WiM 2025

WOMEN IN MATHEMATICS 2025

Department of Mathematics and Computer Science,

University of Palermo, Palermo, Italy

February 6-7, 2025

PROGRAM

February 6, 2025

9.00-9.30	Registration & Opening Session	
9.30-10.05	Helena J. Nussenzveig Lopes Universidade Federal do Rio de Janeiro	*Absence of anomalous dissipation for vortex sheet evolution in 2D incompressible flows*
10.05-10.40	Laura Lea Sacerdote Università degli Studi di Torino	*Robustness of scale free behavior in generalized preferential attachment networks*
10.40-11.15	Maria Rosaria Posteraro Università degli Studi di Napoli Federico II	*Isoperimetric sets for weighted twisted eigenvalues*
11.15-11.45	Coffee Break	
11.45-12.20	Alessandra Celletti Università degli Studi di Roma Tor Vergata	*The weak boundary between pure and applied mathematics: from perturbation theory to the rotation of the Moon, and back*
12.20-12.55	Gisella Croce Université paris I Panthéon-Sorbonne	*On the quantitative isoperimetric inequality*
12.55-15.00	Lunch	
15.00-15.35	Anamari Nakić University of Zagreb	*Additive graph decompositions*
15.35-16.10	Lydia Castronovo Università degli Studi di Palermo	*Fuzzy sets: a conditional probability approach*
16.10-16.45	Eleonora Amoroso Università degli Studi di Messina	*Double phase problems with different boundary conditions*
16.45-18.00	Tea Break & Round-table Discussion	
20.30	Social Dinner	

February 7, 2025

9.00-9.35	Anna Mercaldo Università degli Studi di Napoli Federico II	*Comparison results for elliptic equations via Steiner symmetrization*
9.35-10.10	Mariangela Sciandra Università degli Studi di Palermo	*Women in Science and Digital Innovation: A Statistical Perspective on Online Music Distribution*
10.10-10.45	Alessandra Bernardi Università di Trento	*Geometric and Algebraic Tools in Interdisciplinary Research*
10.45-11.15	Coffee Break	
11.15-11.50	Chiara Giverso Politecnico di Torino	*Mathematical Insights into Angiogenesis and Nutrient Exchange in Biological Tissues*
11.50-12.25	Sihem Mesnager Université Paris VIII	*Algebraic Equations over Finite Fields: Advances in Resolution Techniques and Practical Impacts*
12.25-13.00	Barbara Vantaggi Sapienza Università di Roma	*Going beyond probability in reasoning under uncertainty*
13.00	Lunch	

Organizers: G. Bini; B. Brandolini; G. Falcone; G. Gambino; M.C. Lombardo; M. Sammartino; G. Sanfilippo; E. Tornatore.

Abstracts

♢ **Eleonora Amoroso, Università degli Studi di Messina**
Email: eleonora.amoroso@unime.it

Title: **Double phase problems with different boundary conditions**

Abstract. A differential operator that has found a place in many research fields in recent years is the so-called "double phase operator", defined by

$$u \to -div\left(|\nabla u|^{p(x)-2}\nabla u + \mu(x)|\nabla u|^{q(x)-2}\nabla u\right),$$

for every function u belonging to a suitable Musielak-Orlicz Sobolev space $W^{1,\mathcal{H}(\Omega)}$, where $\Omega \subset \mathbb{R}^N$ is a bounded domain with Lipschitz boundary. Many authors studied problems involving this operator, which has been used to model different phenomena. Among the topics, we mention the elasticity theory in which it describes the behavior of strongly anisotropic materials, whose hardening properties are related to the exponents $p(\cdot)$ and $q(\cdot)$ and significantly change with the point and the coefficient $\mu(\cdot)$ determines the geometry of a composite made of two different materials. Also, this operator generalizes several other differential operators, as the $(p(\cdot), q(\cdot))$- Laplacian when $\inf_{\overline{\Omega}} \mu > 0$ and the $p(\cdot)$-Laplacian if $\mu \equiv 0$, respectively. The aim of this talk is to present some existence and multiplicity re- sults for nonlinear differential equations involving the double phase operator with variable exponents, under different boundary conditions. In particu- lar, we consider Dirichlet parametric problems [1], Neumann problem with nonlinear boundary condition [2] and Robin parametric problems with critical growth [3]. Furthermore, informations on the sign of the solutions are provided. The investigation is based on variational methods, critical point theory and Nehari manifold method.

