Unione Matematica Italiana

1222·2022 800 ANNI

Università degli Studi di Padova

DIPARTIMENTO MATEMATICA
DIPARTIMENTO DI MATEMATICA "TULLIO LEVI-CIVITA"

Program

with abstracts of Plenary Speakers

UMI 100 UniPD

Padova, 23rd-27th May 2022

Welcome from
Organizing Committee and Scientific Committees Chairs

Welcome to Padova and to 100 UMI - 800 UniPD
"100 Years Unione Matematica Italiana - 800 Years Università di Padova"!

In 2022, the Italian Mathematical Union (UMI) and the University of Padova celebrate the 100th anniversary and the 800th anniversary of their founding, respectively. On this unique occasion, UMI and the Department of Mathematics of University of Padova have organized an international conference hosting a world renowned list of plenary speakers and panelists. The conference hosts also the "First UMI Meeting of PhD students".

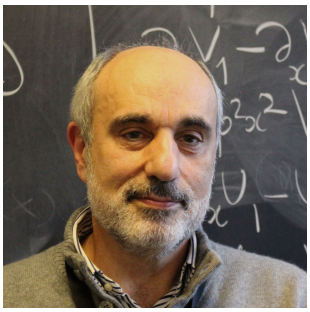
We have done our best to offer a rich program with several and diversified points of attraction. So we sincerely hope that you will find the plenary talks a rewarding experience and the three roundtables a useful opportunity to look into the past, present and future of our community. We have also included in the program two occasions of "mathematical" entertainment involving comics and drama. Last but not least, we welcome with pride the presence of over 110 young speakers coming from all over Italy. They represent the future of mathematics in our country.

We would like to take this opportunity to thank the University of Padova and Rettrice Prof. Daniela Mappelli. Moreover, we would like to thank Prorettore Prof. Marco Ferrante for all his support and helps in organizing this event. We thank as well the Director of the Department of Mathematics Prof. Bruno Chiarellotto. We would like to express our gratitude to Prof. Francesco Rossi and to all members of the Organizing and Scientific Committees who contributed essentially to the success of the final program of this conference. Special thanks are due to Cinzia Clemente and to the administrative and technical staff of the Department of Mathematics, as well as to Gioia Grigolin and to the staff of the area communication and events, for their dedication and professional work in helping to organize every logistic aspect of this conference. We thank also Elisabetta Velabri, Milena Tansini Pagani and Marcello Villani of the staff of UMI for all their valuable contribution.

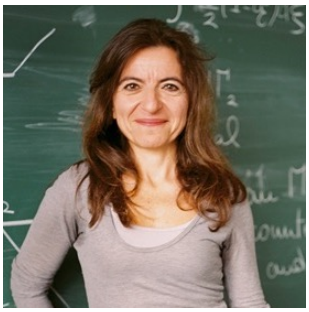
We look forward to your participation in a stimulating and productive environment of the 100 UMI - 800 UniPD conference.

Fabio Ancona

Piermarco Cannarsa



Barbara Nelli



Conference Program

with abstracts of Plenary Speakers

Monday 23rd - Aula Magna di Palazzo Bo

08:30 Registration
09:00 Opening
09:30 **Claire Voisin** - *On the complex cobordism classes of hyper-Kähler manifolds* (Chair: R. Pardini) 5
10:30 Coffee break
11:00 **Martin Hairer** - *A mathematical journey through scales* (Chair: F. Flandoli) 6
12:00 **Livia Giacardi** - *The Unione Matematica Italiana in the interwar period. Scientific, institutional and political aspects* (Chair: C. Ciliberto) 7
12:40 Lunch
14:30 **Laura De Marco** - *Rigidity and uniformity in algebraic dynamics* (Chair: C. Ulcigrai) 8
15:30 **Luca Dell'Aglio** - *Padova and the absolute differential calculus* (Chair: F. Cardin) . . 9
16:10 Coffee break
16:40 **Round Table "The usefulness of useless knowledge"**: J.-P. Bourguignon, P. Corna Pellegrini, I. Daubechies, A. Sangiovanni-Vincentelli (Chair: T. Pievani)
21:00 **Play "Spaghetti e Levi Civita"** by Teatro Boxer of Andrea Pennacchi (Sala dei Giganti, in Italian)

Tuesday 24th - Aula Magna di Palazzo Bo

09:00 **Alberto Bressan** - *Lagrangian Systems Controlled by Active Constraints* (Chair: M. Bardi) 10
10:00 **Peter Scholze** - *Condensed Mathematics* (Chair: B. Chiarellotto) 11
11:00 Coffee break
11:30 **Camillo De Lellis** - *Boundary regularity of minimal surfaces* (Chair: P. Marcati) . . 12
12:30 Lunch
14:30 **Cynthia Dwork** - *Outcome Indistinguishability, Scaffolding Sets, and Pan-Calibration* (Chair: F. Baldassarri) 13
15:30 Coffee break
16:00 **Round Table "Mathematical challenges in an AI driven world"**: P. Baldi, G. Kutyniok, Y. LeCun, T. Poggio (Chair: E. De Vito)

Wednesday 25th - Auditorium Pollini

09:00 **Alessio Figalli** - *Ubiquità del Trasporto Ottimale* (Chair: P. Cannarsa) 14
10:00 **Prizes Award**
10:30 **Corollario Choir concert**
11:00 Coffee break
11:30 **Assemblea UMI**
13:00 Light lunch (NEW LOCATION: Torre Archimede)
Free afternoon
19:00 Free transportation from Torre Archimede to the location of Social Dinner
19:30 Social Dinner (Villa Foscarini-Rossi)

