Under the Auspices
of H.E. the President of the Hellenic Republic
Mr. Constantine An. Tassoulas

Hellenic Mathematical Society
HMS

3rd Congress of Greek Mathematicians TCGM 2026

Abstracts

June 29 - July 4
2026

in cooperation with the

Cyprus Mathematical Society (CMS)

Department of Mathematics, National and Kapodistrian University of Athens

School of Applied Mathematical and Physical Sciences, National Technical University of Athens

Department of Mathematics, Aristotle University of Thessaloniki

Department of Mathematics, University of Patras

Department of Mathematics, University of Ioannina

Department of Mathematics and Applied Mathematics, University of Crete

Department of Mathematics, University of the Aegean

Department of Statistics, Athens University Economics and Business

Department of Statistics, University of Piraeus

Department of Mathematics, University of Thessaly

Department of Mathematics, University of Western Macedonia

School of Science and Technology Hellenic Open University

Department of Mathematics and Statistics University of Cyprus

Under the Auspices
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Third Congress of Greek Mathematicians
TCGM–2026

June 29 – July 3, 2026
Athens, Greece

Hellenic Mathematical Society (HMS)

Organizers

Hellenic Mathematical Society (HMS)

in cooperation with:

	Cyprus Mathematical Society
	Department of Mathematics **Naional and Kapodistrian University of Athens**
	School of Applied Mathematical and Physical Sciencs **National Technical University of Athens**
	Department of Mathematics **Aristotle University of Thessaloniki**
	Department of Mathematics **University of Patras**
	Department of Mathematics **University of Ioannina**
	Department of Mathematics **University of Crete**

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Outline of the Scientific Program

Monday, June 29, 2026
(NKUA, Central Building and Department of Mathematics)

09:00–10:00	Opening Ceremony
10:00–11:00	Georgios Dassios *Finally ellipsoidal waves in closed form do exist*
11:00–12:00	Yiannis Petridis *Counting and equidistribution: from number theory to geometry and automorphic forms*
12:00–16:00	Lunch Break
16:00–17:30	Parallel Sessions
17:30–18:00	Coffee Break
18:00–20:00	Parallel Sessions

Tuesday, June 30, 2026
(NTUA, School of Electrical and Computer Engineering)

09:30–10:30	Agelos Georgakopoulos *On well- and better-quasi-ordering under graph minors*
10:30–11:00	Coffee Break
11:00–12:00	Georgios Raptis *The Legacy of the Euler Characteristic: From Euler's Formula to Manifold Topology and Algebraic K-Theory*
12:30–14:00	Parallel Sessions
14:00–16:00	Lunch Break
16:00–17:30	Parallel Sessions
17:30–18:00	Coffee Break
18:00–20:00	Parallel Sessions

Wednesday, July 1, 2026
(NKUA, Department of Mathematics)

09:30–10:30	Emmanouil H. Georgoulis *Hypocoercivity-preserving Galerkin Discretisations*
10:30–11:00	Coffee Break
11:00–12:00	Alexandros Eskenazis *Metric rigidity of nonpositive curvature*
12:30–14:00	Round Table Dimitris Achlioptas, Dimitris Fotakis, Charalampos Makridakis, Panagiotis Mertikopoulos, Sotirios Sabanis *Effects of AI on mathematical research*
14:00–16:00	Lunch Break
16:00–17:30	Parallel Sessions
17:30–18:00	Coffee Break
18:00–20:00	Parallel Sessions

Thursday, July 2, 2026
(NTUA, School of Electrical and Computer Engineering)

09:30–10:30	Agni Orfanoudaki *Algorithmic Insurance*
10:30–11:00	Coffee Break
11:00–12:00	Michail Kolountzakis *Measurable equidecomposition and common fundamental domains for lattices*
12:30–14:00	Parallel Sessions
14:00–16:00	Lunch Break
16:00–17:30	Parallel Sessions
17:30–18:00	Coffee Break
18:00–20:00	Parallel Sessions

Friday, July 3, 2026
(NKUA, Department of Mathematics)

09:30–10:30	Marina Iliopoulou *On integer distance sets*
10:30–11:00	Coffee Break
11:00–12:00	Stefanos Aretakis *Dynamics of extremal black holes*
12:30–14:00	Parallel Sessions
14:00–16:00	Lunch Break
16:00–17:30	Parallel Sessions
17:30–18:00	Coffee Break
18:00–20:00	Parallel Sessions
20:00	Congress Dinner

Plenary Talks

Stefanos Aretakis

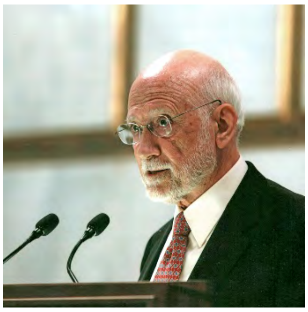
University of Toronto

Dynamics of extremal black holes

We will consider the stability problem for extremal black holes. We will see that such black holes exhibit both stability and instability properties and that their mixed dynamical picture can in fact be used to produce observational signatures.

Georgios Dassios

University of Patras, Academy of Athens



Finally ellipsoidal waves in closed form do exist

189 years ago, the french civil engineer Gabriel Lame introduced the ellipsoidal coordinate system, as well as the solutions of the Laplace equation in this geometry, that is, the Ellipsoidal Harmonics. As it is expected, the interesting problem after the harmonics was to investigate the existence of Ellipsoidal Waves. However, after many attempts it was not possible to construct ellipsoidal waves in closed form. Today we do have expressions of solutions of the wave equation in ellipsoidal geometry for standing as well as genuine waves but only in terms of a series or an integral representation, no one in a closed analytic form. In this presentation a method for generating closed form ellipsoidal waves is demonstrated and a simple ellipsoidal wave in closed form is constructed. This provides the first step towards the development of a more useful structure of Ellipsoidal Waves.

Alexandros Eskenazis

CNRS

Metric rigidity of nonpositive curvature

We shall present a novel rigidity theorem for metric transforms of nonpositively curved Alexandrov spaces. We will then use this result to construct counterexamples to previously conjectured metric formulations of Kwapień's theorem from Banach space theory. Time permitting, further geometric and algorithmic applications will also be discussed. The talks will be based on joint work with M. Mendel and A. Naor.

Agelos Georgakopoulos

University of Warwick

A survey of coarse graph theory

I will survey recent results and open questions on ‘coarse graph theory’, an emerging discipline that combines ideas from graph theory and coarse geometry.

Emmanouil Georgoulis

National Technical University of Athens, The Maxwell Institute for Mathematical Sciences and Heriot-Watt University, IACM-FORTH

Hypocoercivity-preserving Galerkin Discretisations

Numerous physical, chemical, biological, and social dynamic processes are characterised by convergence to long-time equilibria. These are often described as PDEs of kinetic type, whereby ‘position’ and ‘velocity’ are independent variables. These may also arise when modelling multi-agent interacting processes of particles, individuals, etc. In many important cases the diffusion/dissipation required to arrive to such equilibria is explicitly present in some of the spatial directions only, that is there exist evolution PDEs with degenerate diffusion yet converging to equilibrium states as time goes to infinity. This, somewhat counter-intuitive at first, state of affairs suggests that decay to equilibrium is due to finer hidden structure, which allows for the transport terms to also propagate dissipation’ into the spatial directions where no dissipation appears explicitly in the PDE model. Villani coined the term ‘hypocoercivity’ to describe this phenomenon in his celebrated 2009 AMS Memoir, in which he presented abstract sufficient conditions for this property for general classes of PDEs. The question of preserving hypocoercivity structures is highly relevant also in the context of numerical methods for kinetic PDEs, since the trend to equilibrium is often non-monotone and, typical numerical methods are not designed specifically for ‘long-time’ simulations. Taking as a representative example the inhomogeneous (degenerate) Fokker-Plack equation, I will present a framework on how to design numerical methods that provably preserve the same hypocoercivity structures as the equation itself. Of key importance in the construction is the treatment of lack of sufficient higher regularity of standard Galerkin/finite element spaces and how this is circumvented by careful definition of consistent stabilisation mechanisms, thereby, arriving naturally to the proof of hypocoercivity of the numerical solution in appropriate exponentially weighted function spaces. Time-permitting, some comments on the computational complexity of the new class of methods for full kinetic models. We plan to conclude with a series of numerical experiments showcasing the practicality of the proposed numerical methodology.

Marina Iliopoulou

National and Kapodistrian University of Athens

On integer distance sets

An integer distance set is a set in the Euclidean plane with the property that all pairwise distances between its points are integers. In this talk we will show that any integer distance set contains all but very few of its points on a single line or circle. This helps us address some questions by Erdős. In particular, we deduce that integer distance sets in general position (no 3 points on a line, no 4 points on a circle) are very sparse, and we derive a near-optimal lower bound on the diameter of any non-collinear integer distance set of a given size. Our proof uses existing refinements of the Bombieri-Pila determinant method. This is joint work with Rachel Greenfeld and Sarah Peluse.

Mihalis Kolountzakis

University of Crete

Measurable equidecomposition and common fundamental domains for lattices

We prove that for any two lattices $L, M \subseteq \mathbb{R}^d$ of the same volume there exists a measurable, bounded set $E \subseteq \mathbb{R}^d$ such that E tiles $\mathbb{R}^d$ when translated by L or by M. The motivation for this work was the so-called Steinhaus tiling problem which asks for a subset of the plane that simultaneously tiles the plane with all rotates of the integer lattice $\mathbb{Z}^2$. (This has been confirmed by Jackson and Mauldin without measurability and has been disproved in higher dimension for measurable sets by Kolountzakis and Wolff, both more than a quarter century ago.)

Our result is strongly connected with results about equidecomposition of sets by motions that are translations from a given group. The so-called measurable Hall's theorem by Cieśla and Sabok has played an important role in our proof. This theorem provides for measurable equidecompositions of two sets by actions of an abelian group that acts in a measure-preserving way and whose orbits are sufficiently permeating in our sets.

This has been joint work with Mark Etkind, Sigrid Grepstad, Nir Lev and Manos Spyridakis.

Agni Orfanoudaki

University of Oxford

Algorithmic Insurance

Measuring and managing the risks associated with artificial intelligence (AI) is increasingly critical as AI systems are integrated into high-stakes decision-making environments, such as healthcare. Algorithmic insurance offers a scalable financial solution for quantifying, pricing, and managing the risks inherent in AI deployment, complementary to regulation. It provides a structured mechanism for transferring the risks associated with AI systems from developers and users to insurers, creating a financial buffer that incentivizes responsible AI use and mitigates liability. Our work formalizes the concept of algorithmic insurance and proposes quantitative frameworks to estimate the risk exposure of insurance contracts for machine-driven financial risk.

Yiannis Petridis

University College London

Counting and equidistribution: from number theory to geometry and automorphic forms

In Number theory we are interested in arithmetic functions that depend on the factorization of integers. One such is r(n), the number of ways of writing n as sum of two squares. In certain cases, the average values and correlations of these arithmetic functions can be studied using lattice counting problems, in Euclidean and hyperbolic spaces. Such problems (and the associated equidistribution) can be studied with various methods, and I will emphasize automorphic form techniques, originating in the work of H. Huber and studied extensively by A. Good. My collaborators in various aspects of this project are Chatzakos, Lekkas, Risager, and Voskou.

Georgios Raptis

Aristotle University of Thessaloniki

The Legacy of the Euler Characteristic: From Euler's Formula to Manifold Topology and Algebraic K-Theory

The Euler characteristic is among the most fundamental invariants in mathematics, and its influence extends far beyond its classical origins. This survey follows a path from Euler's formula and cut-and-paste invariants of manifolds to the study of manifold automorphisms through algebraic K-theory and index theorems, and further to noncommutative motives of stable ∞-categories. Its aim is to illuminate the conceptual connections between these objects and to highlight the evolution of the notion of an invariant and the frameworks used to study them – from numerical quantities associated with geometric objects, to cohomological and K-theoretic constructions, and ultimately to (higher) categorical structures that encode richer forms of information. Viewed from this perspective, the Euler characteristic appears not only as a classical invariant, but also as a precursor to many of the ideas that continue to shape topology and K-theory.

Round Table

Effects of AI on mathematical research

Dimitris Achlioptas[1], Dimitris Fotakis[2], Charalampos Makridakis[3], Panagiotis Mertikopoulos[4], Sotirios Sabanis[5]

[1]*Department of Informatics and Telecommunications, NKUA,* [2]*School of Electrical and Computer Engineering, NTUA,* [3]*University of Sussex and IACM-FORTH,* [4]*Department of Mathematics, NKUA,* [5]*School of Applied Mathematical and Physical Sciences, NTUA*

Coordinator: Ioannis Emmanouil, Department of Mathematics, National and Kapodistrian University of Athens

Artificial intelligence is rapidly transforming many aspects of mathematical research, from symbolic computation and automated theorem proving to literature exploration and the generation of conjectures. At the same time, it raises important questions concerning reliability, originality, reproducibility, and the future role of human creativity in mathematics. This round table aims to discuss the opportunities and challenges created by AI tools, their current and potential impact on mathematical practice, and the ways in which the mathematical community can responsibly integrate these technologies into research.

Algebra and Number Theory

Organizers

Chatzakos D. (University of Patras)

Geranios Ch. (National and Kapodistrian University of Athens)

Psaroudakis Chr. (Aristotle University of Thessaloniki)

PROGRAM

ALGEBRA AND NUMBER THEORY SESSIONS

	Monday June 29	**Tuesday June 30**	**Wednesday July 1**	**Thursday July 2**	**Friday July 3**
	NKUA, Φ24	**NTUA, ΣΗΜΜΥ, Amf. 2**	**NKUA, Φ24**	**NTUA, ΣΗΜΜΥ, Amf. 2**	**NKUA, Φ24**
12:30-13:10		K. Kartas		E. Gazaki	G. Dalezios
13:15-13:35		G. Politopoulos		A. Terezakis	A. Katsampekis
13:40-14:00		D. Stergiopoulou		C. Vasilakopoulou	A. Galanakis
14:00-16:00	**Break**	**Break**	**Break**	**Break**	**Break**
16:00-16:40	K. Tsouvalas	F. Gounelas	M. Loukaki	S. Afentoulidis - Almpanis	T. Moulinos
16:45-17:05	N. Tsakanikas	M. Karameris	G. Kapetanakis	P. Tselekidis	J. Kountouridis
17:10-17:30	P. Spilioti	K. Golfis	V. D. Moustakas	M. Anagnostopoulou	A. Groutides
17:30-18:00	**Coffee break**	**Coffee break**	**Coffee break**	**Coffee break**	**Coffee break**
18:00-18:20	A. Konstantinou	C. Verasdanis	I. Zachos	V. Petrotou	D. Deligeorgaki
18:30-18:50	E. Agathocleous	C. Katsivelos	P. Kostas	K. Psaromiligkos	T. Kyriopoulos
19:00-19:20	A. Hamakiotes	M. Voskou	A. Kekkou	K. Karagiannis	
19:30-19:50	M. Melistas	S. Sachpazis	M. Karakikes	A. Kalogirou	

Dirac cohomology in Representation Theory

Spyridon Afentoulidis-Almpanis

Department of Mathematics, Bar-Ilan University, Israel

This talk will be a (very short) introduction to Dirac cohomology.

Dirac cohomology is an invariant of representations of real reductive groups (or rather their $(\mathfrak{g}, K)$-modules) originating from the interaction between representation theory, geometry, and mathematical physics. Introduced in the setting of real reductive Lie groups by David Vogan and further developed by Huang and Pandžić, it provides a powerful bridge between infinitesimal character theory and the structure of representations.

The aim of the talk is to provide an accessible overview of the subject and its main ideas, requiring only basic familiarity with Lie algebras and representation theory.

Isogeny Graphs in Superposition: Class Group Actions and Quantum Walks

Eleni Agathocleous

QUEST, The Cyprus Institute, Cyprus

The ideal class group of an imaginary quadratic order acts freely and transitively on the roots of the Hilbert class polynomial, giving rise to highly structured isogeny graphs whose spectrum is governed by values of even Dirichlet characters of the class group. These graphs play a central role in modern isogeny-based post-quantum cryptography.

We lift this picture to the quantum setting, where the notion of a walk bifurcates. On one hand, we describe a universal oracle evaluating the class group action with polynomially many quantum resources, placing entire isogeny cycles in quantum superposition. On the other hand, interpreting each adjacency matrix as a Hamiltonian yields continuous-time quantum walks on isogeny graphs. The commutativity of the resulting quantum evolutions follows from the Bose–Mesner algebra of the underlying cyclic association scheme: the adjacency matrices are simultaneously diagonalizable and generate a commutative algebra of unitaries.

We conclude by indicating how these commutative structures naturally give rise to a fully quantum onion-routing protocol, overcoming limitations intrinsic to layered quantum communication frameworks.

The regularity number of a simple group

Marina Anagnostopoulou-Merkouri

School of Mathematics, University of Bristol, UK

Let G be a transitive permutation group on a set Ω with point stabiliser H. A base for G is a subset of Ω whose pointwise stabiliser in G is trivial. The minimal size of a base is called the base size of G, denoted by $b(G)$, and this classical invariant has been widely studied for many years, finding many applications. We will see that $b(G)$ coincides with the smallest positive integer k such that G has a regular orbit on the Cartesian product $(G/H)^k$. As a natural generalisation, we can consider the minimal number r such that G has a regular orbit on $(G/H_1) \times ... \times (G/H_r)$ for any core-free subgroups $H_1, ..., H_r$ of G. We call this invariant the regularity number of G.

In this talk, we will explain how a combination of probabilistic, combinatorial, computational and geometric methods can be used to study the regularity number of finite almost simple and simple algebraic groups, as well as several other related problems. In particular, we will discuss a generalisation of Cameron's famous base size conjecture and some recent progress on similar problems for simple algebraic groups. This is joint work with Tim Burness.