References

[1] E. Amoroso, G. Bonanno, G. D'Aguì, P. Winkert, Two solutions for Dirichlet double phase problems with variable exponents, *Advanced Nonlinear Studies*, (2024), doi: 10.1515/ans-2023-0134.

[2] E. Amoroso, Á. Crespo-Blanco, P. Pucci, P. Winkert, Superlinear elliptic equations with unbalanced growth and nonlinear boundary condition, *Bulletin des Sciences Mathématiques*, 197 (2024), doi: 10.1016/j.bulsci.2024.103534.

[3] E. Amoroso, V. Morabito, Nonlinear Robin problem with double phase variable ex- ponent operator, *Discrete and Continuous Dynamical Systems Series S*, 17:99 (2024), pp 1–17 doi: 10.3934/dcdss.2024047.

♠ **Alessandra Bernardi, Università di Trento**
Email: alessandra.bernardi@unitn.it

Title: **Geometric and Algebraic Tools in Interdisciplinary Research**

Abstract. Mathematics continues to play a pivotal role in addressing complex problems across various disciplines, from data science to quantum physics. In this talk, I will present recent developments in algebraic and geometric methods, with a focus on their applications in tensor decomposition, quantum information, and the analysis of high-dimensional data. Drawing from

my research and interdisciplinary collaborations, I will illustrate how classical mathematical tools can be adapted and extended to tackle contemporary challenges.

♡ **Lydia Castronovo, Università degli Studi di Messina**
Email: lydia.castronovo@studenti.unime.it

Title: **Fuzzy sets: a conditional probability approach**

A fuzzy set is a set characterized by a membership function which assigns to each object a grade of membership. The probabilistic approach to fuzzy set theory has usually been addressed as not-flexible enough to deal with fuzzy concepts. Coletti and Scozzafava, agreeing that a "classical" probability approach is not adequate to handle fuzzy logic structures, proposed a different approach to fuzzy set theory based on coherent conditional probability. Given a property φ of a random quantity X with range C_X, the authors focused on the conditional events $E_\varphi|A_x$="You claim (that X has) the property φ, knowing that $(X = x)$", for each $X \in C_X$, and they define fuzzy sets based on them. In our work, following their approach, we slightly modify this interpretation of fuzzy sets, looking at them in terms of conditional events and coherent conditional probabilities within the framework of the betting scheme. A revised definition of fuzzy sets is proposed and we introduce operations such as complement and intersection. To achieve this, we employ logical operations among conditional events in the framework of conditional random quantities. In particular in our interpretation, the membership function of a fuzzy set is seen as a coherent conditional prevision assessment on suitable compound conditionals. Furthermore, we provide examples and examine the class of Frank t-norms to describe coherent conditional previsions.
Based on a joint work with Giuseppe Sanfilippo.

References

[1] Castronovo, L., Sanfilippo, G. (2024). Compound Conditionals and Fuzzy Sets. In: Ansari, J., et al. Combining, Modelling and Analyzing Imprecision, Randomness and Dependence. SMPS 2024. Advances in Intelligent Systems and Computing, vol 1458. Springer, Cham.
[2] Coletti, G., Scozzafava, R.: Probabilistic logic in a coherent setting. Kluwer, Dordrecht (2002)
[3] Coletti, G., Scozzafava, R.: Conditional probability, fuzzy sets, and possibility: a unifying view. Fuzzy Sets and Systems **144**(1), 227–249 (2004)
[4] Gilio, A., Sanfilippo, G.: Conditional random quantities and compounds of conditionals. Studia Logica **102**(4), 709–729 (2014)
[5] Klement, E.P., Mesiar, R., Pap, E.: Triangular Norms. Springer, 1 edn. (2000)
[6] L.A. Zadeh: Fuzzy sets. Information and Control **8**(3), 338-353 (1965)

♢ **Alessandra Celletti , Università degli Studi di Roma Tor Vergata**
Email: celletti@mat.uniroma2.it

Title: **The weak boundary between pure and applied mathematics: from perturbation theory to the rotation of the Moon, and back**

Abstract. I will show some rigorous results stemming from perturbation theory and KAM theory on the stability of resonant motion and the existence of invariant tori. I will show how the theoretical results translate into stability results for a very practical problem in Celestial Mechanics.

