

Proceedings of the 2005 Marseille Singularity School and Conference

SINGULARITY THEORY

Dedicated to
Jean-Paul Brasselet
on his 60th Birthday



Denis Chéniot • Nicolas Dutertre • Claudio Murolo
Anne Pichon • David Trotman

Editors

Chéniot
Dutertre
Murolo
Pichon
Trotman



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**Proceedings of the Singularity School and conference
January 24th – February 25th 2005
CIRM, Marseille, France**





Introduction

The Singularity School and Conference was organized from 24 January to 25 February 2005, in the CIRM, Centre International de Rencontres Mathématiques de Luminy, Marseille, France, as a Special School of the Formation Permanente of the French CNRS. Organizers of the five weeks were successively Anne Pichon, Jean-Paul Brasselet, David Trotman, Nicolas Dutertre and Claudio Murolo, Denis Chéniot. Around 200 mathematicians from 31 countries participated in this very successful event. The purpose of the event was to cover recent developments in the area and to introduce young researchers to singularities in geometry and topology.

The five weeks were organized in the following way : Elementary and advanced courses were given during the first week by high level specialists of the subject : Jean-Paul Brasselet, *Characteristic classes for Singular Varieties*; Herwig Hauser, *Basic techniques for resolution of singularities*; Anatoly Libgober, *Topology of the complements to hypersurfaces in projective space*; David Trotman, *Stratifications of subanalytic and semialgebraic sets*; Vladimir Zakalyukin, *Lagrangian and Legendrian singularities*. The second week was devoted to general lectures on singularity theory. During the third week users of singularity theory gave lectures on applications of the theory to various domains: robot manipulation, visualization techniques, medical imaging, nerve cells, resonance tongues, gravitational lensing, etc. . . . During the fourth week young researchers explained their recent results and during the last week lectures were concentrated on geometry and topology in singularity theory.

The book is a collection of courses, surveys, and new results in singularity theory and its applications, presented during the five weeks. It provides a focus for senior researchers and postgraduate students, summarizing the current main ideas in singularity theory and suggesting future research directions in the area.

The main interesting features of the papers in these Proceedings of the Singularity School and Conference are: the elementary and advanced courses in the first part of the book and the papers on applications of singularity theory in the second part, which is an original point in comparison with classical proceedings on the subject. The third part contains surveys on the development and evolution of the most important themes of the theory from the beginning up to now, and research papers on important recent results in the field. They represent the current problems under investigation in the

area and the present state of the art of the subject.

All papers published in the present book have been refereed.

The volume is complementary to the volume published by World Scientific Publishing for the School and Workshop on Singularity theory held in Trieste, 15 August - 3 September 2005.

The event was made possible with the help of the CNRS, Centre National de la Recherche Scientifique, especially the Formation Permanente of CNRS and the local institutions of the CNRS (the FRUMAM, the IML and the LATP), the CIRM, the French Ministry of Research and Technology, the French Ministry of Foreign Affairs, the Science Faculty of the Université de la Méditerranée, the Université de Provence, the City of Marseilles, and the Conseil Général des Bouches-du-Rhône. The organizers thank particularly those participants who funded themselves partially or totally .

It is a great pleasure to thank all the speakers and the participants, whose presence was the real success of the School and Conference. We are also very grateful to the staff of the IML, the LATP and the CIRM for their help in organizing the event. Finally, our thanks go to the editorial staff of World Scientific Publishers for their patience and efficient help with the publication process of the volume.

5 Semaines de Singularités 5 Weeks of Singularities

CIRM - Luminy - Marseille

24/01/2005 - 25/02/2005

24-28 January	31 January-4 February	7-11 February	14-18 February	21-25 February
<i>Introductory Courses on Singularity Theory</i>	<i>General Conference on Singularities</i>	<i>Applications of Singularities</i>	<i>Young Singularists</i>	<i>Geometry and Topology of Singularities</i>



Centre International de Rencontres Mathématiques

Organizing Committee

Jean-Paul Brasselet *IML - Marseille*
 Denis Chéniot *LATP - Marseille*
 Nicolas Dutertre *LATP - Marseille*
 Victor Goryunov *Univ. of Liverpool*
 Lê Dung Tráng *ICTP - Trieste*
 Françoise Michel *Univ. of Toulouse*
 Claudio Murolo *LATP - Marseille*
 Anne Pichon *IML - Marseille*
 Dirk Siersma *Univ. of Utrecht*
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Scientific Committee

Maria Emilia Alonso *Madrid*
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 Terry Wall *Liverpool*
 Claude Weber *Geneva*
 Yosef Yomdin *Weizmann Inst*

PRE-INSCRIPTION / PRE-REGISTRATION FORM : <http://frumam.cnrs-mrs.fr/>

INFORMATIONS : France BODIN, F.R.U.M.A.M. - FR CNRS 2291, Parc Scientifique de Luminy - Case 909
 13288 - Marseille Cedex 9, FRANCE - Tel./Fax : 00 33 (0)4 91 26 95 62
 E-mail : bodin@frumam.cnrs-mrs.fr



This volume is dedicated to our friend and colleague Jean-Paul Brasselet, who reached the round age of 60 in March 2005. We recall here some of his achievements, in particular his influence on research in singularities in Marseille.

