

**Némethi 60**  
**Geometry and Topology of Singularities**

In honor of András Némethi's 60<sup>th</sup> birthday

BOOK OF ABSTRACTS

MTA RÉNYI INSTITUTE OF MATHEMATICS

Budapest, 27-31 May 2019

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**MTA Rényi Institute of Mathematics**, Budapest, Hungary

# Foreword

This small book contains abstracts presented by the invited speakers at the conference *Némethi60: Geometry and Topology of Singularities* that will take place at the MTA Rényi Institute of Mathematics in Budapest from 27-31 May 2019.

The aim of the conference is to bring together researchers from algebraic geometry, singularity theory and low-dimensional topology in order to present and discuss the new perspectives, results and research directions for recent and old problems in the fusion of these fields.

At the same time, this gives a good opportunity to celebrate the scientific achievements of *András Némethi* in honor of his 60th birthday, and also to express a special gratitude to him since his research, which plays a decisive role in the interactions between algebraic geometry, singularity theory and low-dimensional topology, motivated many participants of this conference in their career.

We would like to express a very special thanks to the invited speakers, Klaus Altmann from Freie Universität Berlin (Germany), Enrique Artal from Universidad de Zaragoza (Spain), Maciej Borodzik from University of Warsaw (Poland), Alexandru Dimca and Adam Parusinski from Université de Nice-Sophia Antipolis (France), Gábor Farkas from Humboldt Universität Berlin (Germany), László Fehér from ELTE University (Hungary), Gert-Martin Greuel from TU Kaiserslautern (Germany), Dmitry Kerner from Ben-Gurion University of the Negev (Israel), François Loeser from Sorbonne Université (France), Ignacio Luengo and Alejandro Melle from Universidad Complutense de Madrid (Spain), Karol Palka from IMPAN (Poland), Patrick Popescu-Pampu from Université de Lille (France), Richárd Rimányi from UNC Chapel Hill (USA), José Seade from UNAM (México), Duco van Straten from JGU Mainz (Germany), Zoltán Szabó from Princeton University (USA), Tomohiro Okuma from Yamagata University (Japan), Wim Veys from KU Leuven (Belgium) and Jonathan Wahl from UNC Chapel Hill and Duke University (USA). But we would also like to extend our thanks to all the participants for honoring this conference with their presence.

The realization of this conference would not have been possible without the contribution of our sponsors, the Foundation Compositio Mathematica, NSF-National Science Foundation (USA), NKFIH-National Research, Development and Innovation Office, the Hungarian Academy of Sciences and the MTA Rényi Institute of Mathematics, we appreciate their generous support. Special thanks goes to Richárd Rimányi for his generous help in coordinating the NSF support.

Last but not least, we would like to thank to the administration of the Rényi Institute, but especially to Szomolányi Márta, Szathmári Nóra, Szakonyi Erzsébet, Fodor Ildikó, Vajda Kata, Sztán József and Zaválnij Bogdán for their kind help during the organization.

Finally, we wish all of you a very exciting conference and a pleasant stay in Budapest!