♣ **Gisella Croce , Université Paris 1 Panthéon-Sorbonne**
Email: gisella.croce@univ-paris1.fr

Title: **On the quantitative isoperimetric inequality**

Abstract. The isoperimetric inequality states that the disk minimizes the perimeter among the sets in the plane of given measure. A natural question is: is the disk a stable solution of this optimization problem, that is, given a set Ω with the same area, can we estimate its distance (in some sense) from the disk by the difference of the perimeters? In this talk we will try to answer to this question using the Fraenkel asymmetry and the barycentric asymmetry as distances. The first one is defined as the minimum, among all the disks of same measure, of the area of the symmetric difference between Ω and the disk. The second one is defined as the area of the symmetric difference between the set and the disk centered at the barycentre of the set.

This is a joint work with Chiara Bianchini and Antoine Henrot.

♠ **Chiara Giverso, Politecnico di Torino**
Email: chiara.giverso@polito.it

Title: **Mathematical Insights into Angiogenesis and Nutrient Exchange in Biological Tissues**

Abstract. Angiogenesis is a crucial process that leads to the formation of new blood vessels from an existing vasculature, ensuring the supply of nutrients and oxygen to tissues while facilitating the removal of metabolic waste.

We propose a comprehensive mathematical framework for simulating tumor-induced angiogenesis, integrating the growth of an arbitrarily complex vascular network with fluid flow and oxygen transport in both tissue and vessels, and the dispersion of an angiogenic growth factor (VEGF) within the tissue. The model equations for the three unknowns (namely fluid pressure, oxygen concentration and VEGF concentration) are first defined inside the tissue and within the vessels, represented as cylindrical connected tubes. This initial 3D-3D problem is then reformulated into a corresponding 3D-1D approximation by reducing the cylindrical vessels to their centerlines and simultaneously extending the outer domain to fill the voids. The evolving geometry of the vascular network is captured using a discrete tip-tracking model, which monitors the positions of capillary tips over time, defining a hybrid approach that couples a continuous representations of fluid and chemicals with a discrete model for capillary evolution.

To solve the resulting problem, we employ a numerical scheme based on an PDE constrained domain decomposition strategy that allows to write the 3D and the 1D problem on non conforming meshes and to solve them independently. This coupling strategy ensures robust and flexible handling of the evolving vascular network and it eliminates the need for remeshing as the network grows, simplifying computations for complex geometries.

Numerical simulations performed under varying tissue conditions demonstrate how capillary sprouting and network formation depend on the spatial distributions of VEGF and oxygen. These results highlight the intricate balance between nutrient delivery and angiogenic stimulation, offering valuable insights into tumor-induced angiogenesis and its underlying mechanisms.

♡ **Anna Mercaldo, Università degli Studi di Napoli Federico II**

Email: anna.mercaldo@unina.it

Title: **Comparison results for elliptic equations via Steiner symmetrization**

Abstract. In this talk recent comparison results for a class of homogeneous Dirichlet boundary problems for anisotropic operators of the form $-\mathrm{div}(a(|\nabla_x u|)\nabla_x u) - u_{yy}$ will be presented. These results are obtained by using Steiner symmetrization and show that the problem whose data are symmetrizated in sense of Steiner and the operator is a $p-$laplacian type operator, i.e. $\Delta_{p,x}u - u_{yy}$ has maximum mass concentration. The proof uses the technique of finite-differences discretization in y introduced in two joint papers with J.I.Diaz, A.Ferone, D.Gomez-Castro, where a comparison result with respect to Steiner symmetrization in the nonlinear framework has been proved for the first time.

