Workshop on differential geometry", Timisoara, September 2001).
8. C. Calinescu: Quantum groups of dimension 16 with the Chevalley property, (conference *Noetherian Algebras and Quantum Groups* held at the Royal Belgian Academy).
9. S. Papadima: Braids and Koszulness ("Braids in Cortona", June 2002).
10. S. Papadima: On the I-adic filtration of higher homotopy groups of hyperplane arrangements ("IMAR Workshop AGAT2", Mamaia, September 2002).
11. B. Berceanu: Modeles pour les espaces de configurations des varietes algebriques ("Journées Tresses", CIRM Luminy, June 2003).
12. S. Papadima: Topology of open algebraic varieties ("5-th Congress of Romanian

- mathematicians", Pitesti, June 2003).
- 13.M. Staic: Pure braid Hopf algebras and knot invariants (\sim 5-th Congress of Romanian mathematicians", Pitesti, June 2003).
- 14.G. Massuyeau: Cohomology rings, Rochlin function, linking pairing and Goussarov-Habiro theory of 3-manifolds (\sim Knots in Poland '03", Warsaw, July 2003).

Talks and advanced courses: We list below the main seminar, teaching and research training activities of the Topology team, related to the EURROMMAT program.

- **Topology Seminar workshops** (co-ordination: B. Berceanu and S. Papadima).
 1. *Knizhnik--Zamolodchikov equations and Kontsevich integral* (March--June 2001).
 2. *Combinatorics and topology of hyperplane arrangements* (October--December 2003).
- **Topology Seminar and Conference talks (by EURROMMAT guests):**
 1. L. Funar (Universite de Grenoble): Topological geodesics and virtual rigidity of 3-manifolds (\sim IMAR Workshop AGAT1", Pitesti and Bucharest, August-September 2001).
 2. L. Funar; On geometric simple connectivity of open manifolds (\sim IMAR Workshop AGAT1", Pitesti and Bucharest, August-September 2001).
 3. R. Gini (Universita di Pisa): Cobordism of codimension-one immersions (\sim IMAR Workshop AGAT1", Pitesti and Bucharest, August-September 2001).
 4. A. Dimca (Universite de Bordeaux): On the topology of hyperplane arrangements (\sim IMAR Workshop AGAT1", Pitesti and Bucharest, August-September 2001).
 5. L. Paris (Universite de Dijon): A solution to a conjecture of Tits on Artin groups (\sim IMAR Workshop AGAT1", Pitesti and Bucharest, August-September 2001).
 6. M. Jambu (Universite de Nice): Witt formula and hyperplane arrangements (\sim IMAR Workshop AGAT1", Pitesti and Bucharest, August-September 2001).
 7. M. Jambu: Deformations of arrangements (\sim IMAR Workshop AGAT1", Pitesti and Bucharest, August-September 2001).
 8. E. Remm (PhD fellowship at IMAR): Affine structures on nilpotent Lie algebras (\sim IMAR Workshop AGAT1", Pitesti and Bucharest, August-September 2001).
 9. S. Poirier (post-doc fellowship at IMAR): Configuration space integral for links in \mathbb{R}^3 (\sim IMAR Workshop AGAT1", Pitesti and Bucharest, August-September 2001).
 - 10.S. Kallel (Universite de Lille): Spaces of rational maps (\sim IMAR Workshop AGAT2", Mamaia, September 2002).
 - 11.A. Dimca (Universite de Bordeaux): Vanishing results for twisted homology (\sim IMAR Workshop AGAT2", Mamaia, September 2002).
 - 12.C.T.C. Wall (University of Liverpool): Projection genericity of space curves (\sim IMAR Workshop AGAT2", Mamaia, September 2002).
 - 13.C. Sabbah (Ecole Polytechnique, Paris): Semisimple perverse sheaves and their direct images (\sim IMAR Workshop AGAT2", Mamaia, September 2002).
 - 14.I. Luengo (Universidad Complutense, Madrid): The monodromy conjecture for quasi-ordinary singularities (\sim IMAR Workshop AGAT2", Mamaia, September 2002).
 - 15.P. Bellingeri (PhD fellowship at IMAR): On presentations of surface braid groups (Topology seminar, November 2001).
 - 16.P. Bellingeri: New link polynomial invariants satisfying cubical skein relation (Topology seminar, November 2001).
 - 17.E. Remm (post-doc fellowship at IMAR): Lie admissible algebras and related operads, I and II (Topology seminar, November 2002).
 - 18.E. Remm: Valued deformations of algebras (Topology seminar, December 2002).
 - 19.G. Massuyeau (post-doc fellowship at IMAR): Introduction to the theory of finite type invariants of links and 3-manifolds (Topology seminar, December 2002).
 - 20.G. Massuyeau: Finite type invariants of links and 3-manifolds with spin structures, Part I (Topology seminar, January 2003).
 - 21.G. Massuyeau: Finite type invariants of links and 3-manifolds with spin structures, Part II (Topology seminar, February 2003).

- 22.G. Masbaum (Université Paris 7): Alexander polynomial, Milnor numbers, and the pfaffian matrix-tree theorem (Topology seminar, April 2003).
- 23.G. Masbaum: Involutions on moduli spaces and refinements of the Verlinde formula (Algebraic geometry seminar, April 2003).
- 24.G. Massuyeau: Yang-Baxter operators associated to algebra structures and knot invariants, I and II (Topology seminar, October 2003).
- 25.C. Soule (IHES Paris) conference “*Positive circuits and multistationarity*”, given at IMAR on March 6, 2003.

• **Advanced courses:**

1. V. Sergiescu / Université de Grenoble (EURROMMAT Invited Lecturer): *Groups almost acting on trees - algebraic and geometric aspects* (March and May 2001).
2. M. Markl / Mathematical Institute of the Czech Academy, Prague (EURROMMAT Invited Lecturer): *Operads in algebra, topology and physics* (October 2002).
3. C. Soule / IHES-Paris (EURROMMAT Invited Lecturer): *Introduction to algebraic K-theory* (February-March 2003).
4. B. Berceanu / IMAR: *Differentiable manifolds and maps* (Lecture series at SNS-Bucharest, fall 2001).
5. S. Papadima / IMAR: *Homology theory and duality* (Lecture series at SNS-Bucharest, fall 2001).
6. B. Berceanu / IMAR: *Homotopy theory of CW-complexes* (Lecture series at SNS-Bucharest, spring 2002).
7. B. Berceanu / IMAR: *Learning algebraic topology through examples* (Lecture series at Bucharest University, fall 2003).