The proper stable module category of a group algebra

Georgios Dalezios

Department of Computer Science, Università degli Studi di Verona, Italy

For any group and any commutative ring of coefficients we introduce the proper stable module category of the corresponding group algebra. This is a tensor-triangulated category which satisfies many desirable properties and is constructed by means of abelian model categories. It recovers previous constructions for special classes of groups or rings of coefficients. This is joint work in progress with Juan Omar Gomez.

Canon permutation posets

Danai Deligeorgaki

Department of Mathematics, Universitat de Barcelona, Spain

Canon permutations are multiset permutations in which the subwords formed by the first occurrences, second occurrences, and so on, all coincide (for example, 331412432142). They are motivated from pattern-avoidance considerations analogous to those behind Stirling and quasi-Stirling permutations. Elizalde showed that their descent polynomials factor elegantly as a product of two palindromic polynomials: an Eulerian polynomial and a Narayana polynomial. We explain this phenomenon using Stanley's theory of (P, ω)-partitions, along the way generalizing Elizalde's results. This approach yields a new family of palindromic polynomials arising from descent statistics on multisets, which we conjecture to be γ-positive. For descent polynomials of regular canon permutations, the poset perspective also provides a combinatorial interpretation of their γ-coefficients. This talk is based on joint work with Matthias Beck.

Constructions of Brumer–Stark Units

Alexandros Galanakis

Institut für Theoretische Informatik, Mathematik und Operations Research, Universität der Bundeswehr München, Germany

The Brumer–Stark conjecture predicts the existence of special units in abelian extensions of number fields whose valuations are determined by Stickelberger elements. Over the years, several constructions of Brumer–Stark units have been introduced. In this talk, I will present ongoing work on a construction via adelic Eisenstein classes, following previous joint work with Spiess.

On a conjecture of Colliot-Thelene for zero-cycles over p-adic fields

Evangelia Gazaki

Department of Mathematics, University of Virginia, USA

For a smooth projective variety X over a field k the Chow group of zero-cycles is a generalization to higher dimensions of the Picard group of a smooth projective curve. When X is a curve having a k-rational point, its Picard group can be fully understood by the Abel-Jacobi map, which gives an isomorphism between the degree zero elements of the Picard group and the k-rational points of the Jacobian variety of X. In higher dimensions there is still an Abel-Jacobi map, but the situation is much more chaotic. Namely, over large fields like the complex or the real numbers this map often has an enormous kernel, for which we don't have enough information. In this talk I will focus on the case when the variety X is defined over a finite extension of the field of p-adic numbers. In this case, a famous conjecture of Colliot-Thelene predicts that the kernel of the Abel-Jacobi map decomposes as a direct sum of a divisible group and a finite group. In this talk I will present recent joint work with Jitendra Rathore, where we establish the conjecture for many new classes of surfaces; namely those that admit a dominant rational map from a product of curves.

The cotorsion pair of Gorenstein $\mathcal{X}$-objects

Konstantinos Golfis

Department of Mathematics, National and Kapodistrian Uviversity of Athens, Greece

Let $(\mathcal{X}, \mathcal{Y})$ be a balanced pair in an abelian category $\mathcal{A}$. The class $\mathcal{X}$ induces an exact structure on $\mathcal{A}$, where the classical Ext functor is replaced by the relative one. We aim to generalize some recent results for Gorenstein Projective objects to their relative counterparts. We define and

study the class of Gorenstein $\mathcal{X}$-objects, denoted $G(\mathcal{X})$, which consists of cycles of complexes that are both right and left $\mathcal{X}$-acyclic. We give sufficient conditions, including the deconstructibility of $\mathcal{X}$, under which the pair $(G(\mathcal{X}), G(\mathcal{X})^{\perp *})$ forms a hereditary cotorsion pair with respect to the relative $\mathrm{Ext}_{\mathcal{X}}$.

Some new results on curves on $K3$ surfaces

Frank Gounelas

Mathematical Institute, University of Bonn, Germany

I will summarise some old and new results on the existence of curves on smooth projective complex $K3$ surfaces (eg quartics). To give some examples, it is now know by the work of many people that every such surface contains infinitely many rational curves, and even curves of arbitrary genus. I will focus on recent progress with Chen–Dutta on more refined questions about the non-existence of curves which deform in the $K3$ but remain constant in moduli.

Euler systems for GSp(4) over imaginary quadratic fields

Alexandros Groutides

Mathematics Institute, University of Warwick, UK

n this talk, we will introduce Euler systems associated with p-adic Galois representations and discuss their significance in the study of the Bloch–Kato conjecture. We will then report on recent progress in the construction of Euler systems for GSp(4) over imaginary quadratic fields.

Abelian extensions arising from elliptic curves with complex multiplication

Asimina Hamakiotes

Department of Mathematics, Fordham University, USA

Let K be an imaginary quadratic field, and let $\mathcal{O}_{K,f}$ be an order in K of conductor $f \geq 1$. Let E be an elliptic curve with complex multiplication by $\mathcal{O}_{K,f}$, such that E is defined by a model over $\mathbb{Q}(j(E))$, where $j(E)$ is the j-invariant of E. Let $N \geq 2$ be an integer. The extension $\mathbb{Q}(j(E), E[N])/\mathbb{Q}(j(E))$ is usually not abelian; it is only abelian for $N = 2, 3$, and 4. Let p be a prime and let $n \geq 1$ be an integer. In this talk, we will classify the maximal abelian extension contained in $\mathbb{Q}(E[p^n])/\mathbb{Q}$.

A lower bound for the sums of the reciprocals of the moduli in a distinct covering system

Alexandros Kalogirou

Alfréd Rényi Institute, Budapest, Hungary

We call a (Erdös) distinct covering system, a set of arithmetic progressions $\mathcal{C} = (a_i \mod m_i)$, with $1 < m_0 < m_1 < ... <$, such that every integer belongs in at least one of the arithmetic progressions in $\mathcal{C}$. Addressing the case of a finite covering system with $0 \leq i \leq k$, first, we review the old result of Mirsky and Newman, which shows that

$$1/m_0 + \cdots + 1/m_k > 1.$$

We go over joint work with Michael Filaseta, where we show that if $m_0 > 4$, then the right hand side of the above can be replaced with $1 + c$, for c an absolute positive constant. This fully answers a question of Erdos and Selfridge and uses the distortion method which has been applied to resolve other long-standing conjectures in the field. Time permitting, I will at the end pose an open problem, after I present some aspects of the $\#C$ being infinite case.

Translates of completely normal elements and the Morgan-Mullen conjecture

Giorgos Kapetanakis

Department of Mathematics, University of Thessaly, Greece

Denote by $\mathbb{F}_q$ the finite field of order q and by $\mathbb{F}_{q^n}$ its extension of degree n. Some $a \in \mathbb{F}_{q^n}$ is called primitive if it generates the multiplicative group $\mathbb{F}_{q^n}^*$ and it is called q^n/q-normal if its $\mathbb{F}_q$-conjugates form an $\mathbb{F}_q$-basis of $\mathbb{F}_{q^n}$ when the latter is viewed as an $\mathbb{F}_q$-vector space. Furthermore, some $a \in \mathbb{F}_{q^n}$ is called q^n/q-completely normal if it is q^n/q^d-normal for all $d \mid n$. In this work we prove a new construction of completely normal elements and we establish, under conditions, the existence of elements that are simultaneously primitive and q^n/q-completely normal, covering some yet unresolved cases of a 30-year-old conjecture by Morgan and Mullen. This is joint work with T. Garefalakis.

Gorenstein Duality and the Shape of Betti Tables in Equivariant Algebraic Geometry

Kostas Karagiannis

Department of Mathematics, National and Kapodistrian University of Athens, Greece

Minimal free resolutions encode geometric invariants of projective varieties into the algebraic language of syzygies and Betti tables. For Gorenstein schemes, the shape of these tables is heavily restricted by a numerical symmetry, while the non-zero entries form contiguous blocks. An action of a finite group on the variety enriches this data, elevating Betti numbers to representations. We present a framework to compute and constrain these representations by introducing equivariant Betti tables, equivariantly Gorenstein rings and lifting the classical numerical symmetry to a rigid representation-theoretic duality. Further, we show that the group action alters the classical layout of the table, introducing internal zeros separating the contiguous blocks of non-zero entries.

Homological Aspects of Separable Extensions of Triangulated Categories

Miltiadis Karakikes

Department of Mathematics, National and Kapodistrian University of Athens, Greece

Subcategories of derived categories of rings or schemes have long been studied to recover key homological invariants. Recently, Kostas, Psaroudakis and Vitória defined and systematically studied such intrinsic subcategories for any triangulated category. In joint work with Panagiotis Kostas, we investigate the homological behaviour of compactly generated triangulated categories under separable extensions. We show that finiteness of global dimension, gorensteinness and regularity are preserved under such extensions. We also establish a relation between singularity categories in this setting, proving that the singularity category of a separable extension is equivalent, up to retracts, to a separable extension of the singularity category. Our results unify and extend classical phenomena from commutative and equivariant algebra, and provide new examples involving separable extensions of rings, quotient schemes, and skew group dg algebras.

Iwahori-Spherical Whittaker Functions for Steinberg Representations

Markos Karameris

Faculty of Mathematics, Technion Israel Institute of Technology, Israel

Let G be a split reductive group over a non-archimedean local field and let St_χ denote a Steinberg representation of G. The space of Iwahori-fixed vectors in St_χ is known to be one-dimensional and carries the sign character of the Iwahori Hecke algebra. This vector is ”new” in the sense that it is not fixed by any larger parahoric subgroup. In this talk, we give an explicit formula for the Whittaker function attached to this Iwahori-spherical newvector, based on Hecke algebra computations. We determine the support and exact values of the Whittaker function on every Bruhat cell, obtaining a closed formula valid for general split reductive groups. In particular, for w in the Weyl group and d a torus element satisfying a natural w-dominance condition, we prove that the Whittaker function on dw is given by a simple expression involving the modular character and the Weyl length $\ell(w)$. Joint work with E. M. Baruch.

Tame Banach algebras

Konstantinos Kartas

Mathematics Münster, Universität Münster, Germany

The almost purity theorem is a foundational result in perfectoid geometry which, as the name suggests, holds only in an “almost” sense. We aim to identify a class of rings for which the theorem holds in a genuine (non-almost) form. Joint work in progress with Franziska Jahnke.

Radical splittings of toric ideals

Anargyros Katsampekis

Department of Mathematics, University of Ioannina, Greece

Let $I_A \subset K[x_1, \ldots, x_n]$ be a toric ideal. We provide a necessary and sufficient condition for the toric variety $V(I_A)$, over an algebraically closed field, to be expressed as the set-theoretic intersection of other toric varieties. We also introduce the radical splitting number of I_A, denoted by $\mathrm{Split}_{\mathrm{rad}}(I_A)$, and compute its exact value in several cases, with particular emphasis on toric ideals arising from graphs. In particular, we show that $\mathrm{Split}_{\mathrm{rad}}(I_A) = 3$ for toric ideals of complete bipartite graphs. Additionally, we prove that $\mathrm{Split}_{\mathrm{rad}}(I_A)$ coincides with the binomial arithmetical rank of I_A when the height of I_A is equal to 2.

Local average in the Hyperbolic lattice counting problem

Christos Katsivelos

Department of Mathematics, University of Patras, Greece

Starting from the description of the classical Euclidean circle problem, we pass to the hyperbolic analogue, where we count points in the orbit of a discrete group Γ acting on the hyperbolic space $\mathbb{H}^n$ within a ball of radius $\log X$. We will discuss our results for the local average of the error term of the counting function over compact sets of the orbifold $\Gamma\backslash\mathbb{H}^n$. The case $n = 3$ for the Picard manifold $\mathrm{PSL}_2(\mathbb{Z}[i])\backslash\mathbb{H}^3$ is a joint work with G. Cherubini.

Regular Sequences in Triangulated Categories

Antonia Kekkou

Department of Mathematics, University of Utah, USA

Regular sequences are a fundamental tool in commutative algebra. In this talk, we introduce regular sequences in R-linear triangulated categories, where R is a graded-commutative ring. As

an application of this definition, we show that the length of regular sequences provides lower bounds on levels. This is joint work with Janina C. Letz and Marc Stephan.

The order of the Tate–Shafarevich group modulo squares

Alexandros Konstantinou

IMI-BAS, Sofia, Bulgaria

The Tate–Shafarevich group is a central yet mysterious object in the study of rational points on abelian varieties. It measures the obstruction to algorithmically determining a set of generators for the Mordell–Weil group and plays a crucial role in the Birch and Swinnerton-Dyer conjecture. Yet it is notoriously difficult to compute, or even to prove finite. For elliptic curves, it is known to have square order when finite. In higher dimensions, however, this property can fail, a fact that was long overlooked and often misstated in the literature before being corrected in the late twentieth century. In this talk, we show that every square-free integer arises as the square-free part of the order of the Tate–Shafarevich group of some abelian variety over the rationals.

Intrinsic homological algebra for triangulated categories

Panagiotis Kostas

Department of Mathematics, Aristotle University of Thessaloniki, Greece

It has long been observed that in the derived category of a ring, all the subcategories of interest are intrinsic. Based on this, we introduce far-away orthogonality – a concept which allows us to systematically associate a list of intrinsic subcategories to any compactly generated triangulated category. We will explain how to utilize these subcategories in order to produce reasonable homological notions in this context and examine those attributes for common triangulated categories in representation theory. This is based on joint work with C. Psaroudakis and J. Vitória.

Monodromy of rational singularities in mixed characteristic

Jason Kountouridis

Institut de Mathématique d'Orsay, Université Paris-Saclay, France

We study the geometry of a 1-parameter family of smooth surfaces degenerating to a surface with prescribed rational singularities, and the effect of the resulting monodromy action on the cohomology of the fibers of this family. In the mixed characteristic setting, when the singular fiber is a surface in characteristic p, we get a construction of special Galois representations out of these monodromy actions, which are linked to certain Weyl groups that are naturally associated to rational singularities. Time permitting, we will describe more broadly to what extent these monodromy representations determine the singularities of the degenerate fiber.

Vector spaces with isomorphic duals

Theodoros Kyriopoulos

We consider the assertion $L(\mathbb{F})$: Any two $\mathbb{F}$-vector spaces with isomorphic duals are isomorphic, for a given field (or division ring) $\mathbb{F}$.

We prove the following : (1) If the cardinality of $\mathbb{F}$ does not exceed the continuum then $L(\mathbb{F})$ is non-decidable in ZFC and $L(\mathbb{F})$ holds in ZFC + GCH. (2) If the cardinality of $\mathbb{F}$ exceeds the continuum then $L(\mathbb{F})$ fails in ZFC + GCH.

Three subgroup common transversal

Maria Loukaki

Department of Mathematics and Applied Mathematics, University of Crete, Greece

We completely characterize when three equal-order subgroups of a finite abelian group share a common transversal. Consequently, we determine when three full-rank lattices of equal volume in $\mathbb{R}^d$ admit a common fundamental domain, solving a 1997 problem of Kolountzakis. This is joint work with M.Spyridakis.

Finiteness results on abelian varieties with constrained torsion

Mentzelos Melistas

Department of applied mathematics, University of Twente, The Netherlands

Let L be a number field and let ℓ be a prime number. Rasmussen and Tamagawa conjectured, in a precise sense, that abelian varieties whose field of definition of the ℓ-power torsion is both a pro-ℓ extension of $L(\mu_\ell)$ and unramified away from ℓ are quite rare. In this talk, we will first go over the conjecture and discuss some known results. Then we will explain an analogue of the conjecture for non-isotrivial abelian varieties over functions fields, and present some results towards it.

The homotopical geometry of p-adic cohomology theories

Tasos Moulinos

CNRS chargé, Université de Paris-Saclay, France

In this talk I will discuss recent interactions between p-adic geometry and homotopy theory. A central role will be played by prismatization and syntomification, due to Drinfeld and Bhatt–Lurie. Prismatization attaches to a p-adic formal scheme a geometric object whose coherent

cohomology recovers prismatic cohomology, thereby organizing familiar p-adic cohomology theories, such as de Rham and crystalline cohomology, in a common framework. Syntomification refines this picture and gives a geometric setting for syntomic cohomology, which can be regarded as a p-adic avatar of motivic cohomology and is closely related to p-adic étale cohomology.

I will then explain how this picture connects with spectra, the basic objects of stable homotopy theory in algebraic topology. Spectra provide a flexible way of organizing generalized cohomology theories in topology, while chromatic homotopy theory studies them by decomposing them into successive "chromatic" layers. The first nontrivial layer is controlled by $K(1)$-localization, which can be thought of, morally, as inverting an element v_1. In p-adic geometry, an analogous class v_1 appears as a section of a line bundle on the syntomification of the integers. Cohomologically, inverting this class should correspond to passing from syntomic cohomology to p-adic étale cohomology. The difficulty is that this inversion has no naive algebro-geometric meaning. I will conclude by describing ongoing work using the analytic geometry of Clausen–Scholze to give a precise geometric interpretation of inverting v_1.

From quasisymmetric functions to zeta functions through shuffle compatibility

Vassilis Dionyssis Moustakas

Department of Mathematics and Applied Mathematics, University of Crete, Greece

A permutation statistic st is called shuffle compatible if for any two permutations π and σ on disjoint sets of symbols, its distribution over all shuffles of π and σ depends only on $\mathrm{st}(\pi)$, $\mathrm{st}(\sigma)$ and the lengths of π and σ. It follows from Stanley's work that the descent set constitutes the prototypical example of a shuffle-compatible permutation statistic. Gessel and Zhuang formalized this notion by introducing and studying the associated shuffle algebra. In this talk, we are going to discuss a colored analogue of shuffle compatibility for colored permutation statistics and its connection with Poirier's colored quasisymmetric functions. Additionally, we will present an application of colored shuffle compatibility in computing Hadamard products of certain algebraic zeta functions. This is based on joint work with Angela Carnevale and Tobias Rossmann.