Until 1991 Jean-Paul was at the University of Lille 1, directing the research laboratory from 1985 to 1991 and was instrumental in the creation and construction of a fine new library for the mathematics department. He was one of Henri Cartan's last research students, defending his Thèse d'Etat in 1977 (directed jointly by Cartan and Shih Weishu), and was also strongly influenced by Marie-Hélène Schwartz, his colleague at Lille, who had been working on extending the theory of characteristic classes to singular analytic spaces since the early 50's (and has continued to do so almost to this day - at the age of 87, she published a 216 page research monograph in the year 2000 on Chern classes for analytic spaces, and is thus an inspiration to us all !). The theory of characteristic classes for singular spaces became the dominant theme in Jean-Paul's research. His lecture notes in the present volume provide an introduction to the theory and bear witness to the longevity of his efforts and thus to the richness of the theory.

An unusual feature of his latter activity in Lille was a collaboration with the French National Railways, the SNCF, applying differential geometry to the design of TGV tracks between Paris and Lille. Before leaving for Marseille to become Director of the CIRM, and of the IML, he organised a major singularities conference in Lille with over 230 participants and traditional giant figures, and edited the proceedings in a volume published as volume 201 of the London Mathematical Society Lecture Notes.

He organised another huge singularities conference in Marseille in 1993 (around 150 participants) as well as collaborating in running regular Marseille-Nice meetings, up to 6 a year, from 1991 to 2003. Three doctoral students accompanied Jean-Paul to Marseille - Belkacem Bendiffalah, Michal Kwiecinski and Jianji Zhou. The three made entertaining speeches at the celebration dinner in Marseille in honour of Jean-Paul. The 90's saw a regular expansion of activity in singularity theory in Marseille: Jean-Paul and his students joining David Trotman with his students Laurent Noirel, Stéphane Simon, and then Claudio Murolo, Georges Comte, Dwi Juniati and Guillaume Valette. Denis Chéniot arrived from Nice in 1993 and soon acquired a student in Christophe Eyrat, while in 1994 Lê Dũng Tráng came from Paris with his students including Jawad Snoussi and Meral Tosun, and later Caroline Ausina and Eric Akeke. Hélène Maugendre was appointed Maître de Conférences in 1996, Anne Pichon in 1998, Claudio

Murolo in 2000 and Nicolas Dutertre in 2002. In the creation of a stimulating research environment for this group of mostly young researchers to develop and thrive, Jean-Paul played a leading role by organising many international meetings and by bringing his collaborators to Marseille for extended periods (Paolo Aluffi, Gottfried Barthel, Lev Birbrair, Karl-Heinz Fieseler, Ludger Kaup, André Legrand, Ursula Ludwig, Markus Pflaum, Jörg Schürmann, José Seade, Tatsuo Suwa and Nicolae Teleman).

Recently Jean-Paul was the French organiser of French-Japanese singularities meetings in Sapporo (1998 and 2004), and Luminy (2002), and the 8th São Carlos Singularities Workshop (in Luminy !) in 2004. He has also spent much time in Brussels as a European expert. All this activity meant he had the competence and the confidence to propose that the six of us plan the 5 Weeks of Singularity Theory which took place in January and February 2005. That the whole event went so smoothly and on such a large scale was due in great part to his experience and know-how.

All Jean-Paul's colleagues know his sociability and good humour, also his efficiency in realising ambitious projects. Let this book be a mark of our respect and appreciation and an encouragement for future researchers in singularity theory.

Denis Chéniot
Nicolas Dutertre
Claudio Murolo
Anne Pichon
David Trotman

Marseille, October 12th, 2006

PROGRAMS

Introduction to Singularity Theory 24-28th January 2005

5 courses of 5 hours each :

Jean-Paul Brasselet, Characteristic classes of singular varieties

Herwig Hauser Basic techniques for resolution of singularities

Anatoly Libgober Topology of the complements to hypersurfaces in projective space

David Trotman Subanalytic and semialgebraic sets: stratifications, equisingularity and metric properties

Vladimir Zakalyukin Lagrangian and Legendrian singularities

Singularities
31th January - 4th February 2005

Monday 31th January

- 9:40-10:30 **Anatoly Libgober**, Topology of the complements and geometry of non normal crossings
11:00-11:50 **David Mond**, Linear free divisors and Lie groups
16:00-16:50 **Wim Veys**, Are principal value integrals birational invariants ?
17:00-17:50 **Grigory Mikhalkin**, Complex, real and tropical curves

Tuesday 1st February

- 8:30-9:20 **András Némethi**, On the classification of cuspidal rational projective plane curves
9:40-10:30 **Philippe Du Bois**, Dévissage de la forme de Seifert entière des germes de courbe plane à deux branches
11:00-11:50 **Paolo Aluffi**, Celestial integration and applications
16:00-16:50 **Laurentiu Maxim**, Alexander invariants of hypersurface complements
17:00-17:50 **Anne Fröhbis-Krüger**, Algorithmic resolution of singularities from a practical point of view
18:00-18:50 **Andrzej Weber**, Pure homology of singular varieties

Wednesday 2nd February

- 8:30-9:20 **Richard Rimanyi**, Thom polynomials for quivers 9:40-10:30 **Lázlo Feher**, Relations among Thom Polynomials
11:00-11:50 **Mutsuo Oka**, Zariski pairs in sextics

