ALMA MATER STUDIORUM · UNIVERSITÀ DI BOLOGNA
DIPARTIMENTO DI MATEMATICA

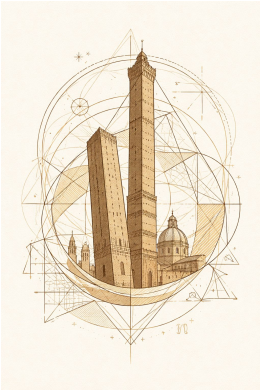
NONPub26

Nonlinear and nonlocal
Partial Differential Equations
at University of Bologna

4–5 June 2026

Aula VIII
Dipartimento di Matematica
Università di Bologna

Fourth edition



Programme

Thursday, 4 June

MORNING SESSION

11:00–11:40 **Anceschi,** *Higher regularity results for a nonlinear Fokker–Planck equation*

11:40–12:20 **Yevgenieva,** *Hölder regularity for mixed singular–degenerate doubly nonlinear equations*

12:20–14:20 *Lunch*

AFTERNOON SESSION

14:20–15:00 **Liontou,** *Signed curvature detection in the primary visual cortex*

15:00–15:40 **Bolelli,** *Heteroclinic realization of cyclic–sequential dynamics in neural population models*

15:40–16:00 *Break*

16:00–16:40 **Piccinini,** *Nonlocal theory for fractional kinetic equations*

16:40–17:20 **Federico,** *Smoothing effect of third-order operators with variable coefficients*

20:30 *Social dinner*

Friday, 5 June

MORNING SESSION

10:00–10:40 **Vianello,** *Boundary monotonicity for local almost-minimizers of the relative perimeter*

10:40–11:20 **Verzellesi,** *Renormalization of contact velocity fields with horizontal Sobolev regularity in Heisenberg groups*

11:20–11:40 *Break*

11:40–12:20 **Bellini,** *Curvature measures and the sub-Riemannian Gauss–Bonnet theorem*

12:20–13:00 **Rossi,** *Interior singularity of sub-Riemannian geodesics and branching*

13:00 *End of proceedings and farewell*

Abstracts

Francesca Anceschi

Università Politecnica delle Marche

Higher regularity results for a nonlinear Fokker–Planck equation

In this talk we investigate local regularity properties for a class of possibly degenerate nonlinear ultraparabolic operators, for which the nonlinear Kolmogorov–Fokker–Planck equation is a prototype. After proving local boundedness estimates for weak subsolutions, we combine them with a suitable Gehring lemma to obtain higher integrability estimates for the gradient in the diffusion direction. This is joint work with J. Guerand and T. Isernia.

Yevgeniia Yevgenieva

Max Planck Institute, Magdeburg

Hölder regularity for mixed singular–degenerate doubly nonlinear equations

We investigate the local Hölder continuity of nonnegative, locally bounded solutions to a class of doubly nonlinear equations. We introduce a new approach that covers the singular–degenerate and degenerate–singular cases, up to the relevant Barenblatt numbers. A key ingredient of the proof is a new integral L^1–L^1 Harnack estimate.

Vasiliki Liontou

Università di Bologna

Signed curvature detection in the primary visual cortex

We present a geometric model for curvature-sensitive cells in the primary visual cortex, motivated by the use of $SE(2)$ geometry in modeling orientation detection. The central observation is that there exists a canonical affine subbundle of the cotangent bundle of the manifold of oriented contact elements of the retina, whose sections measure signed geodesic curvature along lifted curves, and which carries a natural Engel structure related to that of the double Cartan prolongation. On an open dense submanifold of this prolongation, the iterated Lie brackets of a pair of Engel generators span $\mathfrak{sim}(2)$, identifying $SIM(2)$ as the natural symmetry group for curvature detection. This leads to a two-layer integral transform, defined by composing the quasi-regular representations of $SIM(2)$ and $SE(2)$, which under a $SIM(2)$-equivariance condition on the mother window collapses to a $SIM(2)$-transform. The receptive profiles of curvature-sensitive cells are modeled by the coherent state

family of this transform and characterized by a $SIM(2)$-adapted uncertainty principle. Work in collaboration with G. Citti.

Maria Virginia Bolelli

L2S Lab, CentraleSupélec

Heteroclinic realization of cyclic–sequential dynamics in neural population models

We study the realization of cyclic and sequential dynamics in neural population models via heteroclinic structures. We show that low-dimensional Amari-type systems do not admit heteroclinic cycles under biologically plausible assumptions. In contrast, Lotka–Volterra systems generically support robust heteroclinic networks, but lack a direct neural interpretation. Using a universal approximation argument, we approximate Lotka–Volterra vector fields by suitably chosen neural networks. This construction yields a lifting of the original low-dimensional dynamics into a higher-dimensional phase space governed by biologically plausible Amari-type equations. We further show that suitable projections of the resulting high-dimensional dynamics exhibit cyclic–sequential behavior with tunable, constant residence times near equilibria, thereby avoiding the asymptotic slowing typical of classical heteroclinic trajectories. This provides a rigorous framework for cyclic–sequential dynamics in neural populations, with potential applications to cognitive processes such as focused attention meditation.