Thursday 26th - Torre Archimede

09:00* **Alessandro Giuliani** - *Spontaneous breaking of continuous symmetry in the Heisenberg model: old and new* (Chair: B. Nelli) 15
10:00 **Parallel sessions - BDEFGJKLMN**
11:00 Coffee break - Ground Floor
11:30 **Parallel sessions - BDEFGJKLMN**
12:30 Lunch
14:00* **Andrea Mondino** - *Smooth and non-smooth aspects of Ricci curvature lower bounds* (Chair: D. Vittone) 16
15:00 Coffee break - Ground Floor
15:30 **Parallel sessions - ACDEGJKLMN**
16:30* **Round Table "11^2 years after Volterra: applying mathematics to biological and social sciences"**: I. Dorigatti, M. Fornasier, B. Piccoli (Chair: R. Natalini)

Friday 27th - Torre Archimede

08:30 **Parallel sessions - EGJM**
09:00 **Parallel sessions - ABCEGHJLM**
09:30* **Giulia Saccà** - *Holomorphic symplectic manifolds and completely integrable systems* (Chair: B. Nelli) 17
10:30 Coffee break - Ground Floor
11:00* **The after math. Quali lavori per i PhD in Matematica? Incontro con alcune aziende** (in Italian, Chairs: G. Callegaro, A. Larese)
12:00 **Parallel sessions - ABCDFGHIKM**
13:00 Lunch
14:30 **Parallel sessions - ABCDFGIKLM**
15:30* **Daniele Di Pietro** - *From physical models to advanced numerical methods through de Rham cohomology* (Chair: S. De Marchi) 18
16:30 Farewell Spritz - Ground Floor

* In Torre Archimede, all Plenaries and Round Tables are in Room 1A150 - 1st Floor, with live streaming in Room 1C150 - 1st Floor.

Thursday 26th, Friday 27th - List of Parallel Sessions 19

ON THE COMPLEX COBORDISM CLASSES OF HYPER-KÄHLER MANIFOLDS

CLAIRE VOISIN

Hyper-Kähler manifolds are symplectic holomorphic compact Kähler manifolds, a particular class of complex manifolds with trivial canonical bundle. They exist only in even complex dimension, and there are two main series of known deformation classes of hyper-Kähler manifolds, with one model in each even dimension, that I will describe. I will discuss in this introductory talk a result obtained with Georg Oberdieck and Jieao Song on the complex cobordism classes of hyper-Kähler manifolds, and present a number of open questions concerning their Chern numbers.

CNRS, Institut de mathématiques de Jussieu
Email address: claire.voisin@imj-prg.fr
URL: https://webusers.imj-prg.fr/~claire.voisin/

A MATHEMATICAL JOURNEY THROUGH SCALES

MARTIN HAIRER

The tiny world of particles and atoms and the gigantic world of the entire universe are separated by about forty orders of magnitude. As we move from one to the other, the laws of nature can behave in drastically different ways, sometimes obeying quantum physics, general relativity, or Newtons classical mechanics, not to mention other intermediate theories. Understanding the transformations that take place from one scale to another is one of the great classical questions in mathematics and theoretical physics, one that still hasn't been fully resolved. In this lecture, we will explore how these questions still inform and motivate interesting problems in probability theory and why so-called toy models, despite their superficially playful character, can sometimes lead to certain quantitative predictions.

Imperial College London
E-mail address: m.hairer@imperial.ac.uk
URL: www.hairer.org

THE UNIONE MATEMATICA ITALIANA IN THE INTERWAR PERIOD. SCIENTIFIC, INSTITUTIONAL AND POLITICAL ASPECTS

LIVIA GIACARDI

The Italian Mathematical Union (UMI) celebrates its centenary this year. It was indeed set up in 1922 in accordance with a motion approved in Brussels in July 1919 by the International Research Council, which promoted the creation of national scientific committees. The national and international background of this event is very problematic in various respects. 1922 is the year of the March on Rome that brought the fascist party to power, and later on to a gradual transformation of the fascist government into a dictatorship. Furthermore, serious international tensions made the situation even more complex. In particular, in the aftermath of WWI the ex-Central Powers were excluded from the new scientific institutions the International Research Council (1919) and the International Mathematical Union (1920). The recent reorganization of the UMI Archives has made a lot of significant documents available to historians, who can now shed light on the backstage of the first twenty years of UMI's life.

We aim to outline UMI's history in the interwar period by considering three different aspects: autarky versus internationalism; pure mathematics versus applied mathematics; fascist policy versus circulation of people and mathematical ideas. We will focus on the (i) role of Volterra and Pincherle in the foundation of the UMI and certain initial difficulties; (ii) UMI's international relationships and especially Pincherle's involvement in the International Congresses of Mathematicians of Toronto (1924) and of Bologna (1928); (iii) UMI's relations with fascism and their consequences on its Bulletin. Our research is based on unpublished letters and documents contained in the UMI Archives.

This is a joint work with ROSSANA TAZZIOLI (rossana.tazzioli@univ-lille.fr)

References

[1] Giacardi, L., Tazzioli, R., *The UMI Archives. Debates in the Italian Mathematical Community, 1922-1938*, EMS Newsletter, pp. 37–44, 2019

[2] Giacardi, L., Tazzioli, R., *The Unione Matematica Italiana and its Bollettino, 1922-1928. National and International Aspects*, in L. Mazliak, R. Tazzioli (Eds.), *Mathematical Communities in the Reconstruction After the Great War, 1918-1928*, pp. 31–61, Springer, 2021

[3] Giacardi, L., Tazzioli, R., *Le Bollettino della Unione Matematica Italiana (BUMI) et ses enjeux politiques et idéologiques (1922–1943*, in H. Gispert, P. Nabonnand, J. Peiffer (Eds.), *Circulations mathématiques dans et par les journaux : histoire, territoires et publics*, Chap. 1, London, ISTE, to appear

[4] Lehto, O., *Mathematics Without Borders. A History of the International Mathematical Union*, Springer, 1998

Livia Giacardi, Department of Mathematics, University of Turin
E-mail address: livia.giacardi@unito.it

RIGIDITY AND UNIFORMITY IN ALGEBRAIC DYNAMICS

LAURA DE MARCO

The periodic orbits and their structure are fundamental features of a dynamical system. In an algebraic setting, where the system is defined by polynomials, we can use tools from algebraic or arithmetic geometry to study these orbits. Important special cases include endomorphims of abelian varieties, for example as appearing in the proofs of uniform versions of the Mordell or Manin-Mumford Conjectures in the recent breakthroughs of Dimitrov-Gao-Habegger, Kühne, Yuan and others, where the torsion points of the group coincide with the preperiodic points of an endomorphism. In this talk, I will describe some parallel questions and recent progress on more general families of complex and arithmetic dynamical systems.