♣ **Sihem Mesnager, Université Paris VIII**
Email: smesnager@gmail.com

Title:**Algebraic Equations over Finite Fields: Advances in Resolution Techniques and Practical Impacts**

Abstract. This talk will discuss the problem of solving algebraic equations over finite fields. This fundamental issue has become increasingly important due to its critical role in various applied domains, particularly information theory and cryptography. Addressing equations over finite fields is essential from both theoretical and practical perspectives. Historically, researchers have focused on determining the number of solutions for certain equations rather than explicitly deriving all possible solutions. While this limited approach has sufficed for some practical applications in cryptographic function theory, we need to enhance our understanding to yield more comprehensive results. Developing tools and implementing methods to solve an extensive range of equations over finite fields is crucial, as it provides valuable resources for theorists, cryptographers, and coding theorists. We will begin by outlining our primary motivations for this work. Next, we will present significant recent achievements in solving key algebraic equations over finite fields and discuss these developments' methodologies and key mathematical ingredients.

♢ **Anamari Nakić, University of Zagreb**
Email: Anamari.Nakic@fer.hr

Title: **Additive graph decompositions**

Abstract. Given a simple graph Γ, a (K_v, Γ)-*design* is a decomposition of the complete graph K_v into subgraphs (*blocks*) isomorphic to Γ. We say that a (K_v, Γ) design is *additive* if the vertices of K_v are elements of an abelian group G and all the blocks are zero-sum in G. In particular, an additive (K_v, Γ) design where Γ is a clique on k vertices is an additive 2-$(v, k, 1)$ design in the sense of Caggegi, Falcone and Pavone [1].

In this talk we will present our pioneer study on additive (K_v, Γ)-designs with Γ a cycle, a path or a matching. Developing different tools instrumental in constructing these structures we have obtained some infinite classes and many sporadic examples.

References

[1] A. Caggegi, G. Falcone, M. Pavone, *On the additivity of block designs*, J. Algebr. Comb. **45** (2017), 271–294.

♠ **Helena J. Nussenzveig Lopes, Universidade Federal do Rio de Janeiro**
Email: aggahju@gmail.com

Title: **Absence of anomalous dissipation for vortex sheet evolution in 2D incompressible flows**

Abstract. TBA

♡ **Maria Rosaria Posteraro, Università degli Studi di Napoli Federico II**
Email: mariarosaposteraro@unina.it

Title: **Isoperimetric sets for weighted twisted eigenvalues**

Abstract. We present an isoperimetric inequality for the first twisted eigenvalue $\lambda^T_{1,\gamma}(\Omega)$ of a weighted operator, defined as the minimum of the usual Rayleigh quotient when the trial functions belong to the weighted Sobolev space $H^1_0(\Omega, d\gamma)$ and have weighted mean value equal to zero in Ω. We are interested in positive measures $d\gamma = \gamma(x)dx$ for which we are able to identify the optimal sets, namely, the sets that minimize $\lambda^T_{1,\gamma}(\Omega)$ among sets of given weighted measure. In the cases under consideration, the optimal sets are given by two identical and disjoint copies of the isoperimetric sets (for the weighted isoperimetric inequality with respect $d\gamma = \gamma(x)dx$). The results are contained in a joint paper with B. Brandolini, A. Henrot and A. Mercaldo .

♣ **Laura Lea Sacerdote, Università degli Studi di Torino**
Email: laura.sacerdote@unito.it

Title: **Robustness of scale free behavior in generalized preferential attachment networks**

Abstract. Scale free behavior of the degree distribution characterizes a number of real world instances. The seminal work by Barabási and Albert explains the high frequency of this feature in different networks, showing how the preferential attachment rule determines the scale free property for the degree of vertices in graphs. In this framework new and existing nodes are connected according with probabilities proportional to the number of existing links characterizing the considered node. Such attachment rule seems reasonable for different modeling instances but it is often a simplification for more complex behaviors. For example, preferential attachment can coexist with other types of attachments or with detachment phenomena or exhibit a very fast increasing of the number of new attachments. We investigate if these instances can destroy the convergence to the scale free behavior. In particular we present some recent results by the author and some collaborators, discussing whether the scale free behavior is robust with respect to such variants of the attachment rules and illuminating some cases where this feature is destroyed.