The Organizing Committee  
Budapest, May of 2019

## Invited Speakers

**Klaus Altmann** – Freie Universität Berlin, Germany

**Enrique Artal Bartolo** – Universidad de Zaragoza, Spain

**Maciej Borodzik** – University of Warsaw, Poland

**Alexandru Dimca** – Université de Nice-Sophia Antipolis, France

**Gábor Farkas** – Humboldt-Universität Berlin, Germany

**László Fehér** – Eötvös Lóránd University, Budapest, Hungary

**Gert-Martin Greuel** – TU Kaiserslautern, Germany

**Dmitry Kerner** – Ben-Gurion University of the Negev, Israel

**François Loeser** – Sorbonne Université, France

**Ignacio Luengo Velasco** – Univesidad Complutense de Madrid, Spain

**Alejandro Melle Hernández** – Univesidad Complutense de Madrid, Spain

**Karol Palka** – IMPAN-Institute of Mathematics, Warsaw, Poland

**Adam Parusinski** – Université de Nice-Sophia Antipolis, France

**Patrick Popescu-Pampu** – Université de Lille, France

**Richárd Rimányi** – UNC Chapel Hill, USA

**José Seade** – UNAM, México

**Duco van Straten** – Johannes Guttenberg Universität Mainz, Germany

**Zoltán Szabó** – Princeton University, USA

**Tomohiro Okuma** – Yamagata University, Japan

**Wim Veys** – KU Leuven, Belgium

**Jonathan Wahl** – UNC Chapel Hill and Duke University, USA

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# Program

## Monday - 27 May 2019

09:00 - 09:30	Registration and opening
09:30 - 10:30	<b>A. Dimca</b> <i>Generators of the Jacobian syzygy module, and rational cuspidal curves</i>
10:30 - 11:00	Coffee break
11:00 - 12:00	<b>W. Veys</b> <i>Which exceptional divisors contribute to jumping numbers?</i>
12:00 - 12:10	Break
12:10 - 13:10	<b>E. Artal Bartolo</b> <i>Cyclic covers of weighted projective planes; applications to weighted-Lê-Yomdine singularities</i>
13:10 - 15:10	Lunch break
15:10 - 16:10	<b>T. Okuma</b> <i>Normal reduction numbers of normal surface singularities</i>
16:10 - 16:20	Break
16:20 - 17:20	<b>L. Fehér</b> <i>Motivic Chern classes of singularities</i>
17:20 -	Welcome reception

## Tuesday - 28 May 2019

- 09:30 - 10:30 **P. Popescu-Pampu**  
*A tropical and logarithmic study of Milnor fibers*
- 10:30 - 11:00 Coffee break
- 11:00 - 12:00 **A. Melle Hernández**  
*The minimal Tjurina number of irreducible germs of plane curves*
- 12:00 - 12:10 Break
- 12:10 - 13:10 **G. Farkas**  
*Syzygies, Koszul modules and topological invariants of groups*
- 13:10 - 15:10 Lunch break
- 15:10 - 16:10 **A. Parusinski**  
*Whitney's fibering conjecture and arc-wise analytic equisingularity*
- 16:10 - 16:20 Break
- 16:20 - 17:20 **I. Luengo Velasco**  
*Post-quantum Cryptography with high degree polynomials*
- 17:20 - 17:40 Coffee Break
- 17:40 - 18:40 **D. Kerner**  
*Tjurina modules for matrix singularities, finite determinacy, new singularity ideals*

## Wednesday - 29 May 2019

- 09:30 - 10:30 **J. Wahl**  
*Complex surface singularities with rational homology disk smoothings*
- 10:30 - 11:00 Coffee break
- 11:00 - 12:00 **Z. Szabó**  
*Link Floer homology, Thurston norm and bordered algebras*
- 12:00 - 12:10 Break
- 12:10 - 13:10 **J. Seade**  
*On the boundary of the Milnor fiber of non-isolated singularities*
- 13:10 - 15:10 Lunch break
- 15:10 - Free afternoon and Social programs



**Thursday - 30 May 2019**

09:30 - 10:30	<b>F. Loeser</b> <i>Motivic integration on the Hitchin fibration</i>
10:30 - 11:00	Coffee break
11:00 - 12:00	<b>G-M. Greuel</b> <i>Finite determinacy of matrices and ideals</i>
12:00 - 12:10	Break
12:10 - 13:10	<b>K. Palka</b> <i>Singularities of planar curves</i>
13:10 - 15:10	Lunch break
15:10 - 16:10	<b>D. van Straten</b> <i>The Hamiltonian Normal Form</i>
16:10 - 16:20	Break
16:20 - 17:20	<b>NA60</b>
19:00 -	Conference dinner

**Friday - 31 May 2019**

09:30 - 10:30	<b>K. Altmann</b> <i>Infinitesimal <math>qG</math>-deformations of cyclic quotient singularities</i>
10:30 - 11:00	Coffee break
11:00 - 12:00	<b>R. Rimányi</b> <i>From counting partitions to the structure of motivic characteristic classes</i>
12:00 - 12:10	Break
12:10 - 13:10	<b>M. Borodzik</b> <i>Real Seifert forms 20 years after</i>