Thursday 3rd February

- 8:30-9:20 **Alexandru Dimca**, Idaux d'adjonction et idaux des multiplicateurs
9:40-10:30 **Michel Vaquié**, Extension de valuation et polygone de Newton
11:00-11:50 **Adam Parusinski**, Recent results on blow-analytic equivalence of analytic function germs
16:00-16:50 **Inna Scherback**, Intersections of Schubert Cells, Tensor Products of sl_n -module and Critical Points of The Generating Function
17:00-17:50 **Piotr Mormul**, Small growth vectors: a Gödel-like encoding

of the geometric classes of Goursat flags

Friday 4th February

8:30-9:20 **Lê Dung Trang** 9:40-10:30 **Fuensenta Aroca**, An extension of the Newton polyhedron construction to compute solutions of a Partial Differential Equation

11:00-11:50 **Jawad Snoussi**, The Nash modification and point blow-up on surfaces

14:00-14:50 **Andrew Du Plessis**, Projective hypersurfaces admitting a unipotent group action

Applications of Singularities
7-11th February 2005

Monday 7th February

10:00-10:50 **Shyuichi Izumiya**, Pseudo-spherical geometry in Minkowski space and Legendrian dualities

11:30-12:20 **Stanislaw Janeczko**, Integrable singularities of Dirac's generalized Hamiltonian dynamics

16:00-16:50 **Maria Carmen Romero-Fuster**, Generic contacts of surfaces in $\mathbb{R}^5$

17:00-17:50 **Hiroaki Terao**, Arrangements of hyperplanes and hypergeometric integrals

18:00-19:20 **Fernand Pelletier**, Stratifications en dimension infinie et applications

Tuesday 8th February

9:00-9:50 **Gert Vegter**, The Geometry of Resonance Tongues: A Singularity Theory Approach

10:00-10:50 **David Chillingworth**, Bifurcation from a 2-manifold: wavefronts and line congruences

11:30-12:20 **Mike Field**, Singularity and stratification theory applied to dynamical systems

16:00-16:50 **Jacques Furter**, Bifurcations in elasticity : gradient, symmetry breaking structures and path formulation

17:00-17:50 **Isabel Labouriau**, Synchronization and desynchronization of coupled nerve cells

Wednesday 9th February

9:00-9:50 **Peter Giblin**, Recent work on symmetry sets and medial axes in 2 and 3 dimensions

10:00-10:50 **André Diatta**, Vanishing inflexions and vertices in 1-parameter families of plane curves

11:30-12:20 **James Damon**, Understanding the geometry of shapes in $\mathbb{R}^n$ via medial and skeletal structures

Thursday 10th February

9:00-9:50 **Ole Fogh Olsen**, Deep Structure Analysis of Images

10:00-10:50 **Xavier Pennec**, Statistical Computing on Riemannian Manifolds with Applications in Medical image Analysis

11:30-12:20 **Yannick Kergosien**, Singularities and genericity in Medical Imaging and Vision

16:00-16:50 **Alain Joets**, Optical singularities (caustics) as visualization technics. Application to liquid crystals

17:00-17:50 **Arlie Petters**, Singularities in gravitational lensing

18:00-19:20 **Dirk Siersma**, Shape and Morse Theory of the distance function

Friday 11th February

9:00-9:50 **Peter Donelan**, Singularities in Robotics

10:00-10:50 **Bernard Mourrain**, Meshing implicit algebraic surfaces

11:30-12:20 **Yosef Yomdin**, What is "Computational Singularity Theory" and what is it good for?

**Young researchers in Singularities
14-18th February 2005**

Monday 14th February

- 9:00-9:40 **Patrick Popescu-Pampu**, On the contact boundary of an isolated singularity
9:55-10:35 **José Ignacio Cogolludo**, Topology of real and complex line arrangements in $\mathbb{CP}^2$
11:00-12:20 **Dirk Siersma**, The topology of non-isolated singularities I
15:50-16:30 **Gil Guibert**, Motivic Milnor fiber and applications
17:00-17:40 **Johannes Nicaise**, Rigid geometry and the Monodromy conjecture
17:55-18:35 **Goulwen Fichou**, The corank is a blow-Nash invariant

Tuesday 15th February

- 9:00-9:40 **Didier D'Acutto**, Singularités de fonctions modérées : trajectoires de gradient et fonds de vallées
9:55-10:35 **Vincent Grandjean**, Gradient trajectories and singularity at infinity
11:00-12:20 **Walter Neumann**, Splice diagrams I
15:00-15:40 **Mariusz Zajac**, Centre symmetry sets and other affine invariants of algebraic sets
15:50-16:30 **Guillaume Valette**, Hardt's theorem : a bilipschitz version
17:00-17:40 **Rémi Soufflet**, Arc analyticity of sub-analytic functions and related topics

Wednesday 16th February

- 9:00-9:40 **Maria Alberich-Carramiñana**, Contractibility of exceptional curves
9:55-10:35 **Guillaume Rond**, Artin function and a counter-example to a conjecture of Spivakovsky
11:00-11:40 **Dmitry Kerner**, On enumeration of singular curves/hypersurfaces
11:50-12:30 **Wojciech Domitrz**, Volume-preserving diffeomorphisms on germs of singular quasi-homogeneous varieties and $\mathcal{A}_\Omega$ -equivalence of maps-germs

Thursday 17th February

9:00-9:40 **Pedro Gonzalez-Perez**, Harnack's deformations of real plane branch singularities and their amoebas

9:55-10:35 **Romain Bondil**, Multiplicities and vertical components

11:00-12:20 **Dirk Siersma**, The topology of non-isolated singularities II

15:00-15:40 **Christian Sevenheck**, Geometry and deformation theory of lagrangian singularities