Parseval-Rayleigh identities for Cohen-Macaulay rings

Vasiliki Petrotou

Institut de Mathématiques, Jussieu-Paris Rive Gauche, France

Parseval–Rayleigh identities, originally arising in Fourier analysis, have recently acquired an algebraic counterpart in positive characteristic that has proven effective in the study of Lefschetz properties of graded algebras associated with combinatorial objects. As a consequence, these identities have played a central role in resolving unimodality conjectures in combinatorics. In this talk, we study these identities from the perspective of commutative algebra and explain their origin. As a special case of the general framework, we analyze the Parseval-Rayleigh identities for homogeneous complete intersections focusing on their connection to Lefschetz properties for

this class. This is joint work with K. Adiprasito, E. Katz, R. Oba and S. Papadakis.

Enumerative geometry of curves via tautological rings

Georgios Politopoulos

Mathematical Institute, Leiden University, The Netherlands

Enumerative geometry has been at the heart of geometry for more than two millennia. Its aim is to answer questions of the following kind: how many geometric objects X satisfy conditions $Y_1, ..., Y_n$. In this talk, we will discuss how modern algebraic geometry solves such questions for curves by studying the structure of the Chow ring of their moduli space. Along these lines, I will present joint work with Adrien Sauvaget and David Holmes.

Generalizations of the Springer correspondence

Kostas Psaromiligkos

Department of Mathematics, National and Kapodistrian University of Athens, Greece

The Springer correspondence is a very classical and important geometric construction that relates equivariant perverse sheaves on the nilpotent cone of a complex connected reductive group and representations of its Weyl group. The coefficients of both the equivariant perverse sheaves and the representations in the initial version are assumed to be over a field of characteristic 0. Generalizations of it due to Lusztig play a key role in his classification of the irreducible representations of finite groups of Lie type.

In this talk, we will explain a generalized Springer correspondence for possibly disconnected complex reductive groups, and perverse sheaves/representations over any field of coefficients. This is joint work with Simon Riche.

Chowla's conjecture and primes in arithmetic progressions under the presence of Landau-Siegel zeroes

Stelios Sachpazis

Department of Algebra, Faculty of Mathematics and Physics, Charles University, Czech Republic

This talk will be divided into two parts. In the first one, we will discuss Chowla's conjecture in the presence of Landau-Siegel zeroes. In particular, I will briefly present my joint work with Mikko Jaskari which improves the previous bounds of Germán and Kátai, Chinis, and Tao and Teräväinen regarding the linear correlations of the Liouville function under the existence of exceptional characters. The second part of the talk shall be concerned with the conditional study of primes in arithmetic progressions under Landau-Siegel zeroes. We shall actually see that the existence of these exceptional zeroes allows us to go beyond the so-called square-root

barrier of the Generalized Riemann Hypothesis and then, I will show my improvement over the previous related works of Friedlander and Iwaniec, and T. Wright. The common inspiration for the advancements achieved in this work, as well as in my work with Mikko Jaskari, was drawn from a rather recent paper of Matomäki and Merikoski where they assume the existence of Siegel zeroes to examine the 2-point Hardy-Littlewood correlations of the von Mangoldt function.

Determinants of Laplacians and their asymptotics for a sequence of compact Riemannian surfaces of infinite growing volume

Polyxeni Spilioti

Department of Mathematics, University of Patras, Greece

In this talk, we will present some recent results and work in progress, concerning the regularized determinants of Laplacians on compact hyperbolic surfaces, their relation to the Selberg zeta function and their asymptotic behaviour for a sequence of compact hyperbolic surfaces of infinitely growing volume. This is joint work with Jay Jorgenson and Lejla Smajlovic.

Tableaux and orbit harmonics quotients for finite transformation monoids

Dimitra-Dionysia Stergiopoulou

Department of Mathematics, University of Thessaly, Greece

In this talk we connect the polynomial representation theory of the general linear group with the representation theory of important classes of finite monoids. We extend Grood's tableau construction of irreducible representations of the rook monoid and Steinberg's analogous result for the full transformation monoid. Our approach is characteristic-free and applies to any submonoid $M(n)$ of the partial transformation monoid on an n-element set that contains the symmetric group. To achieve this, we introduce and study a functor from the category of rational representations of the monoid of $n \times n$ matrices to the category of finite dimensional representations of $M(n)$. We establish two branching rules. Our main results describe graded module structures of orbit harmonics quotients for the rook, partial transformation and full transformation monoids. This yields analogs of the Cauchy decomposition for polynomial rings in $n \times n$ variables. Joint work with M. Maliakas.

Weak Oort Groups and Integral Representations

Alexios Terezakis

Department of Mathematics, National and Kapodistrian University of Athens, Greece

We will explore how the problem of lifting a curve with a group action can be reduced to studying the group's integral representations. Since these representations are often difficult to understand and even harder to classify, we will discuss the main challenges of this approach. We will conclude with an overview of integral representations and some established results.

On the Beauville-Bogomolov decomposition

Nikolaos Tsakanikas

Institute of Mathematics, École Polytechnique Fédérale de Lausanne, Switzerland

The celebrated Beauville-Bogomolov decomposition theorem asserts that Ricci-flat compact Kähler manifolds can be decomposed, possibly after passing to a finite étale cover, into a product of a complex torus, irreducible Calabi-Yau manifolds, and irreducible holomorphic symplectic (IHS) manifolds. Recent developments in higher-dimensional birational geometry motivate and require, if possible, extensions of this structure theorem that concern projective varieties with mild singularities and numerically trivial canonical class. In this talk I will discuss certain generalizations of the Beauville-Bogomolov decomposition theorem to the "mildly singular" (klt) setting. I will also report on a joint work with F. Bernasconi, S. Filipazzi and Zs. Patakfalvi, where we showed that a Beauville–Bogomolov type decomposition fails, in general, in the "most singular" (lc) setting.

Asymptotic Dimension in Group Theory

Panagiotis Tselekidis

Department of Mathematics, University of the Aegean, Karlovassi, Samos, Greece

The asymptotic dimension was introduced by Gromov as an invariant for finitely generated groups. In 1998, the notion of asymptotic dimension gained particular importance in geometric group theory following a paper by Guoliang Yu, in which he proved the Novikov conjecture for groups with finite asymptotic dimension. Consequently, a central problem in Geometric Group Theory is to determine which groups have finite asymptotic dimension.

The Bass–Serre theory (Graphs of Groups) studies the structure of groups acting “nicely” on simplicial trees. It provides a useful perspective on groups as trees of subgroups.

In this talk, I will present the main tool currently available for computing the asymptotic dimension of groups. More specifically, I will a theorem of mine about the asymptotic dimension of fundamental groups of graphs of groups. In addition, I will present some of my own results on the asymptotic dimension of certain well-known classes of groups, such as Artin groups, Coxeter groups, and one-relator groups.

Stability of discrete representations of hyperbolic groups over local fields

Konstantinos Tsouvalas

Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany

Anosov representations, introduced by Labourie in 2004 and further generalized by Guichard-Wienhard, form a large class of discrete and stable hyperbolic subgroups of semisimple Lie groups, generalizing classical convex cocompact subgroups of rank one Lie groups. After providing a brief introduction on Anosov representations, we will discuss a construction of stable, non-rigid, quasi-isometrically embedded hyperbolic subgroups of $\mathrm{SL}(n, K)$, for any $n > 2$ and any local field K, which are not algebraic limits of Anosov representations. This answers questions raised by F. Kassel and R. Potrie and shows that analogues of Sullivan's structural stability theorem and of the density theorem of Kleinian groups fails for Anosov representations in higher rank.

Commuting tensor products for multicategories and bimodules

Christina Vasilakopoulou

School of Applied Mathematical and Physical Sciences, National Technical University of Athens, Greece

Given two algebraic theories S and T, their commuting tensor product $S \otimes T$ is a new algebraic theory in which the operations of S and T are required to commute with each other. The analogue of this operation for symmetric operads is the famous Boardman-Vogt tensor product. In this work, we extend this analysis in two aspects. First, we generalise to the many-object case, recovering the Boardman-Vogt tensor product of symmetric multicategories (or colored operads). Secondly, we explore how the commuting tensor product acts on bimodules, both between symmetric operads and also multicategories. This work is carried out in the general context of a double category equipped with an oplax monoidal structure, considering monads and bimodules therein.

The singularity category of a separable extension

Charalampos Verasdanis

Czech Academy of Sciences, Prague, Czech Republic

The theory of separability in tensor-triangular geometry was developed to provide a conceptual unification of naturally arising constructions in various contexts. Among others, it allows one to describe derived categories involving separable algebras and etale morphisms of schemes in terms of the base. We will discuss two recent results fitting in this framework: Separable extensions

of commutative noetherian rings and finite etale morphisms of noetherian schemes give rise to separable extensions of singularity categories. In both cases, this is achieved by establishing monadicity of appropriate adjunctions emerging from the given data.

Hyperbolic counting and its arithmetic applications

Marios Voskou

Alfréd Rényi Institute, Budapest, Hungary

In Euclidean space the Gauss' Circle Problem is concerned with estimating the number of lattice points inside a Euclidean circle. In this talk we will discuss various analogous problems in the hyperbolic space. We will also explore arithmetic applications, particularly to the distribution of arithmetic objects such as sums of four squares and norms of ideals in number fields. The methods involved come from the theory of automorphic forms and their spectral theory.

On orthogonal local models of PEL type

Ioannis Zachos

Department of Mathematics, Universität Münster, Germany

Local models of Shimura varieties are integral models of homogeneous spaces, designed to model the singularities arising in the reduction modulo p of Shimura varieties. In this talk, we will discuss recent results on orthogonal local models of PEL type. We will report on a recent proof of a conjecture of Pappas and Rapoport; the result shows that the spin local model is the correct flat local model. If time permits, we will mention results on desingularizations of these local models. This is based on joint work with Jie Yang and Zhihao Zhao.

Mathematical Analysis

Organizers

Dodos P. (National and Kapodistrian University of Athens)

Frantzikinakis N. (University of Crete)

Giannopoulos A. (National Technical University of Athens)

PROGRAM

MATHEMATICAL ANALYSIS SESSIONS

	Monday June 29	**Tuesday June 30**	**Wednesday July 1**	**Thursday July 2**	**Friday July 3**
	NKUA, Φ23	**NTUA, ΣΗΜΜΥ, Amf. 1**	**NKUA, Φ23**	**NTUA, ΣΗΜΜΥ, Amf. 1**	**NKUA, Φ23**
16:00-16:30	A. A. Vogiatzi	A. Menegaki	N-M. Mavraki	M. Chatzakou	M. Manolaki
16:30-17:00	C. Pandis	C. Konidas	A. Zafeiropoulos	S. Lappas	G. Stylogiannis
17:00-17:30	S. Armeniakos	S. Petrakos	A. Sourmelidis	G. Psaromiligkos	M. Kourou
17:30-18:00	**Coffee break**	**Coffee break**	**Coffee break**	**Coffee break**	**Coffee break**
18:00-18:30	N. Tziotziou	G. Kopsacheilis	L. Daskalakis	V. Fragkiadaki	M. Ntekoume
18:30-19:00	C. Kravaris	I-A. Paraskevas	K. Tsinas	V. Mastrantonis	K. Maronikolakis
19:00-19:30	K- J. Prodromidis	K. Konstantos	I. Kousek	A. Malliaris	V. Chousionis
19:30-20:00	M. Pafis	B-H. Vritsiou		P. Kalantzopoulos	

Infinitesimal forms of the Prékopa–Leindler inequality and applications

Sotirios Armeniakos

TU Wien

After presenting (functional) Wulff shapes and their applications to infinitesimal forms of the Prékopa–Leindler inequality, we discuss the dimensional Brunn–Minkowski conjecture for log-concave measures, as well as a new approach via the calculus of variations leading to some partial results.

The talk is based on recent joint work with Jacopo Ulivelli (TU Wien).

High codimension curve shortening flow with free boundary

Aikaterini-Artemis Vogiatzi

University of Copenhagen

In this talk, I will discuss about curve shortening flow in high codimension for arcs with free boundary meeting a fixed smooth barrier orthogonally. We prove curvature and higher-derivative estimates up to the boundary using a Stahl-type localized maximum principle. Using a reflected Gaussian entropy and blow-up analysis, Type I boundary singularities yield a shrinking semicircle model after reflection. Type II blow-ups give a Grim Reaper translator, which is ruled out under a free-boundary entropy bound < 2. Hence in the low-entropy regime the flow either converges to the orthogonal chord or has only semicircle boundary singularities. This is a joint work with Huy T. Nguyen.

On random diameters of convex bodies

Beatrice-Helen Vritsiou

University of Alberta

We provide general upper and lower bounds for diameters of random sections of high-dimensional convex bodies. We apply our results to bound random diameters of p-ellipsoids (images of ℓ_p balls under diagonal operators), improving upon previously known results and obtaining sharp bounds in many cases. This is joint work with O. Guédon, A. Litvak and K. Tatarko.

Pointwise ergodic theorems along sequences of superpolynomial growth

Leonidas Daskalakis

Institute of Mathematics, Polish Academy of Sciences & Institute of Mathematics, University of Wrocław

We establish pointwise convergence for non-conventional ergodic averages modeled along $(\lfloor n^{(\log n)^b} \rfloor)_{n\in\mathbb{N}}$ with $b \in (0, 1/3)$ on L^p, $p \in (1, \infty)$. To the best of the author's knowledge this is the first pointwise ergodic theorem along orbits of superpolynomial growth. The technical heart of the approach is an exponential sum estimate with phases $(\xi\lfloor n^{(\log n)^b} \rfloor)_{n\in\{1,\dots,N\}}$ which we derive via a delicate application of Vinogradov's method. Our analysis affords us to establish uniform multiparameter oscillation estimates for the ergodic averages as well as the corresponding multiparameter pointwise ergodic theorem in the spirit of Dunford and Zygmund.

Twisted Diophantine Approximation on Laurent Series: a Khintchine-type Theorem

Agamemnon Zafeiropoulos

TU Graz, Austria

The t-adic Littlewood Conjecture on fields of Laurent series asks whether for any $\Theta \in \mathbb{F}_q((t^{-1}))$, we have

$$\inf_{Q\in\mathbb{F}_q[t]} |Q||Q|_t\|Q\Theta\| = 0.$$

Recently, a counterexample to the above conjecture was provided when the underlying field $\mathbb{F}_q$ has characteristic equal to 3 by Adiceam, Lunnon and Nesharim, and also when the characteristic is equal to a prime $p \equiv 3 \bmod 4$ by Adiceam and Badziahin.

Let $\Theta \in \mathbb{F}_q((t^{-1}))$ be such a counterexample, $\Lambda = (\ell_n)_{n\geq 1} \subseteq \mathbb{N}$ be an increasing sequence and consider the set

$$W_\Theta(\Lambda) = \Big\{\Gamma \in \mathbb{L} : |Q|_t\|Q\Theta - \Gamma\| < 1/q^{\ell_n} \ \& \ \deg(Q) = n \text{ for i.m. } n \geq 1\Big\}.$$

We formulate and prove a Khintchine-type theorem on the sets $W_\Theta(\Lambda)$. We also show that this is no longer true when the shift Θ is not a counterexample to the t-adic Littlewood Conjecture.

This is joint work in progress with E. Nesharim.

Multidimensional Gaussian Hypercontractivity

Pavlos Kalantzopoulos

University of Waterloo

We study T_z-hypercontractivity for n functions, where T_z denotes the noise operator ($z \in \mathbb{R}$) or the Mehler transform ($z \in \mathbb{C}$). For jointly Gaussian random vectors $\xi_j \in \mathbb{R}^{k_j}$, each standard normal but possibly correlated, we characterize inequalities of the form

$$\mathbb{E}\, F\Big(B\big(|T_{z_1} f_1(\xi_1)|, \ldots, |T_{z_n} f_n(\xi_n)|\big)\Big) \;\leq\; F\Big(\mathbb{E}\, B\big(|f_1(\xi_1)|, \ldots, |f_n(\xi_n)|\big)\Big),$$

via a covariance-weighted matrix positivity condition involving derivatives of F and B. The proof is based on the Beckner–Janson interpolation flow, extended to a multidimensional setting. Consequences include multidimensional versions of the sharp Hausdorff–Young and log-Sobolev inequalities, as well as noisy Gaussian Jensen and Gaussian Brascamp–Lieb inequalities.

Joint work with Paata Ivanisvili.

A Fredholm framework for the wave operator on the Clifton–Pohl torus

Christos Konidas

Northwestern University

The Clifton–Pohl torus is a classical example of a compact Lorentzian manifold with incomplete null geodesics. We prove Fredholm estimates for the wave operator on this manifold acting between suitable variable-order Sobolev spaces. The proof uses the source-sink dynamics of the projectivized null-geodesic flow to rule out the existence of non-trivial microlocal defect measures.

Hyperbolic geometry and conformality at the boundary

Maria Kourou

Julius–Maximilians University of Wuerzburg

We discuss two classical types of conformality of a holomorphic self-map of the unit disk at a boundary point, in terms of the non-tangential asymptotic behaviour of the hyperbolic distortion of the map. Characterizations are given purely with reference to the intrinsic metric geometry of the unit disk. In particular, we relate the classical Julia–Wolff–Carathéodory theorem with the case of equality in the Schwarz–Pick lemma at the boundary. Moreover, we discuss recent developments concerning lower bounds for the hyperbolic distortion that ensure the existence of angular limits and additional geometric properties at boundary points. This talk is based on a joint work with P. Gumenyuk, A. Moucha, and O. Roth.

Infinite sumsets via ergodic theory

Ioannis Kousek

University of Warwick

In this talk, we explain how the structure theory of multiple ergodic averages is connected to recent results regarding the existence of infinite configurations, i.e. sumsets, inside dense subsets of the integers.