# Abstracts

## **Infinitesimal $qG$ -deformations of cyclic quotient singularities**

31 May  
9:30

KLAUS ALTMANN  
Freie Universität Berlin

The subject of the talk is two-dimensional cyclic quotients, i.e. two-dimensional toric singularities. We introduce the classical work of Kollár/Shepherd-Barron relating the components of their deformations and the so-called  $P$ -resolutions, we give several combinatorial descriptions of both gadgets, and we will focus on two special components among them - the Artin component allowing a simultaneous resolution and the  $qG$ -deformations preserving the  $\mathbb{Q}$ -Gorenstein property. That is, it becomes important that several (or all) reflexive powers of the dualizing sheaf fit into the deformation as well. We will study this property in dependence on the exponent  $r$ . While the answers are already known for deformations over reduced base spaces ( $\text{char} = 0$ ), we will now focus on the infinitesimal theory. (Joint work with János Kollár.)

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## **Cyclic covers of weighted projective planes; applications to weighted-Lê-Yomdine singularities**

27 May  
12:10

ENRIQUE ARTAL BARTOLO  
Universidad de Zaragoza

It is well-known since Zariski that the Betti number of a cyclic cover of the projective plane curve ramified along a cuspidal-nodal curve depends on the position of their singularities. Following the work of Esnault–Viehweg, this formula has been generalized for arbitrary curves by several authors. In this talk, we state a version of Esnault–Viehweg results which allows to state a formula for the Betti numbers of a cyclic cover of a weighted projective plane curve ramified along a curve, in terms of the behavior of curves of some fixed degrees with respect to some multiplier ideals on the singular point. This formula follows the lines of the classical one, with some corrections on the singular points of the weighted projective plane. This formula will give information about the monodromy of weighted-Lê-Yomdine singularities of surface; rational cuspidal curves will provide surface singularities whose link is a rational homology sphere. This is a joint work in progress with J.I. Cogolludo and J. Martín-Morales.

---

31 May  
12:10

## Real Seifert forms 20 years after

MACIEJ BORODZIK  
University of Warsaw

In 1995 András Némethi introduced so-called Hodge Variation Structures, that formed a bridge between Picard–Lefschetz theory and link theory. In this talk we show how the ‘Hodge-theoretical’ point of view on knot theory originated by Némethi can help understand twisted Blanchfield pairings for links. This is a joint project with Anthony Conway and Wojciech Politarczyk.

---

27 May  
9:30

## Generators of the Jacobian syzygy module, and rational cuspidal curves

ALEXANDRU DIMCA  
Université de Nice-Sophia Antipolis

We give upper bounds for the number and degrees of generators of the module of Jacobian syzygies of a reduced plane curve. Then we relate these numbers to rational (nearly) cuspidal curves, and to curves realizing the maximum Tjurina number in a well known du Plessis–Wall inequality.

---

28 May  
12:10

## Syzygies, Koszul modules and topological invariants of groups

GÁBOR FARKAS  
Humboldt-Universität Berlin

I will discuss the deep connection between the structure of the equations of certain algebraic varieties and Alexander invariants of groups. On the algebro-geometric side, this parallelism has recently led to a very simple proof of Green’s Conjecture on syzygies of canonical curves, whereas on the topological side has produced a universal bound on the nilpotency index of the fundamental group of non-fibred compact Kähler manifolds. Joint work with Aprodu, Papadima, Raicu and Weyman.

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27 May  
16:20

## Motivic Chern classes of singularities

LÁSZLÓ FEHÉR  
Eötvös Lóránd University, Budapest

Recent progress in calculation of motivic Chern classes and equivariant motivic Chern classes will hopefully make these invariants effective tools to study singular varieties and singularities.

In this lecture I talk about the simplest case: conical singularities.

Specialization of the motivic Chern class ( $y = 0$ ) gives a motivic K-theory fundamental class. This class is different from the sheaf-theoretic and the push-forward K-class for cones over smooth hypersurfaces.

An equivariant version of the study of cones leads to the motivic generalization of the “projective Thom polynomial” formula of Fehér–Némethi–Rimányi.