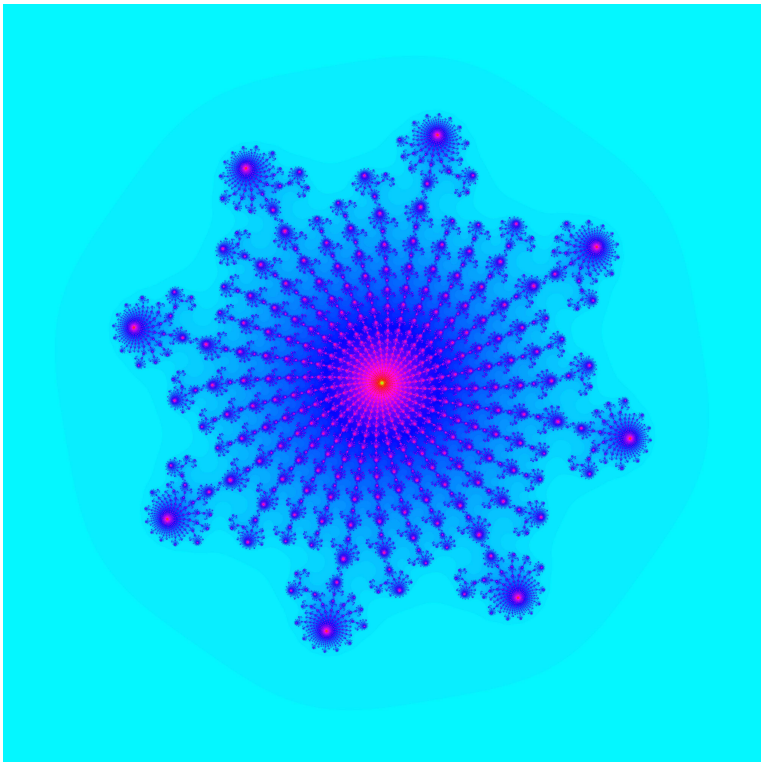


FIGURE 1. The Julia set of a polynomial with symmetries

HARVARD UNIVERSITY
E-mail address: demarco@math.harvard.edu
URL: https://people.math.harvard.edu/~demarco/

PADOVA AND THE ABSOLUTE DIFFERENTIAL CALCULUS

LUCA DELL'AGLIO

The aim of this talk is to highlight the close connections between the University of Padova and the history of the absolute differential calculus, particularly in the period preceding its consideration as the mathematical theory of general relativity. This concerns both the origins and early developments of tensor analysis, above all in relation to the central and differentiated roles played in this context by the research of Gregorio Ricci-Curbastro and Tullio Levi-Civita. Furthermore, the difficulties that the absolute differential calculus found at the time in terms of reception, especially at the national level, are of particular relevance here, being partly accepted from some points of view but not from others. A factor that further accentuated the role played by the scientific context of Padova in the initial phase of the theory's development.

References

[1] Dell'Aglio L., *On the genesis of the concept of covariant differentiation*, Revue d'histoire des mathématiques, 2, pp. 215–264, 1996.

[2] Goodstein J.R., *Einstein's Italian Mathematicians*, American Mathematical Society, Providence, Rhode Island, 2018.

[3] Levi-Civita T., *Nozione di parallelismo in una varietá qualunque e conseguente specificazione geometrica della curvatura riemanniana*, Rendiconti del Circolo Matematico di Palermo, 42, pp. 173–205, 1917.

[4] Reich K., *Die Entwicklung des Tensorkalküls*, Birkhäuser, Basel, 1994.

[5] Ricci-Curbastro G., *Sulla derivazione covariante ad una forma quadratica differenziale*, Rendiconti della Reale Accademia dei Lincei, s. 4, t. 3, pp. 15–18, 1887.

[6] Ricci-Curbastro G., *Sopra certi sistemi di funzioni*, Rendiconti della Reale Accademia dei Lincei, s. 4, t. 5, pp. 112–118, 1889.

[7] Ricci-Curbastro G., Levi-Civita T., *Méthodes de calcul différentiel absolu et leurs applications*, Mathematische Annalen, 54, pp. 125–201, 1901.

University of Calabria
E-mail address: luca.dellaglio@unical.it

LAGRANGIAN SYSTEMS CONTROLLED BY ACTIVE CONSTRAINTS

ALBERTO BRESSAN

The talk will survey various results on the control of mechanical systems, by means of time-dependent, frictionless constraints. The basic mathematical description involves a Riemann manifold, together with a foliation describing the constraints. The equations of motion usually have an impulsive character, containing the time derivative of the control function. Their analytical form is closely linked to the geometric structure of the foliation. This same framework can also be used to study swim-like motion of one or more deformable bodies in a perfect fluid.

Major contributions to this theory were provided by researchers from the University of Padova.

References

[1] A. Bressan, *Impulsive control of Lagrangian systems and locomotion in fluids*, Discr. Cont. Dynam. Syst. **20** (2008), 1–35.

[2] A. Bressan and F. Rampazzo, *On differential systems with vector-valued impulsive controls*, Boll. Un. Mat. Italiana **2-B**, (1988), 641–656.

[3] A. Bressan and F. Rampazzo, *Moving constraints as stabilizing controls in classical mechanics*, Arch. Rational Mech. Anal. **196** (2010), 97–141.