Cartan subalgebras of the Toeplitz algebra

Grigoris Kopsacheilis

KU Leuven

Cartan subalgebras have been objects of central interest in the field of operator algebras, originating in the work of Vershik and Feldman–Moore on the side of von Neumann algebras, and subsequently adapted by Renault and Kumjian on the side of C*-algebras. Roughly speaking, a Cartan subalgebra is a distinguished subalgebra with certain properties that asserts that the ambient operator algebra arises from a dynamical object via canonical constructions.

Various examples of non-standard Cartan subalgebras in classical C*-algebras have appeared in the recent literature, all obtained via applications of classification theory, showcasing the wide variety of dynamical structures that can serve as models for the same C*-algebra. In this talk we will discuss a complete parametrization of Cartan subalgebras of the Toeplitz algebra, i.e. the C*-algebra generated by the Toeplitz operators with continuous symbol (and, more generally, essential unital extensions of continuous functions on the circle by the compact operators). This talk is based on joint work (in progress) with Philipp Sibbel.

L_1 and L_2 embeddings of the symmetric groups

Cosmas Kravaris

Princeton University

We show that the Cayley graph of the symmetric group Sym_n generated by the cycle $(123\ldots n)$ and the transposition (12) embeds into L_1 with bi-Lipschitz distortion < 1000. This answers a question of Ostrovskii, and along with Kassabov's theorem gives the first example of a sequence of groups which embed bi-Lipschitzly into L_1 for one choice of bounded size generating sets, but not for another choice of bounded size generating sets. In particular, the Cayley graphs generated by the cycle and the transposition cannot contain coarsely any unbounded sequence of expander graphs.

Factorization properties of operators on the Rosenthal spaces and the Bourgain-Rosenthal-Schechtman spaces

Konstantinos Konstantos

York University

In this work, we study factorization properties of operators on the Rosenthal X_p space and the Bourgain-Rosenthal-Schechtman R^p_α spaces, $1 \leq \alpha < \omega_1$. We say that a bounded linear operator T on a Banach space X is a factor of the identity operator id on X if there exist bounded linear operators $L, R\colon X \to X$ such that $id = LTR$. Factors of the identity have played a crucial role in Banach space theory, for example, in the study of closed ideals in the Banach algebra $\mathcal{L}(X)$ of all bounded linear operators on a Banach space X, as well as in the study of decompositions of classical Banach spaces (primary spaces). This motivates the following definitions. We say that a Banach space X with its Schauder basis $(e_n)_{n\in\mathbb{N}}$ has the factorization property if every bounded linear operator $T\colon X \to X$ with large diagonal, i.e., such that $\inf_{n\in\mathbb{N}} |e_n^*(T(e_n))| \geq \delta > 0$, is a factor of the identity. For $1 < p < \infty$, we prove that the natural bases of the X_p space and of the limit R^p_α spaces have the factorization property. We say that a Banach space X has the primary factorization property if for every bounded linear operator $T : X \to X$ we have that either T or $id - T$ is a factor of the identity. For $1 < p < \infty$, we prove that X_p and R^p_ω have the primary factorization property. This is joint work with Pavlos Motakis.

Sharp bilinear estimates for singular integral operators and their maximal counterparts with kernels in weighted spaces

Stefanos Lappas

University of Bonn

We discuss the boundedness properties of bilinear singular integral operators (including their maximal versions) associated with rough homogeneous kernels on $\mathbb{R}$. In particular, we focus on the $L^{p_1}(\mathbb{R}) \times L^{p_2}(\mathbb{R}) \to L^p(\mathbb{R})$ bounds in the optimal quasi-Banach range of exponents $1 < p_1, p_2 < \infty$ and $1/2 < p < \infty$, when the angular component Ω of the kernel belongs to weighted L^q-spaces on the unit sphere $\mathbb{S}^1$ and has vanishing integral.

This talk is based on two joint works with Petr Honzík, Lenka Slavíková and Bae Jun Park.

Relevant variables for Boolean functions

Andreas Malliaris

University of Toulouse

Let $f : \{-1,1\}^n \to \{-1,1\}$ be a Boolean function. The i-th variable is called relevant for f if there exists $x \in \{-1,1\}^n$ such that $f(x) \neq f(x_1, \ldots, -x_i, \ldots, x_n)$. Denoting by $R(f)$ the number of relevant variables for f, in this talk we are interested in the quantity

$$R_d = \max\{R(f) \mid f : \{-1,1\}^n \to \{-1,1\} \text{ with } \deg(f) = d\}.$$

The classical work of Nisan and Szegedy gives the bound $R_d \leq d2^{d-1}$, while more recent works of Chiarelli–Hatami–Saks and Wellens prove that there exists a universal constant $C > 0$ such that $R_d \leq C2^d$. We will discuss how these bounds can be improved by deriving several structural properties for the spectrum support of Boolean functions.

This is joint work with Franck Barthe, Paata Ivanisvili and Xinyuan Xie.

Cylinders on which harmonic functions can vanish

Myrto Manolaki

University College Dublin

In 1992, Armitage characterised the cones in $\mathbb{R}^N$ with the property that there is a nontrivial entire harmonic function which vanishes on the cone. In this talk, we will provide the analogous characterisation for harmonic functions vanishing on two coaxial cylinders. As we will see, the motivation comes from recent extension results for harmonic functions vanishing on cylindrical surfaces, and the characterisation involves Bessel functions. This talk is based on an ongoing project with Stephen Gardiner and Josef Greilhuber.

Dense orbits in linear dynamical systems

Konstantinos Maronikolakis

Bilkent University

The dynamics of linear operators have been thoroughly studied in the past century. A central notion is hypercyclicity: if X is a Fréchet space and T is an operator on X, we say that T is hypercyclic if there exists a vector $x \in X$ that has dense orbit under T ($\overline{\{T^n x : n \in \mathbb{N}\}} = X$). We also call such a vector x hypercyclic for T. Ansari's Theorem states that, if T is hypercyclic, then T^a is hypercyclic for any positive integer a and the two operators share the same hypercyclic vectors. In other words, for any hypercyclic vector x for T, we have that $\overline{\{T^{an} x : n \in \mathbb{N}\}} = X$. A natural question that arises is to examine for which other sequences $(\lambda_n)_n$ of positive integers in place of $(an)_n$ the previous result still holds. In this talk, we will explore this question and give generalisations and variations of Ansari's Theorem. In particular, we are able to completely characterise these sequences for some natural hypercyclic operators.

This is joint work with Stéphane Charpentier, Romuald Ernst and Myrto Manolaki.

On Hausdorff–Young inequalities for the Laplace transform

Vlassis Mastrantonis

Cornell University

In a recent talk, we discussed an extension of the Nakamura-Tsuji Hausdorff-Young type inequalities for the Laplace transform to the non-symmetric setting, using the Fokker-Planck heat flow. In this talk, we explain how these inequalities can also be obtained from the geometric L^p-Santaló inequalities by computing, via the Laplace method, the asymptotics of the L^p-Mahler volume of the Euclidean ball, in combination with a careful approximation which allows one to pass from bodies to functions. This is joint work with Tsiamis and Brazitikos.

Bifurcation currents and unlikely intersections

Niki-Myrto Mavraki

University of Toronto

Arithmetic geometry and complex dynamics have had many fruitful interactions in recent years. In this talk, I will focus on one meeting point between the two: unlikely intersections. Very roughly, these are situations where there are “too many” special points for dimension-counting reasons alone, and one tries to explain this abundance by an underlying geometric relation.

I will discuss this idea in families of dynamical systems. My goal is to give a glimpse, through examples, of how arithmetic tools such as heights and equidistribution can shed light on analytic bifurcation phenomena, and how complex dynamics can in turn help reveal the hidden geometric relations behind unlikely intersections.

Quantitative framework for hydrodynamic limits

Aggeliki Menegaki

Imperial College London

We will present a new quantitative approach to the problem of proving hydrodynamic limits from microscopic stochastic particle systems to macroscopic partial differential equations. We will apply it to the zero-range process. Our method combines a modulated Wasserstein distance estimate comparing the law of the stochastic process to the local Gibbs measure, together with stability estimates a la Kruzhkov in weak distance and consistency estimates exploiting the regularity of the limit solution. It is simplified as it avoids the use of the block estimates.

This is a joint work with Clément Mouhot (University of Cambridge).

Homogenization for the cubic nonlinear Schrödinger equation

Maria Ntekoume

Concordia University

The cubic nonlinear Schrödinger equation (NLS) arises as a model for the propagation of intense continuous wave laser beams in a homogeneous medium. In practice, it has also been successful in modeling optical experiments in inhomogeneous settings. This suggests the occurrence of homogenization, that is, in a large scale limit, solutions to the inhomogeneous equation converge to the solution of a homogeneous NLS. We will review some recent homogenization results for physically motivated examples. While materials with a periodic structure are the most natural setting to consider this problem, our examples include a model where strong defects are sprinkled randomly across the medium. Part of this talk is based on joint work with B. Harrop-Griffiths.

Restricted Extremal-Volume Sections and Projections of Certain Convex Bodies

Christos Pandis

University of Crete

The study of lower-dimensional sections and projections of convex bodies is a central theme in asymptotic geometric analysis and high-dimensional geometry. Since the seminal works of Hensley and Ball on hyperplane sections of the unit cube in $\mathbb{R}^n$, the problem of determining extremal hyperplane sections, and more generally extremal lower-dimensional sections and projections, of classical convex bodies such as the unit balls of ℓ_p^n spaces or the n-simplex has proved to be highly nontrivial.

In this talk, we discuss sharp volume estimates for restricted hyperplane sections of classical convex bodies, including the cross-polytope and the simplex. Here "restricted" means that the hyperplane is required to pass through a prescribed point. We will also discuss the dual problem concerning projections.

The results presented are mostly based on joint work with Silouanos Brazitikos.

Embeddings and extension theory of selfadjoint operator spaces

Ioannis Apollon Paraskevas

National and Kapodistrian University of Athens

Operator systems, i.e., closed, selfadjoint subspaces of $\mathcal{B}(H)$ containing its unit, play a central role in the theory of Operator Algebras. Lately, the community has been actively considering selfadjoint operator subspaces, but which need not be unital. In this talk we focus on Werner's unitisation of such spaces and on embeddings between them, that is, completely isometric complete order maps whose unitisation remains completely isometric. The notion of embeddings

is closely related to gauge maximal inclusions of Russell and to having an Arveson's Extension Theorem for completely contractive completely positive maps. We give a characterisation of embeddings and several intrinsic conditions of the selfadjoint operator space that allows various type of extensions of maps. We focus on two classes that have tractable cone structure: approximately positively generated and singly generated selfadjoint operator spaces. Finally, we give some applications in extremal theory involving co-universal objects and hyperrigidity.

Joint work with Alexandros Chatzinikolaou, Evgenios Kakariadis and Se-Jin Kim.

Discrete log-concavity and threshold phenomena for atomic measures

Minas Pafis

National and Kapodistrian University of Athens

We investigate threshold phenomena for random polytopes $K_N = \mathrm{conv}\{X_1, \ldots, X_N\}$ generated by i.i.d. samples from an atomic law μ. We identify and provide a missing justification in the discrete-hypercube threshold argument of Dyer–Füredi–McDiarmid, where the supporting half-space estimate is derived via a smooth (gradient/uniqueness) step that can fail at boundary contact points. We then compare threshold-driving mechanisms in the continuous log-concave setting – through the Cramér transform and Tukey's half-space depth – with their discrete analogues. Within this framework, we establish a sharp threshold for lattice p-balls $\mathbb{Z}^n \cap rB_p^n$. Finally, we present structural counterexamples showing that sharp thresholds need not hold in general discrete log-concave settings.

The talk is based on joint work with Silouanos Brazitikos.

Quantitative orbit equivalence for rank-one systems

Spyridon Petrakos

Chalmers University of Technology & University of Gothenburg

It is known for a long time, due to a celebrated theorem of Ornstein and Weiss, that (classical/plain) orbit equivalence offers no information about free ergodic p.m.p. actions of amenable groups. On the other hand, conjugacy is too intractable, and effectively hopeless to study in full generality. Quantitative orbit equivalence aims to bridge this gap by adding intermediate layers of rigidity—a strategy that has borne fruit already in the late 1960s but was used as a general framework only recently.

In this talk, I will introduce aspects of quantitative orbit equivalence and present a complete picture of it for rank-one systems. This is based on joint projects with Petr Naryshkin and Corentin Correia.

Polynomial Mixing of the critical Ising model on sparse Erdös-Rényi graphs

Kyprianos Iason Prodromidis

Princeton University

We consider the Ising model on Erdös-Rényi random graphs $G(n, d/n)$ at the critical temperature and prove that the mixing time of the corresponding Glauber dynamics is polynomial in the size of the graph. We will discuss some key ideas in the proof, focusing in particular on a method called *stochastic localization*, which was originally developed for isoperimetric problems in convex geometry.

Joint extreme values of L-functions

Athanasios Sourmelidis

CNRS, Université de Lille

In this talk we will discuss about the extremal behavior of L-functions. As a special case we will see that any tuple of distinct primitive GL(1) and GL(2) L-functions can simultaneously attain large values on the critical line. This is an unconditional improvement of a general result due to Heap and Li who have assumed the Riemann Hypothesis for more than three such L-functions. The main machinery is the resonance method of Soundararajan and a variation of Heath-Brown's method for the fractional moments of the Riemann zeta-function. The latter method, in particular, builds on Gabriel's convexity theorems and makes it possible to avoid using any information on the zero distribution of L-functions whose degree is less than three.

On the spectrum of Hausdorff operators on Hardy spaces of the upper half plane

Georgios Stylogiannis

Aristotle University of Thessaloniki

Given a regular Borel measure μ on $(0, \infty)$, we study the spectral theory of *generalized Hausdorff operators* of the form

$$\mathcal{H}_\mu f(z) = \int_0^\infty f\left(\frac{z}{t}\right) \frac{d\mu(t)}{t},$$

acting on the power-weighted Hardy spaces $H^p_{|\cdot|^a}(\mathbb{U})$ of the upper half-plane, where $1 < p < \infty$ and $a > -1$.

Our approach is based on a *logarithmic Mellin–Fourier transfer*: the Hausdorff operator becomes unitarily equivalent to the convolution operator $T_{\nu_{a,p}}$ on $L^p(\mathbb{R})$. The primary technical challenge is that the analytic structure of weighted Hardy spaces is *not* preserved by this transformation, and recovering the full spectrum on $H^p_{|\cdot|^a}(\mathbb{U})$ requires the construction of specialized analytic test functions that do not arise naturally from $L^p(\mathbb{R})$ theory.

Functional perimeter and the dimensional Brunn-Minkowski inequality for log-concave measures

Natalia Tziotziou

National Technical University of Athens

We study the dimensional Brunn–Minkowski inequality for even log-concave probability measures μ on $\mathbb{R}^n$ via an analytic approach based on diffusion operators and gradient estimates. Our main result asserts that for every pair of symmetric convex sets K, L in $\mathbb{R}^n$ and every $\lambda \in (0,1)$,

$$\mu(\lambda K + (1-\lambda)L)^{c_n} \geq \lambda\mu(K)^{c_n} + (1-\lambda)\mu(L)^{c_n},$$

where $c_n \geq c/n^3 \ln n$ for some absolute constant $c > 0$. A key ingredient in our proof is the bound

$$\int_{\mathbb{R}^n} |\nabla\psi| \, d\mu \leq Cn$$

for isotropic log-concave probability measures μ on $\mathbb{R}^n$ with density $e^{-\psi}$, which is optimal in terms of the dimension. This estimate yields structural information on the size of sub-level sets of the gradient of ψ and puts forth a geometric obstruction to further improvements of the Brunn–Minkowski exponent. We also present applications of this estimate to the weighted perimeter of level sets, projections, moment and surface area measures of isotropic log-concave functions, highlighting the central role of the gradient of the logarithmic potential in high-dimensional convexity.

The talk is based on joint work with Alexandros Eskenazis and Apostolos Giannopoulos.

On the density regularity of $\{x, x+y, xy\}$ patterns

Konstantinos Tsinas

École Polytechnique Fédérale de Lausanne

In 1979, Hindman conjectured that in any partition $\mathbb{N} = A_1 \cup \ldots \cup A_k$ of the naturals into finitely many disjoint sets, there exists a set A_i and $x, y \in \mathbb{N}$, such that A_i contains the set $\{x, y, x+y, xy\}$. A celebrated result of Moreira asserts that this holds for the pattern $\{x, x+y, xy\}$.

We introduce some new arguments related to classical structural results of ergodic systems to reprove Moreira's result in a stronger form. Namely, if a set A_i of the partition is large in an appropriate sense, then it contains the pattern $\{x, x+y, xy\}$. Time permitting, we will discuss potential extensions of the method to cover the full pattern $\{x, y, x+y, xy\}$.

Joint work with Florian K. Richter.

Boundedness of paraproduct operators on dyadic fractional Sobolev spaces

Valeria Fragkiadaki

Clemson University

In this talk we give necessary and sufficient conditions for the boundedness of dyadic paraproducts on dyadic fractional Sobolev spaces, H^s. In particular, the L^p boundedness conditions regarding the symbol belonging to the dyadic BMO space are not sufficient for Sobolev spaces that also encode smoothness. Requiring more of the symbol, we show that the correct spaces to characterize this boundedness are certain dyadic fractional BMO spaces, as it was first observed by Coifman and Murai for commutators in the continuous setting. One of the applications of this result is to show the algebra property of H^s, for $s > 1/2$.

Generic simplicity for self-adjoint operators under bounded potential perturbations

Marianna Chatzakou

Ghent University

We will discuss the generic simplicity of the spectrum of self-adjoint operators under bounded potential perturbations. More precisely, given a semibounded self-adjoint operator with compact resolvent and a suitable space of real-valued bounded perturbations, we will analyse whether all eigenvalues of the perturbed operator are simple for a generic choice of the potential. We will also discuss several geometric and analytic settings, including sub-Laplacians and maximally hypoelliptic operators on compact manifolds, Laplacians on bounded domains with different boundary conditions, and Schrodinger-type operators on non-compact spaces.