15:50-16:30 **Nero Budur**, Applications of D -modules

17:00-17:40 **Tristan Torrelli**, Logarithmic comparison theorem and D -modules

17:55-18:35 **Céline Roucairol**, Irregularity of a differential system associated to two polynomials

Friday 18th February

9:00-9:40 **Ricardo Uribe-Vargas**, A new projective invariant associated to special parabolic points of surfaces and to swallowtails

9:55-10:35 **Arnaud Bodin**, Topology of families of complex polynomials

11:00-12:20 **Walter Neumann**, Splice diagrams II

15:00-15:40 **Evelia Garcia-Barroso**, The Lojasiewicz numbers and plane curve singularities

15:50-16:30 **Etienne Mann**, Correspondence between the orbifold cohomology of weighted projective spaces and singularity of a Laurent polynomial

**Topology and Geometry of Singularities
21-25th February 2005**

Monday 21th February

- 9:40-10:30 **Alejandro Melle**, Links and analytic invariants of superisolated singularities
 11:00-11:50 **Stanislaw Janeczko**, Local symplectic invariants and relative Darboux Theorem
 14h30-15:20 **Sabir Gusein-Zade**, Curves on rational surface singularities and Poincaré series
 16:00-16:50 **Françoise Michel**, On the boundary of the Milnor Fiber for non isolated singularities of germs of surfaces
 17:10-18:00 **Anne Pichon**, Real analytic germ from a singularity of normal surface
 18:20-19:10 **Terry Gaffney**, The multiplicity polar theorem, and an application to the indices of vector fields on singular spaces

Tuesday 22th February

- 8:30-9:20 **Ignacio Luengo**, Open problems on plane rational curves
 9:40-10:30 **Georges Comte**, Courbes intégrales de champs lipschitz
 11:00-11:50 **Nicolas Dutertre**, Curvature integrals of the real Milnor fibre
 14:30-15:20 **Marcio Soares**, Singularities of logarithmic foliations
 16:00-16:50 **Patrice Orro**, Some properties of the SR geodesic distance
 17:10-18:00 **Clément Caubel**, Contact structure and isolated singularities : some recent results
 18:20-19:10 **Lev Birbrair**, Metric Theory of Real Surfaces

Wednesday 23th February

- 8:30-9:20 **Walter Neumann**, The Casson Invariant Conjecture
 9:40-10:30 **Victor Goryunov**, Simple symmetric matrix singularities and the subgroups of Weyl groups A_μ, D_μ, E_μ
 11:00-11:50 **Andrew du Plessis**, Fibration, stratification and resolution

Thursday 24th February

Special day for Jean-Paul Brasselet on his 60th Birthday

- 8:30-9:20 **Shoji Yokura**, Characteristic classes of symbolic algebraic vari-

eties

9:40-10:30 **Jörg Schürman**, Motivic characteristic classes for singular spaces,

11:00-11:50 **Nicolae Teleman**, Sur le caractère de Chern

14:30-15:20 **André Legrand**, Singularités coniques isolées et caractère de Chern

16:00-16:50 **Markus Pflaum**, Towards an algebraic index theorem for symplectic orbifolds

17:15 **Concert : Anne Méhat** (violon) and **Ludger Kaup** (piano)

18:00 Apéritif

Birthday dinner

Friday 25th February

8:30-9:20 **José Seade**, Indices of vector fields on singular varieties

9:40-10:30 **Tatsuo Suwa**, Localization of characteristic classes and applications

11:00-11:50 **Lê Dũng Tráng**, Equisingularité sur les surfaces

14h30-15:20 **Gottfried Barthel**, Homologie des variétés toriques

16:00-16:50 **Bernard Teissier**, Valuations and toric geometry

LIST OF PARTICIPANTS

Haydée AGUILAR	Universidad Nacional Autónoma de México Cuernavaca, MEXICO haydee@matcuer.unam.mx
Eric Dago AKEKE	Université de Provence Marseille, FRANCE akeke@cmi.univ-mrs.fr
Maria ALBERICH-CARRAMIÑANA	Universitat de Barcelona Barcelona, SPAIN maria.alberich@upc.edu
Lionel ALBERTI	École Normale Supérieure de Cachan Cachan, FRANCE alberti@dptmaths.ens-cachan.fr
Paolo ALUFFI	Florida State University Tallahassee, U.S.A. aluffi@math.fsu.edu
Fuensanta AROCA	Universidad Nacional Autónoma de México Cuernavaca, MEXICO fuen@matcuer.unam.mx
Gilles BAILLY-MAITRE	Université de La Rochelle La Rochelle, FRANCE gilles.baillymaitre@gmail.com
Gottfried BARTHEL	Universität Konstanz Konstanz, GERMANY Gottfried.Barthel@Uni-Konstanz.de
Lev BIRBRAIR	Universidade Federal do Ceará Fortaleza, BRAZIL lev@agt.uva.es
Rocio BLANCO	Universidad de Valladolid Valladolid, SPAIN rblanco@modulor.arq.uva.es
Vincent BLANLŒIL	Université de Strasbourg Strasbourg, FRANCE blanloeil@math.u-strasbg.fr