[4] Aldo Bressan, *Hyper-impulsive motions and controllizable coordinates for Lagrangean systems*, Atti Accad. Naz. Lincei, Cl. Sci. Fis. Mat. Natur. Mem., Serie VIII, Vol. XIX (1990), 197–246.

[5] Aldo Bressan, *On some control problems concerning the ski or swing*, Atti Accad. Naz. Lincei, Cl. Sci. Fis. Mat. Natur. Mem., Serie IX, Vol. I, (1991), 147–196.

[6] F. Cardin and M. Favretti, *Hyper-impulsive motion on manifolds*, Dynam. Cont. Discr. Imp. Systems **4** (1998), 1–21.

[7] G. Dal Maso and F. Rampazzo, *On systems of ordinary differential equations with measures as controls*, Diff. Integral Equat. **4** (1991), 739–765.

[8] G. Dal Maso, P. LeFloch, and F. Murat, *Definition and weak stability of nonconservative products*, J. Math. Pures Appl. **74** (1995), 483–548.

[9] C. Marle, *Géométrie des systèmes mécaniques à liaisons actives*, in Symplectic Geometry and Mathematical Physics, Birkhäuser, Boston, 1991, pp. 260–287.

[10] M. Motta and F. Rampazzo, *Dynamic programming for nonlinear systems driven by ordinary and impulsive controls*, SIAM J. Control Optim. **34** (1996), 199–225.

[11] F. Rampazzo, *On the Riemannian structure of a Lagrangean system and the problem of adding time-dependent coordinates as controls*, European J. Mechanics A/Solids, **10** (1991), 405-431.

Penn State University
Email address: axb62@psu.edu
URL: http://personal.psu.edu/axb62/index.html

CONDENSED MATHEMATICS

PETER SCHOLZE

One of the most basic notions in mathematics is the notion of a topological space, which formalizes the idea of a space with a notion "nearness" of points. First introduced by Hausdorff in 1914, it has become central in all areas of mathematics. However, in some respects the notion of topological space is not optimal; for example, it can not formalize the idea of "points that are infinitely near but distinct" in a useful way. In 2018, Dustin Clausen came to Bonn, and proposed a certain substitute for topological spaces that we termed condensed sets, and that overcomes these foundational issues. I will try to give an overview of these ideas.

Max-Planck-Institut für Mathematik, Bonn
E-mail address: scholze@mpim-bonn.mpg.de
URL: http://people.mpim-bonn.mpg.de/scholze/

BOUNDARY REGULARITY OF MINIMAL SURFACES

CAMILLO DE LELLIS

The critical points of the area functional, usually called minimal surfaces, have a long history in mathematics. Perhaps the most famous examples are the solutions of the so-called Plateau's problem, i.e. surfaces which minimize the area among the ones spanning a given contour. It is known since long that area minimiziers can form singularities and several concepts of generalized solutions, which serve different purposes, have been introduced in the literature since the first decades of the last century. A wide field of study is the regularity of the latter objects. While there is a quite good understanding of the size of singularities away from the boundary in very many situations, the same cannot be said for the case of boundary singularities, for which we have very satisfactory theorems only in relatively few, albeit important, cases. I will review some results of the last decade which touched for the first time a category of problems in the area, and I will explain a recent joint work with Stefano Nardulli and Simone Steinbruchel which gives a first positive answer to a question of Allard and White.

IAS Princeton
E-mail address: camillo.delellis@ias.edu
URL: https://www.math.ias.edu/delellis/

OUTCOME INDISTINGUISHABILITY, SCAFFOLDING SETS, AND PAN-CALIBRATION

CYNTHIA DWORK

Prediction algorithms score individuals, or individual instances, assigning to each one a number in the range from 0 to 1. That score is often interpreted as a probability: What are the chances that this loan will be repaid? How likely is this tumor to metastasize? A key question lingers: What is the "probability" of a non-repeatable event? This is the defining problem of AI. Without a satisfactory answer, how can we even specify what we want from an ideal algorithm?

This talk will introduce *outcome indistinguishability* [2], a desideratum with roots in computational complexity theory, and will situate the concept within the landscape of algorithmic fairness.

Outcome indistinguishability generalizes *multi-calibration*, a fairness notion for prediction algorithms that requires simultaneous calibration on a (possibly large) pre-specified collection of subsets of the population [3]. Here, too, a question lingers: what can be done to ensure that all subordinated groups – including those whose members cannot advocate for themselves – are included in the collection?

We will show how to circumvent this problem through the use of a *Scaffolding Set* collection [1], and give some simple conditions under which such a collection can be efficiently constructed. When these conditions are not met, no harm is done; when they are satisfied, calibration is achieved simultaneously on all large subpopulations, a concept we call *pan-calibration*.

References

[1] M. Burhanpurkar, Z. Deng, C. Dwork, and L. Zhang, *Scaffolding Sets*, arXiv preprint arXiv:2111.03135, 2021.

[2] C. Dwork, M. P. Kim, O. Reingold, Guy N. Rothblum, and G. Yona, *Outcome Indistinguishability*, Proceedings of the 53rd Annual ACM SIGACT Symposium on Theory of Computing, 1095–1108, 2021

[3] U. Hébert-Johnson, M. P. Kim, O. Reingold, and G. Rothblum, *Multicalibration: Calibration for the (computationally-identifiable) masses*, International Conference on Machine Learning, PMLR, 1939–1948, 2018

Harvard University
Email address: dwork@seas.harvard.edu

UBIQUITÀ DEL TRASPORTO OTTIMALE

ALESSIO FIGALLI

Alla fine del XVIII secolo, Gaspard Monge introdusse il trasporto ottimale come strumento per capire il modo più efficiente di trasportare una distribuzione di materiale da un luogo all'altro per costruire fortificazioni. Più tardi, negli anni '40, Kantorovich sviluppò questa teoria e per il suo lavoro ricevette il premio Nobel per l'economia. Negli ultimi 30 anni il trasporto ottimale ha trovato varie applicazioni in molti problemi, sia matematici che di natura più applicata. In questa presentazione darò una panoramica di questa teoria e di alcune delle sue applicazioni.