The talk is based on a joint work with Bernard Helffer.

Singular integrals and quantitative rectifiability in Heisenberg groups

Vasilis Chousionis

University of Connecticut

Rectifiable sets extend the class of surfaces considered in classical differential geometry; while admitting a few edges and sharp corners, they are still smooth enough to support a rich theory of local analysis. However, for certain questions of global nature the notion of rectifiability is too qualitative. In a series of influential papers around the year 1990, David and Semmes developed an extensive theory of quantitative rectifiability in Euclidean spaces. A motivation for their efforts was the significance of a geometric framework for the study of certain singular integrals and their connections to removability.

We will discuss recent results about singular integrals and quantitative rectifiability for 1-dimensional and 1-codimensional subsets of Heisenberg groups. As in the Euclidean case, partial motivation stems from questions removability. We will see that, in certain aspects, the situation is very different than in Euclidean spaces and new phenomena appear.

Pinned Scalar Configurations and Falconer-Type Distance Problems

Georgios Psaromiligkos

University of Thessaly

The Falconer distance problem lies at the interface of harmonic analysis, geometric measure theory, and additive combinatorics. It asks how large the Hausdorff dimension of a compact set $E \subset \mathbb{R}^d$ must be to ensure that its distance set $\Delta(E) = \{|x-y| : x, y \in E\}$ has positive Lebesgue measure. Although the conjectured threshold $\dim_{\mathcal{H}}(E) > d/2$ remains open, the methods developed around Falconer's problem provide a powerful framework for studying more general configuration sets.

In this talk, I will discuss several Falconer-type configuration problems, including restricted diagonal distance sets, studied by Gaitan–Greenleaf–Palsson–Psaromiligkos, and box-distance sets, studied by Borges–Iosevich–Ou. These problems replace the classical two-point distance map by higher-order configuration maps and are controlled by spherical averages, bilinear estimates, multilinear Fourier integral operators, and Sobolev-type bounds.

I will then describe a related pinned one-parameter viewpoint, motivated by the strongly pinned volume theorem of Greenleaf–Iosevich–Taylor. Given a fixed pin $x_0 \in \mathbb{R}^d$ and a smooth real-valued configuration map $\Phi_{x_0}(x_1, \ldots, x_k) = \Phi(x_1 - x_0, \ldots, x_k - x_0)$, one asks when the pinned configuration set $\{\Phi_{x_0}(x_1, \ldots, x_k) : x_1, \ldots, x_k \in E\}$ has nonempty interior. The associated configuration measure can be written as a pairing between a multilinear generalized Radon transform and a Frostman measure, so the dimension threshold is governed by frequency-localized smoothing estimates for hypersurface averages.

This viewpoint recovers the known exponent in the strongly pinned determinant-volume problem when $k = d$, and suggests lower-order pinned scalar analogues for $2 \leq k < d$, including volume-type and determinant-section configurations under suitable nondegeneracy assumptions. The goal is to place restricted diagonal distances, box-type configurations, pinned volumes, and related one-parameter configuration sets within a common harmonic-analytic framework.

Numerical Analysis and Scientific Computing

Organizers

Chrysafinos K. (National Technical University of Athens)

Karatzas E. (Aristotle University of Thessaloniki)

Vassalos P. (Athens University of Economics and Business))

PROGRAM

NUMERICAL ANALYSIS AND SCIENTIFIC COMPUTING SESSIONS

	Monday June 29	**Tuesday June 30**	**Wednesday July 1**	**Thursday July 2**	**Friday July 3**
		NTUA, ΣΗΜΜΥ, Amf. 5	**NKUA, A32**	**NTUA, ΣΗΜΜΥ, Amf. 5**	
12:30-13:10				C. Makridakis	
13:10-13:35				G. Grekas	
13:35-14:00				E. Kyza	
14:00-16:00				**Break**	
16:00-16:25		M. Mitrouli	16:00-16:40 G. Akrivis	C. Pervolianakis	
16:25-16:50		N. Stylianopoulos	16:40-17:05 D. Noutsos	K. Smaragdakis	
16:50-17:15		D. Antonopoulou	17:05-17:30 G. Tachyridis	T. Papathanasiou	
17:30-18:00		**Coffee break**	**Coffee break**	**Coffee break**	
18:00-18:25		P. Fika	P. Chatzipantelidis	P. Paraschis	
18:25-18:50		K. Kyriakoudi	D. Mitsioudis	N. Rekatsinas	
18:50-19:15		S. Katsoudas	M. Plexousakis		
19:15-19:40			I. Toulopoulos		

Gauss Methods for Harmonic Maps into Spheres

Georgios Akrivis

Department of Computer Science and Engineering, University of Ioannina, Greece, & Institute of Applied and Computational Mathematics, FORTH, Heraklion, Greece

Harmonic maps into spheres are the unit-length critical points of the Dirichlet energy. We consider Alouges' variational formulation of gradient flows for harmonic maps. We devise Gauss methods of any order for such flows that have excellent properties: they satisfy the unit-length property at the nodes exactly and are energy-decaying. In their base form, the methods are nonlinear and cannot be implemented. We also discuss implementable linearizations of the base schemes.

This talk is based on: G. Akrivis, J. Hu, J. Wang, *Gauss methods for harmonic maps*, IMA J. Numer. Anal. (to appear).

Jiashun Hu: The Hong Kong Polytechnic University, Hong Kong. Jilu Wang: Harbin Institute of Technology, Shenzhen, China.

On the Scalar Auxiliary Variable Method for the Numerical Approximation of the Cahn–Hilliard / Allen–Cahn Equation with ε-Dependent Weights

Dimitra Antonopoulou

Department of Mathematics, National and Kapodistrian University of Athens (EKPA)

We consider the Cahn–Hilliard / Allen–Cahn equation from phase transitions, with weights $\delta(\varepsilon) > 0$, $\mu(\varepsilon) \geq 0$ acting on the Cahn–Hilliard and Allen–Cahn operators, respectively. We discuss briefly how mass-conservation classifies the dynamically stable problem into two main categories: the non-mass-conserving case, where the solution's profile is close to that of the Allen–Cahn equation, or close to the Cahn–Hilliard solution when the mass is conserved. We introduce a semi-discrete in time scheme by applying an ε-algebraically stable Runge–Kutta–SAV method, for which we prove the decay of the discrete energy and optimal error estimates.

An Algebraic Flux Correction Scheme for a Chemotaxis System

Panagiotis Chatzipantelidis

Department of Mathematics & Applied Mathematics, University of Crete

For a chemotaxis system in two spatial dimensions we consider a modification of a positivity preserving fully discrete scheme using a local extremum diminishing flux limiter. We discretize space using piecewise linear finite elements on a quasiuniform triangulation of acute type and time by the backward Euler method. We assume that initial data are sufficiently small in order not to have a blow-up of the solution. Under appropriate assumptions on the regularity

of the exact solution and the time step parameter we show the existence of the fully discrete approximation and derive error bounds for the cell density and for the chemical concentration. We also present numerical experiments to illustrate the theoretical results.

Approximation of Quadratic Forms via Aitken's Δ^2 Process in Regularization

Paraskevi Fika

Department of Statistics, Athens University of Economics and Business (OPA)

In the present work, we investigate the use of Aitken's Δ^2 process for approximating unknown terms of the moment sequence $c_k = (x, A^k x)$, $k \in \mathbb{Z}$, associated with a symmetric positive definite matrix $A \in \mathbb{R}^{n \times n}$. Furthermore, we adapt this extrapolation technique to the approximation of quadratic forms arising in Tikhonov regularization and in the generalized cross-validation (GCV) criterion for the estimation of the optimal regularization parameter.

Deep Ritz-PINNs: Neural Networks Trained with Finite Elements

Georgios Grekas

Institute of Applied and Computational Mathematics (IACM), FORTH & KAUST

Over the past few years, neural network methods have evolved in various directions for approximating partial differential equations (PDEs). A promising new development is the integration of neural networks with classical numerical techniques such as finite elements and finite differences. In this work we suggest connecting finite elements and neural network approximations through training, i.e., using finite element spaces to compute the integrals appearing in the loss functionals. This approach retains the simplicity of classical neural network methods for PDEs, uses well established finite element tools (and software) to compute the integrals involved, and gains in efficiency and accuracy. We demonstrate that the proposed methods are stable and furthermore establish that the resulting approximations converge to the solutions of the PDE. Numerical results indicating the efficiency and robustness of the proposed algorithms are presented.

Topological Skeleton Based Identification of Wall Shear Stress Fixed Points in Abdominal Aortic Aneurysms

Spyridon C. Katsoudas

Department of Mathematics, University of Ioannina

Abdominal aortic aneurysms (AAAs) exhibit disturbed hemodynamics characterized by low

time-averaged wall shear stress (TAWSS), elevated oscillatory shear index (OSI), and increased relative residence time (RRT), which have been linked to aneurysm progression and rupture. Recent computational studies have demonstrated that AAA geometries present significantly larger surface areas exposed to low TAWSS and high RRT compared to healthy aortas, with statistically significant differences in the infrarenal and iliac regions.

In this work, we extend these findings by introducing a topology-based framework for the analysis of the wall shear stress (WSS) vector field on patient-specific AAA geometries. Using computational fluid dynamics simulations, we compute the WSS field and identify its critical points (fixed points), including saddles, nodes, and foci. Our analysis shows that aneurysmal aortas exhibit a higher density and complexity of WSS fixed points compared to healthy cases, forming coherent networks within the aneurysmal sac. These structures align with regions of low TAWSS and elevated RRT identified through statistical analysis, reinforcing the link between flow topology and pathological shear environments. Furthermore, regional analysis confirms that the iliac arteries also exhibit significant hemodynamic disturbances, supporting recent statistical findings.

The proposed framework combines hemodynamic indicators with topological descriptors, providing a unified mathematical approach for characterizing AAA flow complexity and offering potential new biomarkers for rupture risk assessment.

Mathematical Modeling of Moving Boundaries in Pathological Geometries: An Euler–Lagrange Approach

Konstantina Kyriakoudi

Department of Mathematics, University of Ioannina

This study presents a three-dimensional computational framework for solving fluid-structure interaction problems, specifically applied to haemodynamics in pathological vessels with moving boundaries. While many numerical studies on aneurysmal haemodynamics assume rigid boundaries, this approach captures the interaction between fluid flow and boundary deformation.

Initially, an Euler–Lagrange formulation is adopted to couple the governing equations of fluid motion with the wall motion. The arterial geometry and pulse are represented by a body-fitted approach based on the generalized curvilinear coordinates (GCCs). The resulting system of PDEs is discretized using the finite-volume method (FVM) on a collocated grid, ensuring conservation properties. Furthermore, the obtained non-linear algebraic system is solved with Newton's method, combined with the Trust Region method.

The findings reveal that incorporating wall pulsatility alters the velocity field, creating recirculation zones and localized pressure gradients. Overall, this work provides a rigorous mathematical and numerical approach for accurately modelling deformable domain effects in the biomedical field.

Adaptive Time-Splitting Spectral Methods for Two-Level Schrödinger Systems with Conical Crossings

Irene Kyza

University of St. Andrews

Two-level Schrödinger systems with conical crossings provide an important quantum-mechanical model for molecular dynamics. Their numerical approximation is particularly challenging because of the singular behaviour induced by conical crossings in the potential matrix, and exact solutions are generally unavailable in physically relevant regimes.

In this talk, we present new results on a posteriori error control for time-splitting spectral methods applied to such systems. Building on these estimators, we develop an adaptive algorithm in time and automatic spatial mesh selection. Numerical experiments demonstrate the efficiency of the proposed approach and enable the simulation of challenging problems that were previously intractable.

Joint work with A. Athanassoulis (University of Dundee) and Y. Wang (University of St. Andrews).

Scientific Machine Learning and Numerical Analysis

Charalambos G. Makridakis

Institute of Applied and Computational Mathematics (IACM), FORTH & University of Sussex

In recent years, substantial progress has been made in understanding the approximation properties of neural networks, with foundational results showing that a range of architectures can efficiently approximate both smooth and singular functions. However, these advances do not by themselves explain the behaviour of machine learning algorithms, especially in applications such as PDE solvers, uncertainty quantification, and generative models.

This talk presents a mathematical framework for analysing ML algorithms through their underlying variational principles and loss functionals. By studying function learning, PDE solvers, and probability-measure approximation from this perspective, we relate classical notions of numerical stability to the properties of the associated variational problems. This approach yields new insights into stability and convergence and motivates the development of new algorithms.

Variational Principles for the Helmholtz Equation: Application to Numerical Approximations

D.A. Mitsoudis

Department of Naval Architecture, University of West Attica & IACM, FORTH, Greece

The Helmholtz equation with impedance (absorbing) boundary conditions is a classical, broadly applicable model, yet accurate numerical approximation at high wavenumbers remains a long-standing challenge, in part because the standard variational formulations are indefinite. In this talk we begin from the variational (Lagrangian) functional naturally associated with the problem, whose stationary points recover its solutions but which is itself indefinite. We then regularise this functional by adding consistent terms that vanish on the exact solution, obtaining strongly coercive functionals whose coercivity constant is independent of the wavenumber k, in a natural k-weighted norm. We illustrate the resulting formulations with finite element and neural network approximations.

Band-Times-Circulant Preconditioners for Non-Symmetric Toeplitz Systems

Dimitrios Noutsos

Department of Mathematics, University of Ioannina

In this presentation, we focus on the preconditioning of square and non-symmetric Toeplitz systems, where the generating function f of the Toeplitz matrix is known a priori. We deal with the well-conditioned case using a specific circulant preconditioner, as well as with the ill-conditioned one using a preconditioner arising from the combination of band Toeplitz and circulant matrices. For the solution of the system we use Krylov subspace methods and more specifically the Conjugate Gradient method for the corresponding preconditioned system of the normal equations (PCGN) and the Preconditioned Generalized Minimal Residual method (PGMRES).

We prove theoretical results that guarantee the efficiency of the proposed technique either when the univariate function f is continuous or piecewise continuous. Furthermore, we discuss the more general case where the generating function is a multivariate one. We analyze the corresponding spectral properties and point out the differences with the univariate case. Finally, we present various numerical experiments that show the efficiency of the proposed preconditioning technique.

An Iterative Solver for Quasi Conforming Finite Elements in Hydroelastic Scattering Applications

Theodosios K. Papathanasiou

Department of Mathematics, School of Applied Mathematical and Physical Sciences, National Technical University of Athens

This study presents a Finite Element approximation of weak solutions for long wave scattering in the presence of pontoon type Very Large Floating Structures (VLFSs). The coupled hydroelastic scattering Boundary Value Problem involves the Helmholtz and biharmonic operator along with appropriate interface and radiation conditions. Nonconforming triangles are employed to discretise the biharmonic operator, thus modelling VLFS heaving motion as Kirchhoff–Love plate deflection. Discretisation of the Helmholtz operator, governing the wave potential evolution, utilises Lagrange Linear Triangles. Hydroelastic coupling is achieved through projecting the wave potential on the deflection discretization basis.

The discrete weak form of the scattering problem, governed now by a perturbed Helmholtz operator, is solved numerically using an iterative method. Starting with the incident wave velocity potential, the algorithm projects on the floating plate deflection basis and then solves a Helmholtz type scattering problem to find the velocity potential update. The method can be classified as an Uzawa type deflection-velocity potential splitting. A key advantage of this approach is that standard preconditioning for the Helmholtz equation can be employed instead of developing preconditioners for coupled biharmonic-Helmholtz discrete operators. Convergence analysis of the iterative procedure is performed and numerical examples are presented to compare its efficiency to that of monolithic solvers.

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hp-Version Robust Interior Penalty Discontinuous Galerkin Methods for the *p*-Laplacian

Panagiotis Paraschis

TU Wien & University of Vienna

We study the full discretization of the elliptic and parabolic p-Laplacian using discontinuous Galerkin methods. First, we consider an *hp*-version *robust* interior penalty discontinuous Galerkin method for the elliptic p-Laplacian on simplicial, as well as essentially arbitrarily-shaped polygonal and curved meshes. By employing novel quasi-norm trace–inverse estimates, we establish quasi-norm error bounds of optimal order with respect to the local mesh sizes and of slightly reduced order with respect to the local polynomial degrees. Moreover, the analogous results for a space-time discontinuous Galerkin formulation of the parabolic p-Laplacian will be discussed. Numerical experiments are presented to validate and illustrate the theoretical results.

Joint work with Konstantinos Chrysafinos (NTU Athens & IACM, FORTH) and Emmanuil H. Georgoulis (NTU Athens & Heriot-Watt Uni. & IACM, FORTH).

A Stabilized Numerical Scheme for an Optimal Control Problem

Christos Pervolianakis

Friedrich Schiller University Jena

In this talk, we consider an optimal control problem governed by a time-dependent convection–diffusion–reaction equation with pointwise control constraints. We adopt the optimize–then–discretize approach, and the resulting optimality conditions yield a coupled system of two time-dependent convection–diffusion–reaction equations.

It is known that convection–diffusion–reaction equations can develop sharp layers, which pose challenges for standard finite element methods. In particular, these layers can cause spurious oscillations, violating physical properties of the solution. To overcome these difficulties, we apply the algebraic flux correction method to stabilize the fully discrete scheme obtained from the optimality conditions. The resulting fully discrete scheme based on the backward Euler method is nonlinear, and we discuss its well-posedness as well as derive error estimates. Additionally, we derive a residual-type a posteriori error estimator. Finally, we provide numerical experiments that validate the theoretical results.

A Posteriori Certification of PDE Approximations with Applications to Neural Networks

Nikolaos Rekatsinas

Institute of Applied and Computational Mathematics (IACM), FORTH

We propose rigorous and efficiently computable lower and upper a posteriori error bounds for given approximations to PDEs on domains that might be geometrically complex. This is done by embedding or enveloping the original domain towards geometrically simpler domains, enabling the use of fast numerical solvers. To this end, we extend and restrict the residual and provide efficient methods to compute those Hahn–Banach extensions. Then, we efficiently compute their Riesz representations on the geometrically simpler domains and obtain the desired a posteriori bounds for which we prove to be sharp.