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## Finite determinacy of matrices and ideals

GERT-MARTIN GREUEL

Technische Universität Kaiserslautern

30 May  
11:00

We characterize ideals  $I$  in the power series ring  $R = K[[x_1, \dots, x_s]]$  that are finitely determined up to contact equivalence. Here two ideals  $I$  and  $J$  are contact equivalent if the local  $K$ -algebras  $R/I$  and  $R/J$  are isomorphic. If  $I$  is minimally generated by  $a_1, \dots, a_m$ , we call  $I$  finitely contact determined if it is contact equivalent to any ideal  $J$  that can be generated by  $b_1, \dots, b_m$  with  $a_i - b_i \in \langle x_1, \dots, x_s \rangle^k$  for some integer  $k$ .

The main result says that  $I$  is finitely contact determined if and only if  $I$  is an isolated complete intersection singularity, provided  $\dim(R/I) > 0$  and  $K$  is an infinite field (of arbitrary characteristic). We give also computable and semicontinuous determinacy bounds.

The above result is proved by considering left–right equivalence on the ring  $M_{m,n}$  of  $m \times n$  matrices  $A$  with entries in  $R$  and we show that the Fitting ideals of a finitely determined matrix in  $M_{m,n}$  have maximal height, a result of independent interest. The case of ideals is treated by considering 1-column matrices. Fitting ideals together with a special construction are used to prove the characterization of finite determinacy for ideals in  $R$ . Some results are known in characteristic 0, but they need new (and more sophisticated) arguments in positive characteristic partly because the tangent space to the orbit of the left-right group cannot be described in the classical way. In addition we point out several other oddities, including the concept of specialization for power series, where the classical approach (due to Krull) does not work anymore. We report also on some open problems and a conjecture. (Joint with Thuy Huong Pham, to appear in J. of Algebra.)

## Tjurina modules for matrix singularities, finite determinacy, new singularity ideals

DMITRY KERNER

Ben-Gurion University of the Negev

28 May  
17:40

Let  $R$  be a local ring over a field of zero characteristic, e.g. power series in several variables. Consider the space of matrices with entries in  $R$ . Consider the action of contact group, the left-right multiplications and the coordinate changes.

We study the corresponding Tjurina module,  $T^1$ , the tangent space to the miniversal deformation.

We obtain various bounds on localizations of  $T^1$  and compute the set theoretic support of  $T^1$ , i.e. the radical of the annihilator of  $T^1$ . This brings the definition of an (apparently new) type of singular locus, the “essential singular locus” of a map/sub-scheme.

It reflects the “unexpected” singularities of a subscheme, ignoring those imposed by the singularities of the ambient space. Unlike the classical singular locus (defined by the Fitting ideal of the module of differentials) the essential one is defined by the annihilator ideal of the module of derivations.

30 May  
09:30

## Motivic integration on the Hitchin fibration

FRANÇOIS LOESER  
Sorbonne Université

Groechenig, Wyss and Ziegler have recently proved a conjecture of Hausel and Thaddeus concerning an equality between stringy Hodge numbers of moduli spaces of Higgs bundles for  $SL_n$  and  $PGL_n$ . A crucial ingredient in their approach is the use of  $p$ -adic integration in the fibres of the Hitchin fibration. We will present a motivic version of their result which is obtained by using motivic integration. This is joint work with Dimitri Wyss.

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28 May  
16:20

## Post-quantum Cryptography with high degree polynomials

IGNACIO LUENGO VELASCO  
Univesidad Complutense de Madrid

Post-quantum cryptography is the public-key cryptography resistant to future quantum computers. In this talk we will talk about a post-quantum cryptosystem called DME (Double Matrix Exponentiation) based on high degree polynomials on a small number of variables that I have developed (using ideas of Algebraic Geometry), patented and present it to the NIST contest to choose the future post-quantum cryptography standard. I will also present some Commutative Algebra open questions related with the algebraic cryptoanalysis of the scheme DME.

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28 May  
11:00

## The minimal Tjurina number of irreducible germs of plane curves

ALEJANDRO MELLE HERNÁNDEZ  
Univesidad Complutense de Madrid

In this talk a closed formula for the minimal Tjurina number of any equisingularity class in terms of the multiplicity sequence of the strict transform along a resolution is given. As a consequence, it gives a positive answer to a question of Dimca and Greuel about the quotient between the Milnor and the Tjurina numbers for any irreducible germ of plane curve singularity. (Joint work with Maria Alberich-Carramiñana, Patricio Almiron and Guillem Blanco).