Mirko Piccinini

Politecnico di Milano

Nonlocal theory for fractional kinetic equations

We extend the De Giorgi–Nash–Moser theory to a class of nonlocal hypoelliptic equations naturally arising in kinetic theory, which combine a first-order skew-symmetric operator with an elliptic operator involving fractional derivatives along only part of the coordinates. Under sufficient integrability along the transport variables on the nonlocal tail, we prove the first local L^∞ estimate for this class of equations. We then establish the first full Harnack inequality for solutions to kinetic integral equations under the aforementioned tail summability assumption, which appears in clear accordance with the very recent counterexample by Kassmann and Weidner (*Adv. Math.*, 2024). This is based on a series of papers by F. Anceschi, M. Kassmann, A. Loher, G. Palatucci, M. Weidner and myself.

Serena Federico

Università di Bologna

Smoothing effect of third-order operators with variable coefficients

In this talk we show the smoothing effect of a class of partial differential operators of order two or three with variable coefficients, which contain, among others, Schrödinger and KdV-type operators. As an application of the smoothing estimates, a local well-posedness result for the associated nonlinear initial value problem will be given.

Giacomo Vianello

UTIA — Czech Academy of Sciences, Prague

Boundary monotonicity for local almost-minimizers of the relative perimeter

Monotonicity formulas play a central role in the regularity theory for minimizers and almost-minimizers of the area functional in an open set $\Omega \subset \mathbb{R}^n$. For interior balls $B(x,r) \subset \Omega$, such formulas are classical. However, when $B(x,r)$ intersects the boundary of Ω, and in particular when $x \in \partial\Omega$, the analysis becomes more delicate and typically requires strong regularity assumptions on the container, such as $\partial\Omega \in C^2$. In this talk I present a recent boundary monotonicity result that holds under a geometric visibility condition on Ω with respect to the point $x \in \partial\Omega$. This condition is satisfied by a large class of nonsmooth Lipschitz domains. In the final part I discuss applications to boundary regularity, showing in particular that, up to subsequences, rescalings of the almost-minimizer converge to a minimizing cone in the tangent cone to Ω at x. This is joint work with G. P. Leonardi.

Simone Verzellesi

Università degli Studi di Padova

Renormalization of contact velocity fields with horizontal Sobolev regularity in Heisenberg groups

The classical Cauchy–Lipschitz theory ensures well-posedness of the flow equation associated with Lipschitz vector fields. A major breakthrough in extending this theory to rough velocity fields was achieved by DiPerna–Lions in the Sobolev setting, and later by Ambrosio in the BV framework. Since then, the theory has been significantly developed under various structural and regularity assumptions, both in Euclidean and metric measure settings. In this talk, after reviewing the existing theory, we present a new well-posedness result for a class of rough velocity fields in the genuinely sub-Riemannian setting of the Heisenberg group. We describe the main ideas of our approach, and we explain why our result cannot be deduced either from existing Eu-

clidean techniques or from available results in the metric measure framework. Based on joint work with L. Ambrosio, G. Somma and D. Vittone.

Eugenio Bellini

Università degli Studi di Padova

Curvature measures and the sub-Riemannian Gauss–Bonnet theorem

It is not uncommon for curvature to concentrate at the singularities of geometric spaces. In this talk we show how this phenomenon occurs for surfaces immersed in 3D contact sub-Riemannian manifolds. Adopting a measure-theoretic viewpoint on the Riemannian approximation scheme, we prove that the Gaussian curvature measure of such a surface is singular and supported on its isolated characteristic points. We identify natural geometric conditions under which this behavior occurs, namely when the surface admits characteristic points of finite order of degeneracy. This is joint work with D. Barilari and A. Pinamonti.

Tommaso Rossi

Università degli Studi dell'Aquila

Interior singularity of sub-Riemannian geodesics and branching

Sub-Riemannian geometry is a generalization of Riemannian geometry in which a metric is defined only on a subset of preferred directions, called a distribution. For curves tangent to the distribution one can define their length, and the curves that minimize length are called sub-Riemannian geodesics. In this talk we present an example of a sub-Riemannian geodesic of class C^2 but not C^3 at an interior point of its domain, extending the recent result by Chitour et al. As a byproduct, we obtain an example of a real-analytic sub-Riemannian manifold with branching geodesics. This is joint work with A. Schiavoni Piazza and A. Socionovo.

Practical information

VENUE

Aula VIII
Dipartimento di Matematica
Università di Bologna

SOCIAL DINNER

Thursday 4 June, 20:30
Casa di Quartiere Giorgio Costa
Via Azzo Gardino 48, Bologna

CONFERENCE WEBSITE

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