The resulting bounds control the error in the natural norm induced by a well-posed variational formulation, require only minimal regularity assumptions, and thus remain applicable on complex geometries. The framework is detailed for elliptic as well as parabolic problems. Numerical experiments demonstrate the good quantitative behavior of the derived upper and lower error bounds.

A central motivation for this work comes from physics-informed and related neural-network approximations of PDEs, which are naturally mesh-free and can be evaluated pointwise on complex or parameter-dependent geometries. Nevertheless, the framework applies to any approximation for which the variational residual can be evaluated.

A Deep Implicit-Explicit Minimizing Movement Method for Partial Integro-Differential Equations, with Application to Option Pricing in Jump-Diffusion Models

Costas Smaragdakis

University of the Aegean & IACM, FORTH

We develop a novel deep learning approach for solving partial integro-differential equations (PIDEs) in high dimensions, involving diffusion and drift terms. To showcase its practicality and versatility, the methodology is presented for the specific challenge of pricing European basket options written on assets that follow jump-diffusion dynamics. The option pricing problem is formulated as a partial integro-differential equation, which is approximated via a new implicit-explicit minimizing movement time-stepping approach, involving approximation by deep, residual-type Artificial Neural Networks (ANNs) for each time step. The integral operator is discretized via two different approaches: (a) a sparse-grid Gauss–Hermite approximation following localised coordinate axes arising from singular value decompositions, and (b) an ANN-based high-dimensional special-purpose quadrature rule. Crucially, the proposed ANN is constructed to ensure the appropriate asymptotic behavior of the solution for large values of

the underlyings and also leads to consistent outputs with respect to a priori known qualitative properties of the solution. The performance and robustness with respect to the dimension of these methods are assessed in a series of numerical experiments involving the Merton jump-diffusion model, while a comparison with the deep Galerkin method and the deep BSDE solver with jumps further supports the merits of the proposed approach.

Measure Recovery from Moment Measurements

Nikolaos Stylianopoulos

Department of Mathematics and Statistics, University of Cyprus

Let μ be a finite positive Borel measure with compact and infinite support $\mathcal{S}(\mu)$ in the complex plane $\mathbb{C}$, and let $\mathcal{P}^2(\mu)$ denote the closure of the analytic polynomials in the Lebesgue space $L^2(\mu)$. We use Thomson's theorem on the orthogonal decomposition of $\mathcal{P}^2(\mu)$ into irreducible summands, in order to describe and analyse a constructive method for recovering the polynomial convex hull of $\mathcal{S}(\mu)$ from moment measurements. This method is based on constructing the orthonormal polynomials associated with the measure μ, and then utilising the properties of Christoffel functions. We also investigate the zero distribution of the orthonormal polynomials, bridging thus operator theory with potential and approximation theory.

Preconditioned MINRES Methods for Symmetrized Multilevel Block Toeplitz Systems

Grigorios Tachyridis

University of Ioannina

In this presentation we focus on a novel preconditioned minimal residual method for a class of real, nonsymmetric multilevel block Toeplitz systems. First, we discuss the symmetrization of a certain real, nonsymmetric multilevel block Toeplitz system with symmetric blocks, using a simple permutation matrix. After showing that its Hermitian part serves as an ideal preconditioner, we present a novel preconditioning strategy for the aforementioned systems, with applications to solving nonlocal evolutionary fractional diffusion equations. Specifically, we first transform the nonsymmetric block Toeplitz all-at-once system arising from the equations into a symmetric block Hankel system. Then, we propose a symmetric positive definite block Tau preconditioner for the symmetrized system, which can be implemented efficiently using the discrete sine transform. Apart from the presented theoretical results for the eigenvalues of the preconditioned matrices, the effectiveness of the proposed preconditioning technique is validated through numerical examples at the end of the presentation.

SUPG Space-Time Finite Elements on Large Aspect Ratio Meshes for General Parabolic Problems

Ioannis Toulopoulos

Department of Informatics, University of Western Macedonia, Greece

In this talk, we discuss error estimators for a unified space-time finite element (FE) discretization on large aspect ratio meshes of a general convection-diffusion-reaction parabolic problem. We interpret $\partial_t u$ as a convection term in an additional spatial direction, and this viewpoint enables us to apply a unified space-time FE discretization over the entire space-time cylinder $Q_T = (0,T]\times\Omega$ using the SUPG methodology.

The main objective of this work is to present fully computable a posteriori error bounds in the SUPG norm employed in the discretization error analysis. The derived estimators are based on standard element and face residual techniques. Their derivation is carried out in a fully general setting: we do not impose restrictive assumptions on mesh stretching ratios, and we do not require compatibility conditions linking the magnitude of the problem data to the aspect ratio of the mesh size. This general framework ensures that the analysis remains valid for anisotropic meshes.

Acknowledgment. This work was partially supported by the DAAD project No. 57729992, Goal-oriented Anisotropic Space-Time Mesh Adaptation (AIMASIM).

This talk is based on: M. Bause, M. P. Bruchhäuser, B. Endtmayer, N. Margenberg, I. Toulopoulos, T. Wick, *A posteriori error estimators for a SUPG space-time finite element scheme on general meshes*, under review, 2026.

Differential Equations

Organizers

Barbatis G. (National and Kapodistrian University of Athens)

Gkintidis Dr. (National Technical University of Athens)

Kamvissis Sp. (University of Crete)

PROGRAM

DIFFERENTIAL EQUATIONS SESSIONS

	Monday June 29	**Tuesday June 30**	**Wednesday July 1**	**Thursday July 2**	**Friday July 3**
	NKUA,	**NTUA, ΣΗΜΜΥ, Amf. 3**	**NKUA, Γ21**	**NTUA, ΣΗΜΜΥ, Amf. 3**	**NKUA, Γ21**
12:30-13:15		I. Giannoulis		G. Moschidis	M. Ntekoume
13:15-14:00		G. Fournodavlos		A. Menegaki	K. Zemas
14:00-16:00		**Break**	**Break**	**Break**	**Break**
16:00-16:45		N. Karachalios	D. Mantzavinos	K. Koumatos	N. Eptaminitakis
16:45-17:30		M. Chatzakou	C. Sourdis	A. Chatziafratis	S. Filippas
17:30-18:00		**Coffee break**	**Coffee break**	**Coffee break**	**Coffee break**
18:00-18:45		K. Bampali M. Hadjinicolaou G. Kamvyssas	L. Mindrinos	J. Karafyllis	E. Protopapas
18:45-19:30			A. Katsabakos	G. Paraskevopoulou	Y. Agelopoulos

The threshold conjecture for extremal black holes in spherical symmetry

Y. Angelopouplos

Beijing Institute of Mathematical Sciences and Applications

I will present some recent results, obtained jointly with Kehle and Unger, on the stability and instability properties of extremal Reissner-Nordström black holes in the context of the Einstein-Maxwell-neutral scalar field system of equations in spherical symmetry.

Geometric Hardy inequalities on the Heisenberg groups via convexity

M. Chatzakou

Department of Mathematics: Analysis, Logic and Discrete Mathematics, Ghent University

We prove L^p -Hardy inequalities with distance-to-the-boundary potentials on the Heisenberg groups and, more generally, on step-two stratified groups. The guiding principle is a geometric condition expressed through horizontal p-superharmonicity of the distance function, which allows the sharp constant $(p-1)/p$ to be recovered. We discuss how this condition applies to Euclidean distance for convex and selected non-convex domains, to the pseudodistance associated with the fundamental solution of the sub-Laplacian on half-spaces and convex polytopes, and to the Carnot–Carathéodory distance on half-spaces and bounded convex domains. The results provide a unified convexity-based approach to geometric Hardy inequalities and extend known sharp inequalities beyond the classical Euclidean framework. Based on joint work with G. Barbatis and A. Tertikas

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Linear Evolution Equations Revisited via the Fokas Unified Transform Method

A. Chatziafratis

Department of Mathematics, National and Kapodistrian University of Athens

We survey some of our recent research results relating to construction of explicit solutions (closed-form integral representations), in the classical sense, as well as to qualitative theory for non-homogeneous initial-boundary-value and interface problems for a variety of linear (systems of) evolution partial differential equations (PDE) with constant and with variable coefficients. Such PDE emerge in connection to a plethora of natural phenomena and mathematical models in physics, biology, chemical engineering, finance and other applied sciences; examples include continuum mechanics, heat transfer, biomedicine, electron optics, and battery technology. Our research program relies on, explores and extends the applicability of the celebrated complex-analytic unified transform method of Fokas. This is joint work with a large global network of collaborators. Notable findings include: long-range instabilities (see e.g. [A. Chatziafratis,

L. Grafakos, S. Kamvissis, “Long-range instabilities for linear evolution PDE on semi-bounded domains via the Fokas method”, Dyn. PDE, 2024] and [A. Chatziafratis, T. Ozawa, S.-F. Tian, “Rigorous analysis of the unified transform method and long-range instabilities for the inhomogeneous time-dependent Schrödinger equation on the quarter-plane”, Math. Annalen, 2023]), time-asymptotic break-down effects (e.g. [J.L. Bona, A. Chatziafratis, H. Chen, S. Kamvissis, “The linear BBM-equation on the half-line revisited”, Lett. Math. Phys., 2024]), and counter-examples to solution uniqueness (e.g. [A. Chatziafratis, S. Kamvissis, “Infinity of solutions to initial-boundary value problems for linear constant-coefficient evolution PDEs on semi-infinite intervals”, Bull. London Math. Soc., 2025] and [A. Chatziafratis, A. Miranville, G. Karali, A.S. Fokas, E.C. Aifantis, "Higher-order diffusion and Cahn–Hilliard-type models revisited on the half-line", Math. Models Methods Appl. Sci., 2025]).

The DC Kerr effect in nonlinear optics

N. Eptaminitakis

Institute of Differential Geometry, Leibniz University Hannover

In this talk we will discuss a forward and inverse problem for the Maxwell system with a cubic Kerr-type nonlinearity. This system models the DC Kerr effect in nonlinear optics, a phenomenon used in the design of ultra-fast optical switches. We describe how to construct and rigorously justify highly oscillatory asymptotic solutions whose behavior is consistent with experimental observations. We then demonstrate how these solutions can be used to recover the unknown nonlinear parameter appearing in the equation. Based on joint work with Plamen Stefanov.

Recovering a matrix-valued potential in stationary spacetimes

S. Filippas

Department of Mathematics and Statistics, University of Helsinki

In this talk we consider the problem of recovering a time dependent matrix-valued potential on a general globally hyperbolic manifold from the knowledge of the source to solution map of a wave equation including a connection 1-form term. We show that this problem can be reduced to studying the injectivity of a non-Abelian light ray transform. Under the assumption that our manifold is stationary, we then prove that injectivity for an appropriately defined Riemannian transform allows to uniquely determine the potential. This is based on a joint work with Lauri Oksanen and Miika Sarkkinen.

On the non-linear stability of Kerr de Sitter spacetimes

G. Fournodavlos

Department of Mathematics and Applied Mathematics, University of Crete

Abstract: The Kerr de Sitter geometry models a rotating black hole in an expanding universe. I will review its stability properties in the context of the Einstein vacuum equations with positive cosmological constant, and present recent progress on the non-linear stability problem for the cosmological region. Among others, the talk describes contributions by H. Friedrich, P. Hintz and A. Vasy, and joint work with Volker Schlue.

Modulation equations for scalar Fermi-Pasta-Ulam-Tsingou systems on 2D square lattices

I. Giannoulis

Department of Mathematics, University of Ioannina

We present results concerning the justification of modulation equations for the dynamics of atoms in a two-dimensional square lattice that interact with their nearest neighbors nonlinearly with respect to the strain between their scalar displacements. When the interaction forces are cubic we show that small macroscopically modulated amplitudes of rapidly oscillating plane waves evolve approximately according to a nonlinear Schrödinger equation, while in the case of quadratic interaction forces the corresponding modulation equation is a Davey-Stewartson system. Due to the dispersive scaling of the small amplitudes, the justification in the latter case is significantly more involved than in the former and necessitates the employment of normal-form transformation techniques. This is joint work with Guido Schneider and Bernd Schmidt.

Analytical Modeling of the Forward EEG Problem in Anisotropic Multi-Shell Spherical Media

Konstantina Bampali[1], Maria Hadjinicolaou[1], Gregory Kamvyssas[2]

[1]*School of Science and Technology, Hellenic Open University, Patras, Greece*
[2]*Department of Mechanical Engineering, University of the Peloponnese, Patras, Greece*

The mathematical modeling of brain electrical activity is based on the theory of elliptic partial differential equations. Determining the electric potential distribution requires solving the Poisson equation within the region containing the neuronal source, while the Laplace equation is applied to the surrounding layers. By applying a spherical harmonics expansion, we derive solutions for the electric potential in spherical coordinates. Furthermore, transmission conditions are incorporated to ensure continuity of the electric potential and of the normal component of the current density. These conditions, together with the conductivity represented as a second-order symmetric tensor, lead to an accurate representation of the electric field within the human head

for biomedical applications in neuroscience research. In this study, the head is represented as concentric conductive regions corresponding to the brain, cerebrospinal fluid, skull, and scalp. Each layer is characterized by distinct radial and tangential conductivity components, allowing the investigation of anisotropy within a quasi-static approximation of Maxwell's equations. Through this methodology, we construct closed-form analytical expressions for the electric potential in each shell. The results indicate that anisotropy significantly affects both the amplitude and spatial distribution of surface potentials, particularly for deeper neuronal sources. Finally, a comparative evaluation contrasts anisotropic and isotropic models, highlighting the influence of directional conductivity on the accuracy of the electroencephalography forward problem. These findings demonstrate that anisotropic conductivity modeling improves EEG source localization accuracy and provides a theoretical benchmark for the validation of numerical methodologies such as FEM and BEM.

Blow-up in finite time for the defocusing Ablowitz-Ladik lattice

N. Karachalios

Department of Mathematics, University of Thessaly

We prove that, in contrast to its continuous limit, the defocusing cubic nonlinear Schrödinger equation, the defocusing Ablowitz-Ladik equation, though also fully integrable, exhibits finite-time singularities (finite-time blow-up). We present the proof for a wide class of initial data. Numerical simulations demonstrate that the analytical formulas for the blow-up time is sharp. We also discuss potential extensions to generalized Ablowitz-Ladik lattices.

Beyond Nonlinear Small-Gain Design: Robust Adaptive Partial-State Feedback Control

I. Karafyllis

Department of Mathematics, National Technical University of Athens

In this work, we study the partial-state regulation problem for a scalar Ordinary Differential Equation (ODE) which is interconnected with a possibly infinite-dimensional system. In such a case the Deadzone-Adapted Disturbance Suppression (DADS) adaptive control scheme allows an escape from the requirements of the small-gain theorem that is mainly used for partial-state feedback design. We prove robust regulation even in the presence of external inputs (disturbances) without assuming knowledge of any disturbance/parameter bounds. The DADS controller is applied to three different cases of the interconnection of an ODE with a completely unknown: (a) heat PDE, (b) transport PDE, and (c) wave PDE with viscous damping. We show that the same DADS controller can achieve robust regulation in all three cases. This is joint work with Miroslav Krstic from the University of California, San Diego.

The linearized inverse boundary value problem in strain gradient elasticity

A. Katsabakos

Department of Mathematics, National Technical University of Athens

This talk will focus on the study of the linearized version of the strain gradient elasticity equation in $\mathbb{R}^2$ with constant coefficients. We prove that one can determine the two Lamé coefficients λ, μ as well as the internal strain gradient parameter g, as indicated by Mindlin in his revolutionary papers in 1963-1965, by boundary measurements. This is accomplished via the investigation of the corresponding Steklov-Poincaré operator, which, in the current situation, stems from a fourth order boundary value problem and merits several qualitative differences in comparison to the classical elasticity problem. The investigation of the Frechet derivative of this operator is the cornerstone in the realm of the solvability of the inverse problem. This is joint work with Antonios Charalambopoulos.

Quasimonotone stresses in viscoelasticity

K. Koumatos

School of Mathematical and Physical Sciences, University of Sussex

Quasimonotonicity is a mean monotonicity condition for multidimensional systems establishing existence of weak solutions for non-variational, divergence form elliptic PDEs. Similar conditions have been utilised in the theory of the Navier-Stokes equations, also resulting in the existence of weak solutions. In this talk, we show a Gårding inequality for quasimonotone stresses and use it to prove weak-strong uniqueness results in the dynamic theory of viscoelasticity. In particular, for viscoelastic solids, we propose quasimonotone stresses as a candidate class of viscous stresses potentially compatible with frame-indifference. This is joint work with Myrto Galanopoulou and Judith Campos-Cordero (UNAM, Mexico).

Analysis of nonhomogeneous initial-boundary value problems for nonlinear dispersive equations

D. Mantzavinos

Department of Mathematics, University of Kansas

A variety of physical phenomena are modeled by dispersive partial differential equations, whose study has been at the center of interest within the broader PDE/harmonic analysis/nonlinear waves communities during the past fifty years or so. In this talk, we will focus on the analysis of dispersive equations in the presence of nonzero boundary conditions. Such conditions are directly motivated by applications that arise in domains with a boundary, either in nature or in the laboratory. The relevant problems are known as initial-boundary value problems and can be significantly more involved than the (more standard) initial value problems, which take place on

fully unbounded domains. Fundamental dispersive PDEs like the nonlinear Schrödinger (NLS) and the Korteweg-de Vries (KdV) equations will serve as motivating examples and help guide us through the main steps of the analysis.