Arnaud BODIN	Université Lille 1 Villeneuve d'Ascq, FRANCE Arnaud.Bodin@math.univ-lille1.fr
Romain BONDIL	Université de Montpellier Montpellier, FRANCE bondil.romain@neuf.fr
Jean-Paul BRASSELET	Institut de Mathématiques de Luminy, CNRS Marseille, FRANCE jpb@iml.univ-mrs.fr
Gábor BRAUN	Eötvös Loránd Tudományegyetem Budapest, HUNGARY braung@renyi.hu
Thomas BRÉLIVET	Universidad de Valladolid Valladolid, SPAIN brelivet@agt.uva.es
Shirley BROMBERG	Universidad Autónoma Metropolitana Mexico, MEXICO stbs@xanum.uam.mx
Erwan BRUGALLE	Université Toulouse 3 Toulouse, FRANCE brugalle@picard.ups-tlse.fr
Clemens BRUSCHEK	Universität Innsbruck Innsbruck, AUSTRIA csac8572@uibk.ac.at
Nero BUDUR	Johns Hopkins University Baltimore, U.S.A. nbudur@math.jhu.edu
Igor BURBAN	Universität Bonn Bonn, GERMANY burban@mpim-bonn.mpg.de
Pierrette CASSOU-NOGUÈS	Université Bordeaux I Talence, FRANCE cassou@math.u-bordeaux1.fr
Clément CAUBEL	Université Paris 7 Paris, FRANCE caubel@math.jussieu.fr
Denis CHÉNIOT	Université de Provence Marseille, FRANCE cheniot@cmi.univ-mrs.fr

- David CHILLINGWORTH University of Southampton
Southampton, UNITED KINGDOM
drjc@maths.soton.ac.uk
- José Luis CISNEROS Universidad Nacional Autónoma de México
Cuernavaca, MEXICO
jlcm@matcuer.unam.mx
- Helena COBO PABLOS Universidad de Madrid
Madrid, SPAIN
hcobopab@mat.ucm.es
- José Ignacio COGOLLUDO Universidad de Zaragoza
Zaragoza, SPAIN
jicogo@unizar.es
- Georges COMTE Université de Nice
Nice, FRANCE
comte@math.unice.fr
- Nuria CORRAL Universidad de Vigo
Pontevedra, SPAIN
ncorral@uvigo.es
- Didier D'ACUNTO Università di Pisa
Pisa, ITALY
ddacu@univ-savoie.fr
- James DAMON University of North Carolina
Chapel Hill, U.S.A.
jndamon@math.unc.edu
- Declan DAVIS University of Liverpool
Liverpool, UNITED KINGDOM
d.davis@liverpool.ac.uk
- André DIATTA University of Liverpool
Liverpool, UNITED KINGDOM
adiatta@liv.ac.uk
- Alexandru DIMCA Université de Nice
Nice, FRANCE
dimca@math.unice.fr
- DINH Si Tiep Université de Savoie
Le Bourget du Lac, FRANCE
dinhstitiep@voila.fr
- Vladimir DOBRYNSKIY University of Kiev
Kiev, UKRAINE
dobry@imp.kiev.ua

- Wojciech DOMITRZ
Politechnika Warszawska
Warszawa, POLAND
domitrz@mini.pw.edu.pl
- Peter DONELAN
University of Wellington
Wellington, NEW ZEALAND
peter.donelan@vuw.ac.nz
- Philippe DU BOIS
Université d'Angers
Angers, FRANCE
pdubois@univ-angers.fr
- Andrew DU PLESSIS
Aarhus Universitet
Aarhus, DENMARK
matadp@imf.au.dk
- Delphine DUPONT
Université de Nice
Nice, FRANCE
ddupont@math.unice.fr
- Nicolas DUTERTRE
Université de Provence
Marseille, FRANCE
dutertre@cmi.univ-mrs.fr
- Wolfgang EBELING
Universität Hannover
Hannover, GERMANY
ebeling@math.uni-hannover.de
- Mohammed EL AMRANI
Université d'Angers
Angers, FRANCE
mohammed.elamrani@univ-angers.fr
- László FEHÉR
Eötvös Loránd Tudományegyetem
Budapest, HUNGARY
lfeher@renyi.hu
- Javier FERNÁNDEZ DE BOBADILLA
Universiteit Utrecht
Utrecht, NETHERLANDS
bobadilla@math.uu.nl
- Goulwen FICHOU
Université de Rennes
Rennes, FRANCE
goulwen.fichou@univ-rennes1.fr
- Michael FIELD
University of Houston
Houston, U.S.A.
mf@uh.edu
- Karl Heinz FIESELER
Uppsala Universitet
Uppsala, SWEDEN
khf@math.uu.se