ETH Zürich
E-mail address: alessio.figalli@math.ethz.ch
URL: https://people.math.ethz.ch/~afigalli/

SPONTANEOUS BREAKING OF CONTINUOUS SYMMETRY IN THE HEISENBERG MODEL: OLD AND NEW

ALESSANDRO GIULIANI

In this talk I will first introduce the notion of spontaneous symmetry breaking in statistical mechanics, with particular emphasis on the case of broken continuous symmetry for models of interacting continuous spins, such as the XY model or the Heisenberg model. Then I will review the state of the art, describing some of the most important and influential results on the low temperature behavior of such systems, most notably the one of Frohlich-Simon-Spencer, who proved, in 1976, the existence of orientational long range order for the 3D classical Heisenberg model via the first application of reflection positivity methods to statistical mechanics, and the one of Dyson-Lieb-Simon, who extended this result, in 1978, to the case of the quantum anti-ferromagnetic Heisenberg model. Next I will discuss some important open problems and review recent advances on the understanding of the low temperature behavior of classical and quantum Heisenberg models in three dimensions.

Università Roma 3
E-mail address: giuliani@mat.uniroma3.it

SMOOTH AND NON-SMOOTH ASPECTS OF RICCI CURVATURE LOWER BOUNDS

ANDREA MONDINO

After recalling the basic notions coming from differential geometry, the talk will be focused on spaces satisfying Ricci curvature lower bounds. The idea of compactifying the space of Riemannian manifolds satisfying Ricci curvature lower bounds goes back to Gromov in the 80s and was pushed by Cheeger and Colding in the 90s who investigated the fine structure of possibly non-smooth limit spaces. A completely new approach via optimal transportation was proposed by Sturm and Lott-Villani around fifteen years ago. Via such an approach one can give a precise definition of what means for a non-smooth space to have Ricci curvature bounded below. Such an approach has been refined in the last years giving new insights to the theory and yielding applications which seems to be new even for smooth Riemannian manifolds.

The talk is meant to be an introduction to the topic, accessible to non-specialists and as self-contained as possible.

University of Oxford
E-mail address: andrea.mondino@maths.ox.ac.uk
URL: https://www.maths.ox.ac.uk/people/andrea.mondino

HOLOMORPHIC SYMPLECTIC MANIFOLDS AND COMPLETELY INTEGRABLE SYSTEMS

GIULIA SACCÀ

Irreducible holomorphic symplectic manifolds are one of the building blocks of compact Kähler manifolds with trivial first Chern class. They made their first appearance in algebraic geometry in the 80's [1, 3], thanks to results in differential geometry, and since then have attracted significant attention. Their rich geometry has ties to other areas of mathematics, such as representation theory and mathematical physics.

Some irreducible holomorphic symplectic manifolds have a structure of completely integrable system which, in this context, means that they admit a fibration whose general fiber is a complex torus which is Lagrangian [2]. These fibrations are called Lagrangian and it turns out they are extremely useful for constructing and studying examples of irreducible holomorphic symplectic manifolds. In this talk I will give an introduction to irreducible holomorphic symplectic manifolds, with a focus on Lagrangian fibrations.

References

[1] A. Beauville. Variétés Kähleriennes dont la première classe de Chern est nulle. *J. Diff. Geom.*, 18:755–782, 1983.

[2] A. Beauville. Systèmes hamiltoniens complètament intégrables associés aux surface K3. *Symp. Math.*, 32 pp 25031, 1991.

[3] S. Mukai. Symplectic structure of the moduli space of sheaves on an abelian or $K3$ surface. *Invent. Math.*, 77(1):101–116, 1984.

Columbia University

FROM PHYSICAL MODELS TO ADVANCED NUMERICAL METHODS THROUGH DE RHAM COHOMOLOGY

DANIELE A. DI PIETRO

The well-posedness of relevant physical models expressed in terms of partial differential equations (PDE) hinges on subtle analytical, homological, and algebraic properties underlying Hilbert complexes [1]. The best-known example is the de Rham complex which, in practically relevant situations, can be expressed through vector proxies as the sequence of Hilbert spaces H^1, $\boldsymbol{H}(\mathbf{curl})$, $\boldsymbol{H}(\mathrm{div})$, and L^2 connected by the vector calculus operators gradiend, curl, and divergence. In the first part of this presentation, we illustrate the role of the de Rham complex in the well-posedness of several PDE problems arising in various fields of physics.

The design of efficient numerical methods for such problems is challenging for several reasons: on one hand, stability requires to mimic, at the discrete level, the homological and analytical properties of the de Rham complex (leading to the notion of "compatible method"); on the other hand, the complicated geometrical features of the domain and behaviours of the solution require a great flexibility in terms of supported meshes and approximation orders. In the second part of this presentation we provide an introduction to the recently introduced Discrete de Rham (DDR) paradigm [4, 2, 3] for the design and analysis of compatible discretization methods supporting general polyhedral meshes and arbitrary orders.

The general principle of DDR methods is to replace both spaces and operators by discrete counterparts designed so as to be compatible with the cohomology properties of the continuous complex. Specifically:

- The discrete spaces are spanned by vectors of polynomials with components attached to mesh entities in order to mimic, through their single-valuedness, global (complete or partial) continuity properties of the continuous spaces. The local polynomial spaces can be either full or incomplete.
- The discrete operators are obtained in two steps: first, reconstructions in full polynomial spaces are built mimicking an approximate version of the Stokes formula; second, whenever needed, the L^2-orthogonal projection on the appropriate incomplete polynomial space is taken.

A full set of results for DDR methods have been recently proved [2], including cohomology-related properties, Poincar inequalities, as well as primal and adjoint consistency of the discrete vector calculus operators. An overview of such results, along with examples of applications, is provided.