Phonon Boltzmann Equation: Entropy maximisers and their stability

A. Menegaki

Department of Mathemtics, Imperial College

In this talk we consider the four-waves spatially homogeneous kinetic equation arising in weak wave turbulence theory from one-dimensional microscopic oscillator chains. This equation is sometimes referred to as the Phonon Boltzmann Equation. I will discuss the entropy maximisation problem, the collisional invariants, and properties of solutions of the kinetic equation near the Rayleigh-Jeans (RJ) thermodynamic equilibria, in the case where the microscopic model is the Fermi-Pasta-Ulam-Tsingou (FPUT) chain. This is based on joint works with Miguel Escobedo (Bilbao), Pierre Germain (Imperial College London) and Joonhyun La (KIAS).

Direct and Inverse Problems for a Linear Advection–Diffusion Equation

L. Mindrinos

Department of Natural Resources Development and Agricultural Engineering, Agricultural University of Athens

Motivated by vertical infiltration in porous media, we formulate an initial boundary value problem for the linearized Richards equation on a finite interval. Different boundary conditions are considered to model distinct physical scenarios. We first study the direct problem and compute the water content using the Unified transform method. The resulting analytical solution is compared with classical Fourier series solutions, showing perfect agreement. We then address two inverse problems: an optimal control problem and a parameter identification problem aimed at recovering soil properties from a limited number of measurements. Numerical results demonstrate the effectiveness and applicability of the proposed approaches. This is a joint work with K. Kalimeris (Academy of Athens).

Naked singularities with finite blue-shift for the Einstein–massless Vlasov system.

G. Moschidis

Institute of Mathematics, École Polytechnique Fédérale de Lausanne

In his celebrated proof of the weak cosmic censorship conjecture for the spherically symmetric Einstein-scalar field system, Christodoulou exploited the following property of that specific matter model: Naked singularities, when they arise, exhibit infinite blue-shift along the null geodesics terminating at the singularity. This behaviour is consistent with self-similarity: Even for more general spherically symmetric matter models, it can be shown that self-similar naked singularities must exhibit infinite blue-shift. Whether, for these more general models, all naked singularities have the infinite blue shift property (and hence are potentially subject to an instability mechanism analogous to that introduced by Christodoulou) still remains an open question.

In this talk, we will present the construction of a spherically symmetric solution to the Einstein-massless Vlasov system which contains a locally naked singularity with finite total blue-shift along its past null cone. The initial data giving rise to this solution have limited differentiability, but belong to a regularity class above the scale invariant threshold.

Symplectic non-squeezing for some integrable PDEs on the line

M. Ntekoume

Department of Mathematics, Concordia University

Gromov's symplectic non-squeezing theorem asserts that a smooth symplectomorphism cannot map a ball wholly inside a thinner cylinder. In this talk we will discuss the question of obtaining infinite-dimensional analogues of this theorem for Hamiltonian PDEs. In particular, we will prove that the KdV and the 5th-order KdV flow on the line cannot squeeze a ball in the symplectic space $\dot{H}^{-\frac{1}{2}}$ into a cylinder of lesser radius. The key to these results is exploiting the completely integrable nature of these equations to create a finite-dimensional approximation scheme.

Algorithm for Electroencephalography

G. Paraskevopoulou

Department of Mathematics, School of Applied Mathematics and Physical Sciences, National Technical University of Athens / Mathematics Research Center, Academy of Athens

Electroencephalography (EEG) current localization aims to reconstruct the neuronal currents responsible for the electrical potentials recorded on the scalp. Despite the ill-posed nature of the inverse EEG problem, a unique solution can be obtained under a minimum-energy constraint. It has been established that EEG measurements are sensitive only to the irrotational component of the primary neuronal current. In this work, we present a new algorithm for solving the

inverse EEG problem in realistic head models, which combines a linear algebraic framework with machine learning techniques. Specifically, a deep neural network is trained to approximate forward EEG solutions, thereby enabling efficient computation of the gradients of an auxiliary function that plays a crucial role in the inverse EEG solution. The irrotational component of the neuronal current is represented using an inverse multiquadratic radial basis function expansion. The new algorithm is assessed using synthetic EEG data generated from realistic head geometries and is benchmarked against the established methods sLORETA and eLORETA. The results indicate enhanced localization accuracy, reduced spatial dispersion, and improved robustness to noise. These findings suggest that the new algorithm constitutes a computationally efficient and accurate alternative for EEG current localization.

A Mathematical Framework for Water Safety: Tracking Pollutants in Interconnected Ponds using Fractional Calculus

E. Protopapas

School of Science and Technology, Hellenic Open University

Aquatic pollution in aquaculture systems significantly threatens biodiversity and the safety of fish for human consumption. This study investigates pollutant dynamics within a system of interconnected ponds characterized by constant volumes and steady flow rates. We transition from a classical framework, utilizing ordinary differential equations (ODEs) to a more sophisticated fractional-order model. By employing the Caputo–Liouville fractional derivative, the model accounts for memory effects and anomalous diffusion—phenomena frequently observed in complex fluid environments that integer-order models often fail to capture. Analytical solutions are derived for both the classical and fractional formulations to track pollutant concentration across the pond chain. A comparative analysis reveals that while both models identify critical thresholds for water quality, the fractional approach provides a more realistic representation of long-term pollutant behavior and "hereditary" system traits. Key findings indicate that maximizing water discharge effectively mitigates pollutant accumulation, whereas reduced flow rates coupled with steady inflow lead to heightened contamination levels. By integrating memory-driven dynamics into the modeling of aquaculture systems, this research offers enhanced predictive accuracy for water quality management. These insights are vital for developing sustainable fish farming practices and ensuring the ecological stability of freshwater resources.

On a linear equation arising in the study of phase separation of Bose-Einstein condensates

C. Sourdis

19th High School, Athens

We consider the inner limit system describing the phase separation in two-component Bose-Einstein condensates linearized around the one-dimensional solution in an infinite strip with zero and periodic boundary conditions, and obtain optimal invertibility estimates for the Fourier modes without necessarily assuming orthogonality conditions.

Stochastic homogenization of nonlinear variational problems in generic randomly perforated domains

K. Zemas

Institute for Applied Mathematics, Univeristy of Bonn

We discuss the convergence of nonlinear Dirichlet problems for systems of variational elliptic PDEs defined on randomly perforated domains of $\mathbb{R}^n$. Under the assumption that the perforations are small balls whose centers and radii are generated by a stationary shortrange marked point process, we obtain in the critical-scaling limit an averaged nonlinear analogue of the extra term obtained in the seminal work of Cioranescu and Murat (1982). In analogy to the random setting introduced by Giunti, Höfer and Velazquez (2018) for the classical Poisson equation, we only require that the random radii have finite $(n-q)$-moment, $1 < q < n$ being the growth-exponent of the associated energy functionals. On the one hand, this ensures that the limit capacitary problem is well-defined, but on the other, it does not exclude the presence of perforation with large radii that can create complicated geometric clusters. We show however that the critical rescaling of the perforations is sufficient to ensure that no percolating-like structures appear in the limit. This is joint work with Lucia Scardia (Heriot Watt University, Edinburgh) and Caterina Zeppieri (University of Muenster) .

History and Philosophy of Mathematics

Organizers

Christopoulou D. (National and Kapodistrian University of Athens)

Sialaros M. (National and Kapodistrian University of Athens)

PROGRAM

HISTORY AND PHILOSOPHY OF MATHEMATICS SESSIONS

	Monday June 29	**Tuesday June 30**	**Wednesday July 1**	**Thursday July 2**	**Friday July 3**
					NKUA, A22
12:30-13:10					D. Anapolitanos
13:10-13:50					D. Christopoulou
13:50-14:10					N. Elthini
14:10-14:30					N. M. Pettas
14:30-16:00					Break
16:00-16:40					S. Negrepontis
16:40-17:20					J. Christianidis
17:30-18:00					Break
18:00-18:40					M. Sialaros
18:40-19:00					A. Doxanaki
19:00-19:20					D. Touliatou
19:20-19:40					E. Barmbas
19:40-20:00					N. Marakas

The History of Ancient Greek Mathematics up to Euclid Illuminated by Plato's Philosophy

Stylianos Negrepontis

Department of Mathematics, NKUA

Jointly with Vassiliki Farmaki, we are in the final stages of composing our work entitled The History of Greek Mathematics up to Euclid Illuminated by Plato's Philosophy.

Numerous works have been written on Greek Mathematics, from Heath (1921), Zeuthen (1910), van der Waerden (1954), and Knorr (1975), to Netz (2022).

Our work differs from all preceding ones in that, as the title indicates, it is the only one grounded in and illuminated by the Philosophy of Plato.

I will outline how Plato illuminates two fundamental, hitherto essentially unanswered, questions in the History of Greek Mathematics.

From the study of the Platonic dialogues Theaetetus, Sophist, and Meno, it emerges: (a) that the foundation of Platonic philosophy is periodic anthyphairesis (reciprocal subtraction)—the precursor of modern continued fractions and the geometric form of the Pythagorean/Euclidean algorithm—and (b) that the method of proving the quadratic irrationalities by Theodorus and Theaetetus was based on periodic anthyphairesis.

Without the decisive aid of Plato, this entire matter remained without a definitive answer.

One of the greatest unanswered questions in the History of Greek Mathematics is the general question of the contribution of Pythagoras and the early Pythagoreans.

Burkert (1972) argues that Pythagorean Mathematics did not influence Eleatic philosophy (Parmenides, Zeno) and that "Ontology is prior to Mathematics", while Netz (1999, 2022) maintains that "the mathematician Pythagoras is a myth".

However, from the Platonic dialogues Parmenides and Sophist, in conjunction with the verbatim citation of Zeno's fragments B1, B2, and B3 by Simplicius in his Commentary on Aristotle's Physics, the conclusion emerges that the intelligible beings (*νοητὰ ὄντα*) of Plato and the true beings (*ἀληθῆ ὄντα*) of Zeno coincide; hence, the philosophical thought of Zeno is based upon the mathematics of periodic anthyphairesis—a mathematics that can originate only from Pythagoras and Hippasus.

By virtue of this irrefutable argument, the views of Burkert and Netz are rejected.

Diophantus, Premodern Algebra, and the History of Algebra: Some Reflections on the State of the Art

Jean Christianidis

Department of History and Philosophy of Science, NKUA

The lecture focuses on the recent scholarship regarding the Arithmetica of Diophantus of Alexandria, drawing on three landmark publications:

(1) Jean Christianidis and Jeffrey Oaks, The Arithmetica of Diophantus: A Complete Transla-

tion and Commentary (Routledge, 2023).

(2) Jean Christianidis and Jeffrey Oaks, The Arithmetica of Diophantus: A Complete Translation and Commentary (Crete University Press, 2026 – Greek translation of the above, forthcoming).

(3) Jean Christianidis, Diophantine researches (in Greek, Crete University Press, 2026 – forthcoming).

Its aim is to demonstrate that Diophantus' treatise is a work of algebra and that Diophantus himself was an algebraist — with the terms "algebra" and "algebraist" being employed in their premodern sense.

Following the obsolescence of premodern algebra due to the advent of modern algebra from the 17th century onwards, Diophantus' work was no longer viewed as algebraic in character by practicing mathematicians.

At the same time, as the field of modern Number Theory began to emerge, so did the image of a "number-theoretic Diophantus," in whose treatise mathematicians found a source of inspiration for research no longer in the domain of algebra, but in that of Number Theory.

National Discourse and Pre-Revolutionary Greek Mathematical Texts

Michalis Sialaros

Department of History and Philosophy of Science, NKUA

The present paper examines Greek printed mathematical works of the final decades prior to the Revolution of 1821 as cultural artifacts rather than exclusively as vehicles of technical knowledge.

Although mathematical discourse is frequently considered neutral and detached from ideological or cultural functions, pre-revolutionary mathematical textbooks contain paratextual elements—such as prefaces, dedications, epigrams, frontispieces, and iconographic material—which allow for a different approach to their content and function.

The study of these elements demonstrates that the printed mathematical works of the period functioned not only as means of mathematical education but also as vehicles of collective identity and national discourse.

Particular emphasis is placed on the manner in which authors, translators, and publishers connected mathematical education with broader demands for intellectual cultivation and national rebirth.

From Geometric Models to Interactive Exhibits: The Challenge of Displaying Mathematics in the Museum

Anastasia Doxanaki

Department of History and Philosophy of Science, NKUA

How can a discipline as fundamentally immaterial and abstract as mathematics acquire a material and narrative presence in the museum?

The question of how to represent mathematics in exhibition contexts has occupied the museum community since the late twentieth century, with varying degrees of intensity across different national traditions.

This paper focuses on the curatorial strategies for exhibiting mathematics in museums in Greece and abroad, attempting to map their historical trajectory and identify the trends that have emerged over recent decades.

Traditionally, mathematics was displayed through geometric models and scientific instruments, which functioned primarily as teaching and research tools for a specialized audience (mathematicians, engineers, and students).

Since the mid-twentieth century, however, the emphasis has shifted towards the creation of interactive mathematical exhibitions addressed to the general public, a development that gradually led to the establishment of dedicated mathematics museums.

In the Greek case, nevertheless, the picture is markedly different.

Mathematics is integrated mainly into narratives of ancient science, technology, or culture, where the mathematical dimension is frequently interpretatively occluded.

Thus, the challenge for mathematics to constitute an autonomous exhibition narrative remains, within the Greek context, largely unresolved.

The Metrica of Heron of Alexandria: Some Reflections on the Current State of Research

Dora Touliatou

Department of History and Philosophy of Science, NKUA

In recent years, the work of Heron has been the subject of systematic research, attracting the interest of numerous contemporary scholars.

As a result of this research activity, a rich body of literature has been produced, from which we indicatively cite the following editions: (1) Fabio Acerbi and Bernard Vitrac, Héron d'Alexandrie, Metrica: Introduction, édition critique, traduction française et commentaires (Pisa: Fabrizio Serra, 2014) (2) Heron of Alexandria: Metrica. Introduction, translation and commentary, Dora Touliatou, Crete University Press (forthcoming).

This paper, drawing upon the findings of contemporary international research, focuses on the methods for solving problems of geometric metrology as these are proposed and developed by Heron in the Metrica.

The Revival of the Controversy over Geometric Algebra

Elias Barmbas

Department of History and Philosophy of Science, NKUA

Over approximately the last fifty years, following the publication of Sabetai Unguru's controversial 1975 paper on the need to rewrite the history of Ancient Greek Mathematics, a dialogue has developed that has been sufficiently analyzed.

The present paper presents studies conducted over the last five years which have enriched the existing historiography, highlighting the complexity of the research field of the History of Ancient Greek Mathematics.

The entirety of the historiography is distinguished into two historiographical categories, independent of the time of composition: the first phase of the controversy and the revival of the controversy.

Within this framework, a new reading is attempted of what is admittedly now the most controversial topic of recent decades in the field of Ancient Greek Mathematics, namely the dialogue on geometric algebra.

Under this prism, the pivotal points of friction in the controversy are re-examined, such as the use of modern symbolic notation in the translation of ancient mathematical texts, the relationship between the Greek and Babylonian traditions in mathematics, as well as the starting point of these issues, which stems from how the representatives of the opposing sides perceive the subject matter of the History of Mathematics and the role of the historian of Mathematics.

The Philosophical Reception of Mathematical Science in Late Antiquity: Proclus as a Commentator on Euclid.

Nikos Marakas

Department of History and Philosophy of Science, NKUA

The commentary of the Late Antique Neoplatonic philosopher, Proclus Lycius, on the first book of Euclid's Elements constitutes one of the few fully preserved commentarial works on the Euclidean corpus and serves as a fundamental source for the study of the history of ancient Greek mathematics.

Its distinct value lies not only in the precious historical information it preserves regarding the evolution of mathematical science from the Hellenistic period to Late Antiquity, but also in the way it highlights the significance of mathematics within the framework of the Neoplatonic philosophical program.

The present paper examines the manner in which Proclus utilizes Euclidean geometry as a tool for shaping, grounding, and defending Neoplatonic philosophy.

Through the analysis of selected passages from his commentary on the first book of the Elements, it will investigate how mathematical discourse is organically integrated into the Neoplatonic theory of knowledge and the ontological structure of reality.

Concurrently, it will demonstrate how the commentary on a preeminently mathematical text becomes a platform for philosophical interpretation and the systematic development of core principles of Neoplatonic thought.

The objective of this paper is to demonstrate that, in Late Antiquity, the relationship between mathematics and philosophy is not confined to an instrumental affinity, but constitutes a profound and organic unity, within which geometry assumes a central role in the constitution of Neoplatonic philosophical discourse.

The temporality of Ideas and Temporality as an Idea

D.A. Anapolitanos

Department of History and Philosophy of Science, NKUA

The ontological localization of the space of our ideas is presented as a basic philosophical problem granted that, as an abstract space, it demands its appropriate definition in order that its durability is emphasized. Besides it is necessary to focus on the importance of temporality as an Idea, given that one should highlight its role in the definition of duration as semantically containing the dimensional and the dimensionless. Moreover, it is essential to point out the basic differences between the discrete and the continuum as well as between the right and the wrong, given that their semantical scope does not appear to be affected by the idea of temporality.

Restrictive Principles concerning the mathematical activity during the first half of the 20th century. A case study.

Demetra Christopoulou

Department of Mathematics, NKUA

During the first half of 20th cent. some mathematicians made proposals about certain restrictive principles for the mathematical activity, in their attempt to avoid the inconvenience caused by the paradoxes. Those principles precluded either the development of some methodologies or the acceptance of new mathematical objects. Indeed, some of them are purported to safeguard coherence of mathematical thinking whereas others work as factors of restraining its growth. However, other mathematicians were skeptical or announced their explicit opposition to the restrictive principles so that theoretical disputes took place in the mathematical community. One of the tasks of the Philosophy of Mathematics is to investigate such conflicts, to seek and detect certain philosophical presuppositions, intellectual inclinations and conceptual commitments at the background of positions and discussions and attempt to define the impact of them on the mathematical development.