- Sergey FINASHIN
Orta Doğu Teknik Üniversitesi
Ankara, TURKEY
serge@metu.edu.tr
- Anne FRÜHBIS-KRÜGER
Universität Kaiserslautern
Kaiserslautern, GERMANY
anne@mathematik.uni-kl.de
- Jacques-Élie FURTER
Brunel University
Uxbridge, UNITED KINGDOM
mastjef@brunel.ac.uk
- Terence GAFFNEY
Northeastern University
Boston, U.S.A.
gaff@neu.edu
- Mario GARCÍA FERNÁNDEZ
Universitat de València
Burjassot, SPAIN
garferma@alumni.uv.es
- Evelia GARCÍA BARROSO
Universidad de La Laguna
La Laguna, SPAIN
ergarcia@ull.es
- Peter GIBLIN
University of Liverpool
Liverpool, UNITED KINGDOM
pjgiblin@liv.ac.uk
- Arturo GILES
Universidad Nacional Autónoma
de México
Cuernavaca, MEXICO
arturo@matcuer.unam.mx
- Paweł GOLDSTEIN
Uniwersytet Warszawski
Warszawa, POLAND
goldie@mimuw.edu.pl
- Pedro Daniel GONZÁLEZ PÉREZ
Universidad de Madrid
Madrid, SPAIN
pgonzalez@mat.ucm.es
- Manuel GONZÁLEZ VILLA
Universidad de Madrid
Madrid, SPAIN
mgv@mat.ucm.es
- Victor GORYUNOV
University of Liverpool
Liverpool, UNITED KINGDOM
goryunov@liv.ac.uk
- Vincent GRANDJEAN
University of Bath
Bath, UNITED KINGDOM
cssvg@bath.ac.uk

- Jean-Michel GRANGER Université d'Angers
Angers, FRANCE
granger@univ-angers.fr
- Gil GUIBERT Lyce Chaptal
Paris, FRANCE
guibert9@wanadoo.fr
- Sabir GUSEIN-ZADE Moscow State University
Moscow, RUSSIA
sabir@mccme.ru
- Helmut HAMM Universität Münster
Münster, GERMANY
hamm@math.uni-muenster.de
- Herwig HAUSER Universität Innsbruck
Innsbruck, AUSTRIA
herwig.hauser@uibk.ac.at
- Fernando HERNANDO Universidad de Valladolid
Valladolid, SPAIN
hernando@agt.uva.es
- Michel HILSUM Université Paris 7
Paris, FRANCE
hilsum@math.jussieu.fr
- Kevin HOUSTON Leeds University
Leeds, UNITED KINGDOM
k.houston@leeds.ac.uk
- Dimce IVANOVSKI Université Toulouse 3
Toulouse, FRANCE
divanovski@yahoo.fr
- Shuichi IZUMIYA Hokkaido University
Sapporo, JAPAN
izumiya@math.sci.hokudai.ac.jp
- Stanislaw JANECKO Instytut Matematyczny Polskiej Akademii Nauk
Warszawa, POLAND
janeczko@impan.gov.pl
- Alain JOETS Université Paris-Sud
Orsay, FRANCE
joets@lps.u-psud.fr

- Ludger KAUP Universität Konstanz
Konstanz, GERMANY
Ludger.Kaup@Uni-Konstanz.de
- Yannick KERGOSIEN Université de Cergy-Pontoise
Cergy-Pontoise, FRANCE
yannick.kergosien@libertysurf.fr
- Dmitry KERNER Tel Aviv University
Tel Aviv, ISRAEL
kernerdm@post.tau.ac.il
- Balázs KÔMÛVES Közép-Európai Egyetem
Budapest, HUNGARY
komuves@renyi.hu
- Nikolai KRYLOV Universität Bremen
Bremen, GERMANY
n.krylov@iu-bremen.de
- Isabel LABOURIAU Universidade do Porto
Porto, PORTUGAL
islabour@fc.up.pt
- Mustapha LAHYANE Universidad de Valladolid
Valladolid, SPAIN
lahyane@agt.uva.es
- Peter LAMBERSON Columbia University
New York, U.S.A.
pjl2002@columbia.edu
- Radu LAZA Columbia University
New York, U.S.A.
laza@math.columbia.edu
- LÊ Dũng Tráng International Centre for Theoretical Physics
Trieste, ITALY
ledt@ictp.trieste.it
- André LEGRAND Université Toulouse 3
Toulouse, FRANCE
legrand@picard.ups-tlse.fr
- Ann LEMAHIEU Katholieke Universiteit Leuven
Leuven, BELGIUM
ann.lemahieu@wis.kuleuven.ac.be
- Andrzej LENARCIK Politechnika Świętokrzyska w Kielcach
Kielce, POLAND
ztpal@tu.kielce.pl

- Anatoly LIBGOBER
University of Illinois
Chicago, U.S.A.
libgober@math.uic.edu
- Gábor LIPPNER
Eötvös Loránd Tudományegyetem
Budapest, HUNGARY
lipi@cs.elte.hu
- Michael LÖNNE
Universität Hannover
Hannover, GERMANY
loenne@math.uni-hannover.de
- Ursula LUDWIG
Universität Freiburg
Freiburg, GERMANY
ursula.ludwig@math.uni-freiburg.de
- Ignacio LUENGO
Universidad de Madrid
Madrid, SPAIN
iluengo@mat.ucm.es
- Daniela Anca MĂCINIC
Institutul de Matematică "Simion Stoilow"
București, ROUMANIA
Anca.Macinic@imar.ro
- Etienne MANN
Université de Strasbourg
Strasbourg, FRANCE
mann@math.u-strasbg.fr
- Matilde MARCOLLI
Max-Planck-Institut für Mathematik
Bonn, GERMANY
marcolli@mpim-bonn.mpg.de
- Thomas MARKWIG
Universität Kaiserslautern
Kaiserslautern, GERMANY
keilen@mathematik.uni-kl.de
- Sergio MARTÍNEZ
Universidad de Zaragoza
Zaragoza, SPAIN
sergiomj@unizar.es
- Rodrigo MARTINS
Universidade de São Paulo
São Carlos, BRAZIL
rmartins@icmc.usp.br
- Laurentiu MAXIM
University of Pennsylvania
Philadelphia, U.S.A.
lmaxim@math.upenn.edu
- Alejandro MELLE HERNÁNDEZ
Universidad de Madrid
Madrid, SPAIN
amelles@mat.ucm.es