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30 May  
12:10

## Singularities of planar curves

KAROL PALKA  
IMPAN-Institute of Mathematics, Warsaw

The number of singular points of a planar curve can be bounded in terms of homological invariants of the curve. But the existing bounds are far from optimal. We show how to improve them using the minimal model program for log surfaces.

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## Whitney's fibering conjecture and arc-wise analytic equisingularity

ADAM PARUSINSKI

Université de Nice-Sophia Antipolis

28 May  
15:10

We give a report on a recent result on Zariski equisingularity including a construction of an arc-wise analytic stratification and the proof of Whitney's fibering conjecture. We apply this construction to give a stratified general position theorem in real and complex algebraic geometry.

We also discuss the relation between Zariski equisingularity and Lipschitz stratification as well as several open problems.

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## A tropical and logarithmic study of Milnor fibers

PATRICK POPESCU-PAMPU

Université de Lille

28 May  
09:30

I will present joint work with Maria Angelica Cueto and Dmitry Stepanov, explaining how to combine tools from tropical and logarithmic geometries in order to understand the structure of Milnor fibers of complex singularities.

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## From counting partitions to the structure of motivic characteristic classes

RICHÁRD RIMÁNYI

University of North Carolina at Chapel Hill

31 May  
11:00

The 19th century idea of a “Durfee squares” produced an effective combinatorial trick to count partitions. (In fact, one of its modern applications is the h-index measuring mathematicians' productivity.) It has been reinterpreted in Donaldson–Thomas theory as the comparison of two ways of calculating DT invariants of the  $A_2$  quiver. In this talk, we will explore the Donaldson–Thomas quantum dilogarithm identities and their infinite-variable generalizations via motivic characteristic classes.

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## On the boundary of the Milnor fiber of non-isolated singularities

JOSÉ SEADE

Universidad Nacional Autónoma de México

29 May  
12:10

It is well-known that there is a rich interplay between isolated complex surface singularities and 3-manifolds theory. In the book by Némethi and Szilárd they bring this interesting interplay a step forward by studying the boundary  $\partial F$  of the Milnor fiber of non-isolated complex surface singularities in  $\mathbb{C}^3$ . They do so by comparing  $\partial F$  with the link  $K$ , which is itself a singular variety. The idea is reminiscent of the classical way for looking at the topology of hypersurface singularities by thinking of these as a degeneration of the non-critical levels of the defining function. This talk is about joint work with Aurelio Menegon and others, and I will discuss how these ideas can be applied to study the boundary of non-isolated singularities in general.

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30 May  
15:10

## The Hamiltonian Normal Form

DUCO VAN STRATEN

Johannes Gutenberg Universität Mainz

We describe an iteration leading to a normal form for Hamiltonian systems near a Morse critical point that is suitable for the analysis invariant tori. Under a Bruno condition on the frequency vector the iteration is convergent. We point out some consequences. This is joint work with M. Garay.

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29 May  
11:00

## Link Floer homology, Thurston norm and bordered algebras

ZOLTÁN SZABÓ

Princeton University

In a recent joint work with Peter Ozsváth, we extended the bordered algebraic approach to Link Floer homology. The lecture will explain some of the new ingredients, and discuss a relationship between these invariants and the Thurston norm.

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27 May  
15:10

## Normal reduction numbers of normal surface singularities

TOMOHIRO OKUMA

Yamagata University

We discuss the normal reduction number of the local ring of normal surface singularities. This invariant is also defined in terms of cohomology of line bundles on a resolution space. It is known that a normal surface singularity is rational if and only if the normal reduction number is one. In this talk, we show fundamental properties of normal reduction number, and then give an upper-bound in terms of the geometric genus and formulas for some special cases.

This is a joint work with Kei-ichi Watanabe and Ken-ichi Yoshida.