♢ **Mariangela Sciandra, SEAS Department, Università degli Studi di Palermo**
Email: mariangela.sciandra@unipa.it

Title: Women in Science and Digital Innovation: A Statistical Perspective on Online Music Distribution

Women play a vital role in advancing scientific and technological innovation, often operating in fields where male representation is predominant. This presentation explores the application of statistical methods to digital data analysis, focusing on a recent study of online music distribution. By analyzing audio features of songs and leveraging data management mechanisms provided by the Spotify Web API, the talk introduces statistical tools to identify the determinants of musical popularity.

In particular, the analysis employs a Generalized Linear Mixed Model (GLMM) with Beta distribution and random effects to capture the relationship between song characteristics and their popularity. The model is described as follows:

$$\log\left(\frac{\mu_{ij}}{1-\mu_{ij}}\right) = x_{ij}^{\top}\beta + z_{ij}^{\top}b_i, \quad b_i \sim \mathcal{N}(0, G)$$

where μ_{ij} represents the expected popularity, x_{ij} denotes explanatory variables, and b_i accounts for random effects, providing insights into the variability across different groups of songs.

The digital music industry, historically dominated by male figures, highlights the need for greater equity and diversity in both scientific and creative domains. According to a study by USC Annenberg, between 2012 and 2020, only 21.6% of artists were women, with even lower percentages among composers (12.6%) and producers (2.6%) (*source: musicianwave.com*). This presentation reflects on how women, as scientists and creators, contribute to developing innovative methodologies and fostering inclusivity in the digital era.

References

[1] S. Ferrari and F. Cribari-Neto, "Beta regression for modelling rates and proportions," *J. Appl. Stat.*, vol. 31, pp. 799–815, 2004.
[2] J. A. Sloboda, "Music in everyday life, the role of emotions," in *Handbook of Music and Emotion: Theory, Research, Applications*, P. N. Juslin and J. Sloboda, Eds., Oxford University Press, Oxford, 2011, pp. 1–37.
[3] M. Hunger, A. Dring, and R. Holle, "Longitudinal beta regression models for analyzing health-related quality of life scores over time," *BMC Med. Res. Methodol.*, vol. 12, 2012.
[4] M. Sciandra and I. C. Spera, "A model-based approach to Spotify data analysis: A Beta GLMM," *J. Appl. Stat.*, vol. 49, no. 1, pp. 214–229, 2022. doi: 10.1080/02664763.2020.1803810.

♠ **Barbara Vantaggi, Sapienza Università di Roma**
Email: barbara.vantaggi@uniroma1.it

***Title:* Going beyond probability in reasoning under uncertainty**

Abstract. Reasoning under uncertainty is an active branch of Artificial Intelligence (AI), demanding for explainable models and "soft" methods, as well as sound norma- tive theories of decision making. In this talk we start by presenting some modern non-additive uncertainty theories complying with conditioning, showing their connections to probabil- ity theory through de Finetti's coherent approach (de Finetti 1937). Indeed, though de Finetti's betting scheme was originally introduced to justify additive probability measures, it "naturally" gives rise to non-additive uncertainty mea- sures, where lower and upper envelopes encode a pessimistic and an optimistic attitude towards uncertainty, respectively. Among the theories based on non- additive measures we refer to Dempster-Shafer theory (Dempster 1967, Shafer 1976),

whose conditional versions are investigated in (Coletti et al 2016). In- side the Dempster-Shafer theory we formulate a theory of imprecise processes: a time-homogeneous Markov multiplicative binomial process (DS-multiplicative binomial process), characterized by a distinguished family of transition belief functions introduced in (Cinfrignini et al. 2023). A distinguished financial application of this process is given by a dynamic bid pricing rule (Cinfrignini et al. 2023, Petturiti and Vantaggi 2023), defined as a one-step discounted conditional Choquet expectation (Choquet 1954). An important feature of the quoted imprecise process is its parameterization based on two parameters only, that has a direct impact on calibration tasks, favoring scalability.