Joël MERKER	Laboratoire d'Analyse, Topologie et Probabilités, CNRS Marseille, FRANCE merker@cmi.univ-mrs.fr
Françoise MICHEL	Université Toulouse 3 Toulouse, FRANCE fmichel@picard.ups-tlse.fr
Grigory MIKHALKIN	University of Toronto Toronto, CANADA mikha@math.toronto.edu
Małgorzata MIKOSZ	Politechnika Warszawska Warszawa, POLAND emmikosz@adam.mech.pw.edu.pl
David MOND	University of Warwick Coventry, UNITED KINGDOM mond@maths.warwick.ac.uk
Simone MORAES	Universidade Federal de Viçosa Viçosa, BRAZIL smoraes@ufv.br
Heidi Camilla MORK	Universitetet i Oslo Oslo, NORWAY heidisu@math.uio.no
Piotr MORMUL	Uniwersytet Warszawski Warszawa, POLAND mormul@mimuw.edu.pl
Bernard MOURRAIN	Institut National de Recherche en Informatique et en Automatique Sophia Antipolis, FRANCE mourrain@sophia.inria.fr
Julio-José MOYANO-FERNÁNDEZ	Universidad de Valladolid Valladolid, SPAIN moyano@agt.uva.es
Claudio MUROLO	Université de Provence Marseille, FRANCE murolo@cmi.univ-mrs.fr
András NÉMETHI	Rényi Alfréd Matematikai Kutatóintézet Budapest, HUNGARY nemethi@renyi.hu
Orlando NETO	Universidade de Lisboa Lisboa, PORTUGAL orlando@ptmat.fc.ul.pt

- Walter NEUMANN Columbia University
New York, U.S.A.
neumann@math.columbia.edu
- NGUYỄN Việt Anh Max-Planck-Institut für Mathematik
Bonn, GERMANY
nguyen@mpim-bonn.mpg.de
- Johannes NICAISE Katholieke Universiteit Leuven
Leuven, BELGIUM
johannes.nicaise@wis.kuleuven.ac.be
- Alicia NIETO REYES University of Warwick
Coventry, UNITED KINGDOM
alicia@maths.warwick.ac.uk
- Mounir NISSE Université Paris 6
Paris, FRANCE
nisse@math.jussieu.fr
- Aleksandra NOWEL Uniwersytet Gdański
Gdańsk, POLAND
olanowel@math.univ.gda.pl
- Oliver OBLANCA Universidad de Valladolid
Valladolid, SPAIN
oblanca@agt.uva.es
- Mutsuo OKA Tokyo Metropolitan University
Tokyo, JAPAN
oka@comp.metro-u.ac.jp
- Ole Fogh OLSEN IT-Universitetet i København
København, DENMARK
fogh@itu.dk
- Patrice ORRO Université de Savoie
Le Bourget du Lac, FRANCE
orro@univ-savoie.fr
- Raúl OSET SINHA Universitat de València
Burjassot, SPAIN
soyperrymason@hotmail.com
- Adam PARUSIŃSKI Université d'Angers
Angers, FRANCE
adam.parusinski@univ-angers.fr
- Helge Møller PEDERSEN Aarhus Universitet
Aarhus, DENMARK
helge@imf.au.dk

- Fernand PELLETIER
Université de Savoie
Le Bourget du Lac, FRANCE
pelletier@univ-savoie.fr
- Xavier PENNEC
Institut National de Recherche
en Informatique et en Automatique
Sophia Antipolis, FRANCE
xavier.pennec@sophia.inria.fr
- Arlie PETTERS
Duke University
Durham, U.S.A.
petters@math.duke.edu
- Markus PFLAUM
Johann Wolfgang Goethe Universität
Frankfurt am Main, GERMANY
pflaum@math.uni-frankfurt.de
- Anne PICHON
Université de la Méditerranée
Marseille, FRANCE
pichon@iml.univ-mrs.fr
- Rafał PIERZCHAŁA
Uniwersytet Jagielloński w Krakowie
Kraków, POLAND
Rafal.Pierzchala@im.uj.edu.pl
- Camille PLÉNAT
Université du Mans
Le Mans, FRANCE
camille.plenat@univ-lemans.fr
- Dorin POPESCU
Universitatea din București
București, ROUMANIA
dorin.popescu@uni-due.de
- Patrick POPESCU-PAMPU
Université Paris 7
Paris, FRANCE
ppopescu@math.jussieu.fr
- Anna PRATOUSSEVITCH
Universität Bonn
Bonn, GERMANY
anna@math.uni-bonn.de
- Serge RANDRIAMBOLOLONA
Université de Savoie
Le Bourget du Lac, FRANCE
srand@univ-savoie.fr
- Carine REYDY
Université Bordeaux 1
Talence, FRANCE
Carine.Reydy@math.u-bordeaux1.fr
- Richárd RIMÁNYI
University of North Carolina
Chapel Hill, U.S.A.
rimanyi@email.unc.edu