References

[1] D. Arnold, *Finite Element Exterior Calculus*, SIAM, 2018

[2] D. A. Di Pietro and J. Droniou, *An arbitrary-order discrete de Rham complex on polyhedral meshes: Exactness, Poincar inequalities, and consistency*, Found. Comput. Math., DOI: 10.1007/s10208-021-09542-8, 2021.

[3] D. A. Di Pietro and J. Droniou, *An arbitrary-order method for magnetostatics on polyhedral meshes based on a discrete de Rham sequence*, J. Comput. Phys., 429:109991, 2021.

[4] D. A. Di Pietro and J. Droniou and F. Rapetti, *Fully discrete polynomial de Rham sequences of arbitrary degree on polygons and polyhedra*, Math. Models Methods Appl. Sci., 30:9, pp. 1809–1855, 2020.

Institut Montpellirain Alexander Grothendieck, Universit de Montpellier, CNRS, France
E-mail address: daniele.di-pietro@umontpellier.fr
URL: https://imag.umontpellier.fr/~di-pietro/

Parallel Sessions

Session A - Logica, Storia, Didattica

Thursday - Room 2AB45 - 2nd Floor

15.30: E. Scalambro - *Material and non-material heritage of the Italian School of algebraic geometry (1880-1950)*
16.00: C. Agostini - *Polish-like spaces and Descriptive Set Theory at uncountable cardinals*

Friday - Room 2AB45 - 2nd Floor

09.00: D. Pasquazi - *Dynamic imagination for solving geometric problems*
12.00: G. Bini - *Mathematical memes: from internet phenomenon to digital educational resource*
12.30: S. Bagossi - *Second-order covariation: an analysis of students' forms of reasoning and teacher's interventions when modelling real phenomena*
14.30: V. Delle Rose - *Probabilistic vs deterministic gamblers*
15.00: C. Manolino - *Semiosphere lens for Mathematics Teacher Education*

Session B - Algebra

Thursday - Room 2AB45 - 2nd Floor

10.00: C. Cisto - *Irreducible generalized numerical semigroups and a generalization of Wilf's conjecture*
10.30: S. Di Trani - *Exterior algebra: new and old results, open problems and generalizations*
11.30: P. Magrone - *Generalized Heegner cycles and p-adic L-functions in a quaternionic setting*
12.00: M. Mazzotta - *Recent developments of the set-theoretical solutions to the pentagon equation*

Friday - Room 1BC50 - 1st Floor

09.00: M. Rogers - *Toposes of Monoid Actions*
12.00: H. Yu - *N-fiber-full modules*
12.30: D. Taufer - *Elliptic Loops*
14.30: M. Noce - *Engel conditions in groups*
15.00: S. Pavon - *Derived equivalences for commutative noetherian rings*

Session C - Geometria Algebrica

Thursday - Room ASTA - 2nd Floor

15.30: S. Secci - *Fano manifolds with Lefschetz defect 3*
16.00: I. Spelta - *On special subvarieties of the Torelli locus*

Friday - Room 2BC30 - 2nd Floor

09.00: Y. Prieto-Montañez - *Automorphisms on algebraic varieties: K3 surfaces, hyperkähler manifolds, and applications on Ulrich bundles*
12.00: M. Pernice - *Results about the Chow ring of moduli of stable curves of genus three.*
12.30: A. Franceschini - *Equivariant birational transformations and generalizations of matrix inversion*
14.30: F. Conti - *Surfaces close to the Severi lines*
15.00: F. Fallucca - *Surfaces with canonical map of high degree*

Session D - Geometria Differenziale e Topologia

Thursday - Room 1AD100 - 1st Floor

10.00: V. Fantini - *Infinitesimal deformations and the Extended Tropical Vertex group*
10.30: M. Fogagnolo - *Capacitary potentials in Riemannian manifolds and geometric applications*
11.30: E. Landi - *Equivariant localization methods, orientations and modularity*
12.00: L. Mathis - *Zonoids: what are they and how to multiply them*
15.30: A. Roncoroni - *Extremals and critical points of the Sobolev inequality*
16.00: F. Sarti - *Numerical invariants for measurable cocycles*

Friday - Room 1AD100 - 1st Floor

12.00: M. Stecconi - *Random Differential Topology*
12.30: S. Spessato - *A pullback functor for L2-cohomology*
14.30: E. Savi - *The topology of real algebraic sets with isolated singularities is determined by the field of rational numbers*
15.00: C. Scarpa - *K-stability and the Hitchin-cscK system*

Session E - Calcolo delle Variazioni

Thursday - Room 1BC50 - 1st Floor

10.00: A. Merlo - *Geometry of 1-codimensional measures in the Heisenberg groups*
10.30: G. Stefani - *A distributional approach to fractional Sobolev spaces and fractional variation*
11.30: A. Maione - *Variational convergences for functionals and differential operators depending on vector fields*
12.00: F. Oronzio - *A Green's function proof of the positive mass theorem*
15.30: G. Canneori - *Symbolic dynamics for the anisotropic N-centre problem*
16.00: L. Lombardini - *Nonlocal minimal graphs*

Friday - Room ASTA - 2nd Floor

08.30: D. Semola - *Geometric measure theory under lower Ricci curvature bounds: a non smooth perspective*
09.00: S. Frassu - *Multiple constant sign and nodal solutions for the fractional p-Laplacian*

Session F - Teoria del controllo

Thursday - Room ASTA - 2nd Floor

10.00: C. Mendico - *Asymptotic behavior of solutions to Hamilton-Jacobi-Bellmann equations*
10.30: A. Scagliotti - *Deep Learning approximation of diffeomorphisms via linear-control systems*
11.30: C. Urbani - *Bilinear control of evolution equations on compact networks*
12.00: S. Baranzini - *The Morse index for constrained optimal problems*

Friday - Room ASTA - 2nd Floor

12.00: L. Marzufero - *A time-dependent switching mean-field game on networks*
12.30: G. Fusco - *Nondegenerate abnormality and gap phenomena in optimal control with state constraints*
14.30: M. Chiri - *Controlling the spread of invasive biological species*
15.00: G. Ciampa - *Vanishing viscosity in mean-field optimal control*