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27 May  
11:00

## Which exceptional divisors contribute to jumping numbers?

WIM VEYS

KU Leuven

The multiplier ideals of a hypersurface encode subtle information about its singularities. They induce important discrete invariants of such a singularity, its so-called jumping numbers, including the log canonical threshold. Given a hypersurface singularity  $(D, 0)$ , one can establish a complete list of 'candidate jumping numbers' in terms of an embedded resolution of  $(D, 0)$ . More precisely, every exceptional (prime) divisor of the resolution induces some candidate jumping numbers. However, this list is in general much too large, and it is a challenge to determine the actual jumping numbers in the list. For instance, typically many exceptional divisors induce only false candidates. When  $D$  is a curve, Smith–Thompson and Tucker found geometric characterisations of the exceptional divisors that contribute to actual jumping numbers. In particular, the ones that contribute are precisely those that already occur in a certain partial log resolution of  $(D, 0)$ , its so-called log canonical model. We investigate if and how this result generalizes to higher dimensions. This is joint work with Hans Baumers.

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## Complex surface singularities with rational homology disk smoothings

JONATHAN WAHL

University of North Carolina at Chapel Hill and Duke University

29 May  
09:30

Consider a complex normal surface singularity  $(V, 0)$  with a smoothing whose Milnor number is 0, i.e., the Milnor fibre has no rational homology. Such a  $(V, 0)$  must be a rational singularity, and all cyclic quotient singularities of type  $p^2/pq - 1$  ( $0 < q < p$ ,  $(p, q) = 1$ ) have a unique such smoothing ([3], 9.2). In the 1980's, we discovered three triply-infinite and six singly-infinite families of such singularities, all weighted homogeneous. Later work of Stipsicz, Szabó, Bhupal, and myself ([2], [1]) proved that these were the only weighted homogeneous examples. In his unpublished PhD thesis, our student Jacob Fowler made substantial progress on remaining questions about these examples, such as counting the number of distinct smoothings in each case; calculating the fundamental group of the Milnor fibre (it is finite but can be non-abelian [4]); determining the analytic type when there is a modulus in the resolution graph. We will describe these results as well as some recent progress on a few unsettled issues. We have conjectured that the above are the only surface singularities with rational homology disk smoothings. These questions have analogues in symplectic/contact geometry issues (such as the relation to the existence of symplectic fillings of the links), with related results by Stipsicz and others.

### References

- [1] M. Bhupal and A. Stipsicz, Weighted homogeneous singularities and rational homology disk smoothings. *Amer. J. Math.* **133** (2011), no. 5, 1259-1297.
  - [2] A. Stipsicz, Z. Szabó, and J. Wahl, Rational blowdowns and smoothings of surface singularities. *Journal of Topology* **1** (2008), 477-517.
  - [3] J. Wahl, Smoothings of normal surface singularities. *Topology* **20** (1981), 219-246.
  - [4] J. Wahl, On rational homology disk smoothings of valency 4 surface singularities. *Geom. Topol.* **15** (2011), 1125-1156.
-



# List of Participants

1. Antonio Alfieri – MTA Rényi Institute of Math., Budapest, Hungary
2. Hassan Al-Zoubi – Al-Zaytoonah University, Jordan
3. Patricio Almiron – Univesidad Complutense de Madrid, Spain
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5. Enrique Artal Bartolo – Universidad de Zaragoza, Spain
6. Tamás Ágoston – ELTE University, Budapest, Hungary
7. Guillem Blanco – Universitat Politècnica de Catalunya, Spain
8. József Bodnár – Stony Brook University, USA
9. Maciej Borodzik – University of Warsaw, Poland
10. Alberto Cavallo – MPI Bonn, Germany
11. Octave Curmi – Aix-Marseille Université
12. Anand Dessai – Université de Fribourg, Switzerland
13. Alexandru Dimca – Université de Nice-Sophia Antipolis, France
14. Gábor Farkas – Humboldt-Universität Berlin, Germany
15. Michal Farnik – Jagiellonian University, Krakow, Poland
16. László Fehér – ELTE University, Budapest, Hungary
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18. Edoardo Fossati – SNS Pisa, Italy
19. Viktória Földvári – ELTE University, Budapest, Hungary
20. Søren Gammelgaard – University of Oxford, UK
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