Nicholas ROBBINS	Duke University Durham, U.S.A. robbins@math.duke.edu
Ana RODRIGUES	Universidade do Porto Porto, PORTUGAL ana.rodrigues@fc.up.pt
Beatriz RODRÍGUEZ GONZÁLEZ	Universidad de Sevilla Sevilla, SPAIN rgbea@algebra.us.es
María Carmen ROMERO FUSTER	Universitat de València Burjassot, SPAIN carmen.romero@uv.es
Guillaume ROND	Université Toulouse 3 Toulouse, FRANCE rond@picard.ups-tlse.fr
Céline ROUCAIROL	Université de Nice Nice, FRANCE roucair@math.unice.fr
Nermin SALEPÇİ	Orta Doğu Teknik Üniversitesi Ankara, TURKEY nermins@metu.edu.tr
Esther SANABRIA-CODESAL	Universitat Politècnica de València València, SPAIN esanabri@mat.upv.es
Luis SANHERMELANDO	Universitat de València Burjassot, SPAIN dep.geometria.i.topologia@uv.es
Jan SCHEPERS	Katholieke Universiteit Leuven Leuven, BELGIUM jan.schepers@wis.kuleuven.ac.be
Inna SCHERBAK	Tel Aviv University Tel Aviv, ISRAEL scherbak@post.tau.ac.il
Jörg SCHÜRMANN	Universität Münster Münster, GERMANY jschuerm@math.uni-muenster.de
José SEADE	Universidad Nacional Autónoma de México Cuernavaca, MEXICO jseade@matcuer.unam.mx

- Christian SEVENHECK Universität Mannheim
Mannheim, GERMANY
Christian.Sevenheck@uni-mannheim.de
- Dirk SIERSMA Universiteit Utrecht
Utrecht, NETHERLANDS
siersma@math.uu.nl
- Alexandre SINE Université d'Angers
Angers, FRANCE
Adam.Parusinski@univ-angers.fr
- Dana SKRBO Universitetet i Oslo
Oslo, NORWAY
danaskr@math.uio.no
- Jawad SNOUSSI Universidad Nacional Autónoma de México
Cuernavaca, MEXICO
jsnoussi@matcuer.unam.mx
- Márcio SOARES Universidade Federal de Minas Gerais
Belo Horizonte, BRAZIL
msoares@mat.ufmg.br
- Rémi SOUFFLET Université Lyon 1
Villeurbanne, FRANCE
soufflet@igd.univ-lyon1.fr
- Anna STASICA Uniwersytet Jagielloński w Krakowie
Kraków, POLAND
anna.stasica@im.uj.edu.pl
- Tatsuo SUWA Niigata University
Niigata, JAPON
suwa@ie.niigata-u.ac.jp
- Aviva SZPIRGLAS Université de Poitiers
Chasseneuil, FRANCE
aviva@math.univ-poitiers.fr
- Jean-Pierre TECOURT Institut National de Recherche
en Informatique et en Automatique
Sophia Antipolis, FRANCE
Jean-Pierre.Tecourt@sophia.inria.fr
- Bernard TEISSIER Institut de Mathématiques de Jussieu, CNRS
Paris, FRANCE
teissier@math.jussieu.fr
- Nicolae TELEMAN Università Politecnica delle Marche
Ancona, ITALY
teleman@dipmat.univpm.it

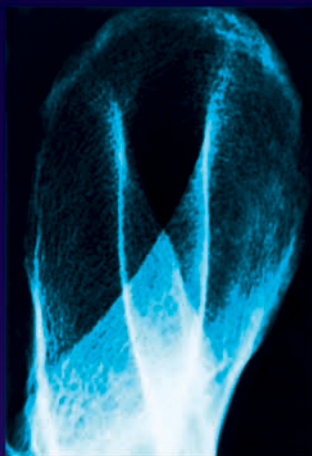
Hiroaki TERAOKA	Tokyo Metropolitan University Tokyo, JAPAN hterao@comp.metro-u.ac.jp
Tristan TORRELLI	Universidad de Valladolid Valladolid, SPAIN torrelli@math.unice.fr
David TROTMAN	Université de Provence Marseille, FRANCE trotman@cmi.univ-mrs.fr
Ricardo URIBE-VARGAS	Collège de France Paris, FRANCE uribe@math.jussieu.fr
Guillaume VALETTE	Uniwersytet Jagielloński w Krakowie Kraków, POLAND guillaume.valette@im.uj.edu.pl
Michel VAQUIÉ	Université Toulouse 3 Toulouse, FRANCE vaquie@picard.ups-tlse.fr
Gert VEGTER	Rijksuniversiteit Groningen Groningen, NETHERLANDS G.Vegter@cs.rug.nl
Willem VEYS	Katholieke Universiteit Leuven Leuven, BELGIUM wim.veys@wis.kuleuven.ac.be
Dominique WAGNER	Universität Innsbruck Innsbruck, AUSTRIA csac8698@uibk.ac.at
Andrzej WEBER	Uniwersytet Warszawski Warszawa, POLAND aweber@mimuw.edu.pl
Claude WEBER	Université de Genève Genève, SWITZERLAND Claude.Weber@math.unige.ch
Shoji YOKURA	University of Kagoshima Kagoshima, JAPAN yokura@sci.kagoshima-u.ac.jp
Yosef YOMDIN	Weizmann Institute Rehovot, ISRAEL yosef.yomdin@weizmann.ac.il

Mariusz ZAJĄC

Politechnika Warszawska
Warszawa, POLAND
zajac@mini.pw.edu.pl

Vladimir ZAKALYUKIN

Moscow University
Moscou, RUSSIA
zakalyu@mail.ru



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