Session G - Equazioni a derivate parziali

Thursday - Room 1A150 - 1st Floor

10.00: E. Affili - *Decay estimates in evolution equations with classical and fractional time-derivatives*
10.30: A. Falocchi - *Some regularity results for the 3D evolution Navier-Stokes equations under Navier boundary conditions in some Lipschitz domains*
11.30: M. Zaccaron - *Spectral sensitivity analysis of electromagnetic cavities*
12.00: A. Goffi - *Optimal gradient regularity for semilinear and quasilinear equations with power-growth nonlinearities*
15.30: U. Guarnotta - *Strongly singular convective elliptic equations in RN driven by a non-homogeneous operator*
16.00: L. Hientzsch - *The asymptotic lake equations for vanishing or emerging islands*

Friday - Room 1A150 - 1st Floor

08.30: G. Comi - *Refined Gauss-Green formulas*
09.00: G. Girardi - *Asymptotic profile for a two-terms time fractional diffusion problem*
12.00: E. Proietti Lippi - *Nonlocal Neumann boundary conditions: properties and problems*
12.30: C. Patriarca - *Attractors for a fluid-structure interaction problem with time-dependent phase space*
14.30: A. Gentile - *Higher differentiability results for solutions to some non-autonomous elliptic obstacle problems*
15.00: G. Meglioli - *Smoothing effects and infinite time blowup for reaction-diffusion equations: an approach via Sobolev and Poincaré inequalities*

Session H - Equazioni a derivate parziali lineari

Friday - Room 2BC60 - 2nd Floor

09.00: N. Forcillo - *A recent perturbative method to the free boundary regularity in the one-phase Stefan problem*
12.00: P. Luzzini - *Heat equation and layer potentials: old and new results*
12.30: R. Ognibene - *Spectral stability of the Laplacian under perturbation of the boundary conditions*

Session I - Analisi Funzionale

Friday - Room 2AB40 - 2nd Floor

12.00: M. Maiuriello - *Linear Dynamics: an analysis of the behavior of composition operators on L^p spaces*
12.30: N. Chalmoukis - *Exceptional sets for Hardy Sobolev spaces in several complex variables*
14.30: F. Bartolucci - *Unitarization and Inversion Formulae for the Radon Transform between Dual Pairs*
15.00: M. Capolli - *Lusin Approximation Theorems of Order m in Carnot Groups*

Session J - Probabilità, Ricerca operativa, Statistica

Thursday - Room 2BC30 - 2nd Floor

10.00: M. Catalano - *A Wasserstein index of dependence for Bayesian nonparametric modeling*
10.30: M. Aleandri - *Opinion dynamics: conformist and nonconformist interacting agents*
11.30: G. Ascione - *Semi-Markov processes, time-nonlocal equations and related spectral methods*
15.30: A. Doldi - *Entropy martingale optimal transport and nonlinear pricing-hedging duality*
16.00: F. Grotto - *Random Wave Models on Hyperbolic Space*

Friday - Room 1BC45 - 1st Floor

08.30: M. Quattropani - *The stationary distribution of random walks on random directed graphs*
09.00: M. Martini - *Kolmogorov equations on spaces of measures associated to nonlinear filtering processes*

Session K - Fisica Matematica

Thursday - Room 1BC45 - 1st Floor

10.00: G. Bevilacqua - *Pattern formation in soft matter: emergence of faraday instability in soft solids*
10.30: F. Camilli - *Glassy behavior in mismatched rank-one matrix estimation*
11.30: C. Caraci - *Bose-Einstein condensation for two dimensional interacting bosons in the Gross-Pitaevskii scaling*
12.00: M. Dolce - *Linear stability properties of shear flows in inhomogeneous fluids*
15.30: C. Koudjinan - *On non coexistence of 2 & 3-rational caustics in nearly circular billiard tables*
16.00: S. Paparini - *Mathematical Models for Chromonic Liquid Crystals*

Friday - Room 1BC45 - 1st Floor

12.00: N. Loy - *Direction-Dependent Turning Leads to Anisotropic Diffusion and Persistence*
12.30: M. Viviani - *Canonical Scale Separation in 2D Incompressible Hydrodynamics*
14.30: P. Vergallo - *Second order homogeneous Hamiltonian operators and projective geometry*
15.00: S. Trapasso - *Harmonic analysis of Feynman path integrals*

Session L - Analisi Numerica

Thursday - Room 2BC60 - 2nd Floor

10.00: A. Andò - *Convergence of the piecewise orthogonal collocation for periodic solutions of delay equations*

10.30: N. Caruso - *Krylov Solvability in a Perturbative Framework*

11.30: G. Di Credico - *Energetic Boundary Element Method for 2D Elastodynamics Problems in Time Domain*

12.00: S. Di Giovacchino - *Structure-preserving discretizations to stochastic differential equations*

15.30: G. Franchini - *Neural architecture search via standard machine learning methodologies*

16.00: E. Macca - *Adaptive High Order Well Balanced Compact Approximate Method for Systems of Conservation and Balance law*

Friday - Room 2AB40 - 2nd Floor

09.00: M. Visinoni - *A family of three-dimensional Virtual Elements for Hellinger-Reissner elasticity problems*

Friday - Room 2BC60 - 2nd Floor

14.30: F. Pes - *Gauss-Newton type method for solving nonlinear least-squares problems*

15.00: M. Manucci - *Contour Integral Methods and Certified Reduced Basis for parametric dynamical problems*

Session M - Math 4 Real World

Thursday - Room 1C150 - 1st Floor

10.00: E. Bachini - *Intrinsic Surface Finite Element Method for PDEs on fixed and moving surfaces*

10.30: E. Biagioli - *Depth-averaged Finite Volume numerical model for viscous fluids with application to the simulation of lava flows*

11.30: D. Losapio - *A Local Embedded Method for Flow in Fractured Porous Media with Numerical Upscaling and Machine Learning*

12.00: F. Marchetti - *Variably scaled (discontinuous) kernels: from image reconstruction to supervised learning*

15.30: L. Melas - *Three-dimensional physics-based numerical simulations of earthquake ground motion for advanced seismic risk assessment*

16.00: L. Meneghetti - *Reduced Convolutional Neural Networks for image recognition and object detection*

Friday - Room 1C150 - 1st Floor

08.30: M. Seracini - *Sampling Kantorovich operators for the solution of concrete real world problems*

09.00: N. Urbinati - *A topological analysis of competitive economies*

12.00: R. Della Marca - *Human-induced oscillations in a network landscape model*

12.30: M. Dessole - *Sparse recovery via fast nonnegative least squares*

14.30: N. Gastaldon - *Meta-heuristic algorithms for a Multi-Attribute Vehicle Routing Problem in express freight transportation*

15.00: G. Colajanni - *Constrained Optimization Models based on UAV networks with 5G technologies*

Session N - Biomatematica

Thursday - Room 2AB40 - 2nd Floor

10.00: S. Fresca - *Deep learning-based reduced order models for nonlinear parametrized PDEs: application to cardiac electrophysiology*
10.30: R. Piersanti - *Mathematical and Numerical Modeling of Cardiac Fiber Generation and Electromechanical Function: Towards a Realistic Simulation of the Whole Heart*
11.30: M. Salvador - *Mathematical and numerical modeling of cardiac electromechanics in ventricles with ischemic cardiomyopathy*
12.00: N. Huynh - *Scalable and parallel non-linear solvers for the cardiac Bidomain system*
15.30: A. Zingaro - *Mathematical and Numerical Models for the Fluid Dynamics of the Human Heart*
16.00: M. Sensi - *A Geometric Singular Perturbation approach to epidemic compartmental models*

Sponsors

Con il Patrocinio del Comune di Padova:

Funded by: STARS Consolidator Grants (STARS-CoG)@UNIPD 2019 -
ConNECT - Control of Nonlocal Equations for Crowd and Traffic models

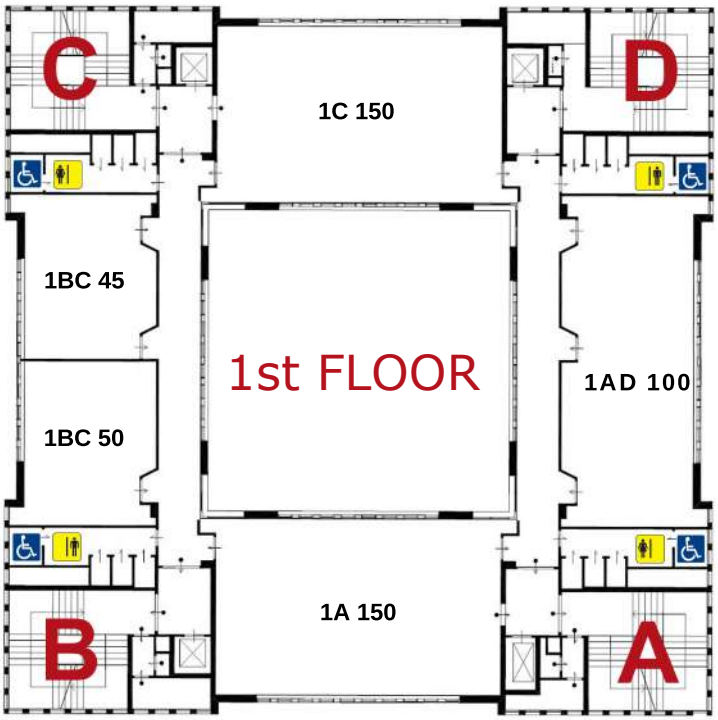
---

Conference Committees

Scientific committee of 100-800 meeting at Palazzo Bo (23rd-24th May)
Francesco Baldassarri (Univ. Padova), Piermarco Cannarsa (**Chair**, Univ. Roma "Tor Vergata"), Lucia Caporaso (Univ. Roma Tre), Michelangelo Conforti (Univ. Padova), Franco Flandoli (SNS di Pisa), Corinna Ulcigrai (Univ. Zürich).

Scientific committee of the First UMI meeting of PhD students (26th-27th May)
Martino Bardi (Univ. Padova), Anna Fino (Univ. Torino), Adriana Garroni ("Sapienza" Univ. Roma), Angelo Felice Lopez (Univ. Roma Tre), Benedetta Morini (Univ. Firenze), Barbara Nelli (**Chair**, Univ. dell'Aquila), Gianluca Vinti (Univ. Perugia).

Organizing committee
Univ. Padova: Fabio Ancona (**Chair**), Davide Barilari, Martino Bardi, Olga Bernardi, Alessandra Bianchi, Laura Caravenna, Giovanna Carnovale, Francesco Ciraulo, Marco Ferrante, Antonia Larese, Paola Mannucci, Fabio Marcuzzi, Ernesto C. Mistretta, Francesco Rossi, Alberto Tonolo.
Alessandra Bernardi (Univ. Trento), Fausto Ferrari (Univ. Bologna)



Dipartimento di Matematica

Torre Archimede
via Trieste, 63

UMI 1900 UniPD

D DIPARTIMENTO DI MATEMATICA
via Trieste 63

E POLO UNIV. BEATO PELLEGRINO
via Beato Pellegrino, 32

MUMBLE!
MATEMATICA A FUMETTI

B SALA DEI GIGANTI - Palazzo del Liviano
Piazza Capitaniato

C AUDITORIUM Conservatorio Pollini
via Carlo Cassan, 17

A AULA MAGNA - Palazzo del Bo
via VIII febbraio, 2

Organizers

Unione Matematica Italiana

800 ANNI 1222-2022

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO MATEMATICA
DIPARTIMENTO DI MATEMATICA "TULLIO LEVI-CIVITA"