Problems of material implication and the intervention of the relevance logic

N. Elthini

Department of Mathematics, NKUA

In the field of classical propositional logic, material implication shows certain paradoxes (or puzzles) that have been a subject of discussion in the philosophy of logic. Material implication is defined truth-functionally through its truth table, in such a way that the only case in which it is false is when the antecedent is true and the consequent is false. One of its counterintuitive features is, for example, that it is true whenever the antecedent is false, regardless of the truth value of the consequent. Furthermore, no semantic connection is required between the antecedent and the consequent. Similarly, no semantic or relevant connection is required between the premises and the conclusion of an argument, since its validity in classical logic depends solely on the truth table of the corresponding implication. This lecture has a twofold aim: (a) to describe some paradoxical and counterintuitive situations concerning material implication, and (b) to examine, in connection with (a), some of the motivations that led to the development of relevance logic. Relevance logic approaches implication, as well as the validity of arguments, under different conditions, requiring a stronger connection between premises and conclusion.

The Naturalistic Epistemological Approach of W.V.O. QUINE

M.N. Pettas

Department of Mathematics, NKUA

Since the publication of Quine's work, in his book Ontological Relativity and Other Essays, entitled Epistemology Naturalised in 1969, naturalistic epistemology has become one of the most promising programs for pursuing epistemological questions. However, even after all these years, many philosophers continue to wonder what exactly Quine's naturalistic epistemology is about. In an essay entitled Naturalism; Or, Living Within One's Means (1995), he attempts to clearly define the position of Naturalism, citing some excerpts from his book Theories and Things (1981), specifically writing: In defining the philosophical position I call naturalism, I will simply describe my own position, without prejudging possible divergent uses of the term. In my book Theories and Things, I wrote that naturalism is "the recognition that reality is to be recognized and described within science itself and not in some prior philosophy" . Quine defends holism in his confirmation account, i.e. he argues that scientific theories are confirmed as wholes (Quine-Duhme position). If a scientific theory is experimentally confirmed by its empirical conclusions, then the entire theory is confirmed, namely physical as well as mathematical parts of the theory are equally confirmed. His position makes mathematics dependent on the success of scientific theories. Besides, he supports indispensability arguments according to which we accept the existence of mathematical objects to the extend we accept the existence of non-observable physical entities because they both are indispensable in the constitution of scientific theories.

Set Theory and Logic

Organizers

Gregoriadis V. (National Technical University of Athens)

Souldatos I. (Aristotle University of Thessaloniki)

Stefaneas P. (National Technical University of Athens)

PROGRAM

LOGIC AND SET THEORY SESSIONS

	Monday June 29	**Tuesday June 30**	**Wednesday July 1**	**Thursday July 2**	**Friday July 3**
				NTUA, ΣΗΜΜΥ, Room 1	**NKUA, Γ23**
12:30-13:00				C. Dimitrakopoulos	A. Kakkas
13:00-13:30				G. Barmpalias	S. Almpani, A. Gantzounis, P. Stefaneas
13:30-14:00				G. Marangelis	K. Mbonos, A. Gantzounis
14:00-16:00				**Break**	**Break**
16:00-16:20				C. Tassopoulou	M. Dimarogkona
16:20-16:40				A. Gantzounis, A. Plythas	S. Lianou
16:40-17:00				D. Serakioti	Y. Kiouvrekis
17:00-17:20				I. G. Eskiadi	Y. Gastouniotis, A. Fikiori

Subsystems of Peano Arithmetic

C. Dimitrakopoulos

Department of History and Philosophy of Science, University of Athens

The study of subsystems of Peano arithmetic began in the 1970s and continues to this day. In my lecture, I will briefly discuss theorems and problems concerning the strength of such systems.

The logic of Argumentation: From Aristotle to Quantum Mechanics and Artificial Intelligence

A. Kakas

Department of Computer Science, University of Cyprus

The main concern of Logic is to resolve conflicts within a theory, some knowledge taken as given, aiming to thus arrive at a logical conclusion, a new piece of information that (necessarily) follows from the given knowledge. This is the overall framework under which Aristotle carries out his original study of logic and reasoning at large. One of the major challenges in the systematization of logic is how to incorporate in the formal system of logic the element of Proof by Contradiction (or Reductio ad Absurdum) taken as an underlying principle of logical reasoning. The challenge arises when the given theory is itself inherently uncertain and inconsistent, a case which is typical in the modern realms of Quantum Mechanics and Artificial Intelligence. In this talk we will present Argumentation Logic (AL) as a logic that naturally applies to logical reasoning under any set of premises, consistent or not. We will present how AL naturally re-expresses and generalizes Reductio ad Absurdum irrespective of the consistency nature of the given knowledge and show how AL captures as a limiting case the classical logical reasoning with consistent premises. We will also discuss the links of AL to the foundations of Quantum Mechanics and to the need of Value Alignment in Artificial Intelligence.

Games, maps and randomness

G. Barmpalias

Institute of Software, Chinese Academy of Sciences

Key problems in algorithmic information can be framed in terms of maps on the reals as well as adversarial games on finite domains. In the first part I will talk about the complexity of probabilistic inversions of measure-preserving maps on the reals and report recent progress on this topic. The second part will focus on reductions to random reals and the associated open problems, which depend on solving finite allocation games on the binary strings. My aim is to draw attention to problems that originated in algorithmic information but can be stated, motivated and studied (and perhaps solved) without specialized knowledge or terminology.

Shelah's conjecture fails for higher cardinalities

Georgios Marangelis

Department of Mathematics, Aristotle University of Thessaloniki

The main goal of this paper is to generalize the results that where presented in [2] for $\aleph_1$-Kurepa trees to $\aleph_{\alpha+1}$-Kurepa trees.

We construct an $\mathcal{L}_{\omega_1,\omega}$-sentence ψ_α, that codes $\aleph_{\alpha+1}$-Kurepa trees, for some countable α. One of the main results for its spectrum (the spectrum of a sentence is the class of all cardinals for which there exists some model of the sentence) is the following:

It is consistent that $2^{\aleph_\alpha} < 2^{\aleph_{\alpha+1}}$, that $2^{\aleph_{\alpha+1}}$ is weakly inaccessible and that the spectrum of ψ_α is equal to $[\aleph_0, 2^{\aleph_{\alpha+1}})$.

This relates to a conjecture of Shelah, that if $\aleph_{\omega_1} < 2^{\aleph_0}$ and there is a model of some $\mathcal{L}_{\omega_1,\omega}$-sentence of size $\aleph_{\omega_1}$, then there is a model of size $2^{\aleph_0}$. Shelah calls $\aleph_{\omega_1}$ the local Hanf number below $2^{\aleph_0}$ and proves the consistency of his conjecture in [1]. It is open if the negation of Shelah's conjecture is consistent. Our result proves that if we replace $2^{\aleph_0}$ by $2^{\aleph_{\alpha+1}}$, it is consistent that there is no local Hanf number.

There are some interesting results for the amalgamation spectrum too (the amalgamation spectrum is defined similarly to the spectrum, but we require that κ-amalgamation holds plus there is at least one model of size κ). We prove that κ-amalgamation for $\mathcal{L}_{\omega_1,\omega}$- sentences is not absolute. More specifically we prove for $\alpha > 0$ finite, it is consistent that:

- $2^{\aleph_\alpha} = \aleph_{\alpha+1} < \lambda \leq 2^{\aleph_{\alpha+1}}, cf(\lambda) > \aleph_\alpha$ and $AP - Spec(\psi_\alpha)$ contains the whole interval $[\aleph_{\alpha+2}, \lambda]$ and possibly $\aleph_{\alpha+1}$.
- $2^{\aleph_\alpha} = \aleph_{\alpha+1} < 2^{\aleph_{\alpha+1}}$, $2^{\aleph_{\alpha+1}}$ is weakly inaccessible and $AP - Spec(\psi_\alpha)$ contains the whole interval $[\aleph_{\alpha+2}, 2^{\aleph_{\alpha+1}})$ and possibly $\aleph_{\alpha+1}$.

[1] Saharon Shelah. Borel sets with large squares. *Fund. Math.* 159(1):1–50, 1999.

[2] Dima Sinapova and Ioannis Souldatos. Kurepa trees and spectra of $\mathcal{L}_{\omega_1,\omega}$-sentences. *Arch. Math. Logic* 59(7–8):939–956, 2020.

A hybrid approach to Classical Borel Uniformizations

C. Tassopoulou

School of Applied Mathematics and Physical Sciences, National Technical University of Athens

In this talk, we present a new hybrid approach to classical Borel uniformization. Our goal is to bring effective uniformization strategies into the classical topological setting without utilizing recursion theory. For this purpose, we introduce the notion of hybrid points. These points, defined through purely classical tools, serve as a direct analogue to effective hyperarithmetical points. We will demonstrate how this framework allows us to translate fundamental effective results into the classical context, providing new proofs for the classical theorems.

Argumentation Logic for Explainable Goal-Oriented Reasoning in Multi-agent Systems

S. Almpani A. Gkantzounis and P. Stefaneas

School of Applied Mathematics and Physical Sciences, National Technical University of Athens, Technical University of Crete and National Technical University of Athens (second author)

APEC-PS is a collaborative argumentation framework for goal-oriented reasoning that integrates Argumentationbased Proof-Events with the Provers' System [1,2]. It provides a symbolic and temporal model for representing how multiple actors generate, challenge, refine, and validate claims while working toward shared or competing goals. By capturing proof-events, support and attack moves, actor states, fluents, temporal predicates, and levels of argumentation, APEC-PS makes explicit not only which conclusions are reached, but also how they emerge through interaction, conflict, revision, and validation. This places APEC-PS within the broader tradition of logic-based and defeasible argumentation [4,5,6], where conclusions are evaluated through structured relations among arguments, counterarguments, warrants, and attacks. Goal-oriented decisions are represented as argumentation-based proof-events of the form $e = \langle\langle \Phi, c\rangle, w\rangle$, where Φ denotes premises, c the claim, and w the warrant connecting evidence to action. Support, and attach moves are used to capture conflicts among goals, while temporal predicates are used to represent the evolution of multiagent reasoning across decision points. This paper applies APEC-PS to UAV swarms as a specific instance of multi-agent goal-oriented collaboration. The example demonstrates how this method can make explicit the logical dependencies between evidence, assumptions, warrants, attacks, and accepted mission actions. The proposed APEC-PS model connects formal logic with human-centered and symbolic AI by producing explicit reasoning traces for autonomous decisions [3]. This supports transparency, auditability, and trust in cyber-physical multi-agent systems, while preserving a formal basis for defeasible and temporally evolving reasoning [7]. Keywords: APEC-PS; argumentation logic; defeasible reasoning; temporal logic; symbolic AI; humancentered AI.

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ligence: A Survey. The Knowledge Engineering Review 36, e5 (2021).
https://doi.org/10.1017/S0269888921000011

From Arguments to Beliefs: Modeling Validation State Evolution in Deliberative Dialogues

K. Mbonos and A. Gkantzounis

School of Electrical and Computer Engineering, National Technical University of Athens, Technical University of Crete and National Technical University of Athens

Argumentation is a fundamental mechanism for collaborative reasoning and decision- making in environments where multiple participants contribute evidence, challenge assumptions, and revise their positions over time. This paper presents a formal framework for modeling argumentation as a dynamic and evolving process based on the Argumentation-based Proof-Event Calculus and Provers' Systems (APEC-PS). The proposed approach introduces explicit representations of arguments, proof-events, validation states, and belief-update mechanisms, enabling the analysis of how argumentative interactions influence reasoning outcomes. Validation states provide a graded measure of argument acceptance, while proof-events capture the temporal evolution of support, attack, and revision activities. Belief revision is modeled as a continuous process driven by the cumulative effect of successive argumentative interactions rather than by isolated decisive events. An illustrative deliberative dialogue is used to demonstrate how argument strength changes over time and how confidence in competing claims evolves. The proposed framework provides a formal mechanism for analyzing the temporal evolution of argument validation and belief revision in collaborative reasoning environments.

Chisholm's Puzzle and the Preservation of Factual and Deontic Detachment

A. Gkantzounis and A. Plythas

Technical University of Crete and National Technical University of Athens, School of Applied Mathematics and Physical Sciences, National Technical University of Athens

Chisholm's Puzzle is one of the central challenges in Deontic Logic, arising from the interaction of conditional obligation with the Principles of Factual and Deontic Detachment. Traditional responses to the puzzle typically preserve one form of Detachment at the expense of the other. A more recent approach by Kit Fine preserves both Factual and Deontic Detachment by introducing a richer semantic framework. We sketch an alternative semantic approach in which action and deontic transitions are represented by distinct relations. Factual and Deontic Detachment may then be understood as different forms of path composition, suggesting a new perspective on the source of the puzzle.

From graded semantic concepts to fuzzy logic: An empirical investigation of the sorites paradox

D. Serakioti

University of Western Macedonia

Sorites paradox is one of the most important challenges for the logic and semantics of fuzzy concepts. Its source arises from the fact that many natural language categories do not have clear boundaries, but present a graded structure. Concepts such as tall, short, blue, do not seem to be organized into discrete categories with absolute criteria, but into continuous regions where the boundaries between categories are indistinct. The aim of the experiment was to investigate whether speakers place clear and commonly accepted boundaries between the two categories or whether their semantic judgments are gradational and variable. At the same time, it was examined whether these empirical judgments are consistent with the fuzzy logic hypothesis, according to which inclusion in a category is not binary but scalar, taking on different degrees of participation. The research results showed that different speakers chose different points on the same continuous color spectrum as the boundaries between blue and green. This finding is a characteristic manifestation of linguistic vagueness, as the categories "blue" and "green" do not correspond to strictly separated sets, but to semantic regions with unclear and variable boundaries.

Deontic Logic and formal represention of XR ethics

I. G. Eskiadi

School of Applied Mathematics and Physical Sciences, National Technical University of Athens

The rapid development of Extended Reality (XR) technologies, including Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), raises new challenges concerning information management, behavioral influence, and the ethical regulation of interactive computational environments. Unlike traditional digital media, immersive systems do not operate merely as mechanisms for information representation but rather as dynamic environments of interaction that shape user perception, cognitive processing, and behavior. This paper proposes a formally grounded framework for the ethical evaluation of XR systems based on deontic logic, argumentation frameworks, and formal ethical specifications. The objective is to model obligations, prohibitions, permissions, and conflicting normative conditions within immersive environments. Particular emphasis is placed on:

- the development of an ontology of ethical risks and normative relationships in XR systems,
- the formal representation of ethical violations and behavioral influence mechanisms,
- and the creation of machine-readable normative systems for immersive environments.

The study seeks to examine the transition from descriptive approaches to XR ethics toward operational ethical architectures, where ethics is not treated as an external evaluation mechanism but as an integrated component of computational design ("ethics-by-design"). Finally, the paper proposes an extension of the PET (Privacy, Empowerment, Transparency) model into a PET-XR Ethical Scoring Framework capable of evaluating immersive and AI-driven interactive systems

in terms of transparency, privacy, user empowerment, and the degree of behavioral influence they exert. The research is situated at the intersection of mathematical logic, formal methods, computational ethics, and immersive media studies, proposing an interdisciplinary framework for the formal analysis of ethical and normative properties in complex XR systems.

An Algebraic-Categorical Framework for Multimodal Normative Reasoning in Autonomous Systems

M. Dimarogkona

School of Applied Mathematics and Physical Sciences, National Technical University of Athens

We present an algebraic-categorical multimodal logical framework for normative reasoning in autonomous systems operating in dynamically evolving environments. The approach is based on the theory of c-parchments, developed within institution theory for the modular combination of logical systems while preserving key metatheoretic properties such as soundness and completeness. The framework combines single-agent variants of deontic, epistemic-doxastic, and action logics in order to represent obligations, permissions, knowledge, belief, and action constraints. By merging their Hilbert-style axiomatizations and Kripke-style semantics through the universal fibring construction provided by c-parchments, we obtain a multimodal logical system supporting the formally verifiable derivation of admissible action policies. We investigate the transfer of fundamental logical properties from the component systems to the combined framework, emphasizing in particular the preservation of soundness and completeness. We further show that completeness is not automatically preserved in the presence of cross-modal interaction rules and must therefore be established separately, for example via proof-assistant verification. The framework is illustrated through a representative example demonstrating the derivation of admissible actions in a workflow with normative constraints. We briefly discuss a possible executable implementation based on Maude, together with related verification considerations, and outline directions toward a more general architecture supporting both system-level and metatheoretic analysis. The work contributes a formally grounded multimodal framework for normative reasoning in autonomous systems, supporting the derivation and formal verification of admissible action policies within a unified modal-logical setting.

Formalizing ReAct Agents using Rewriting Logic

S. Lianou

School of Applied Mathematics and Physical Sciences, National Technical University of Athens

Rewriting Logic, first introduced by José Meseguer in 1990, has been proposed as a logical and semantic framework for the specification of systems and programming languages. Reactive rules are used to formalize and analyze event-driven systems. In recent years, autonomous AI agents have become increasingly prevalent in real- world applications, raising important concerns regarding safety, interpretability, and verifiability. These challenges motivate the use of formal methods for specifying and analyzing agent behavior. In this work, we adopt rewriting logic as a semantic foundation for modeling ReAct- style agents, which operate through iterative cycles of reasoning, action selection, and interaction with the environment. As an initial approach,

we model such agents as a minimal behavioral system: where denotes the internal reasoning state of the agent and defines iterative state transitions driven by inputs, tool interactions, and environmental observations. This formalization enables the specification of reactive agent behavior using algebraic and rule-based semantics, with the potential for executable modeling and analysis using rewriting logic frameworks such as Maude.

The Necessity of Mathematical Logic in the Foundations of Neuro-Symbolic AI

Y. Kiouvrekis

Department of Public and One Health, University of Thessaly

The rapid advancement of artificial intelligence has exposed a fundamental tension: while neural models achieve remarkable performance in learning and pattern recognition, they lack principled mechanisms for reasoning, interpretability, and formal correctness guarantees. Neuro-Symbolic AI has emerged as a leading paradigm for resolving this tension, integrating data-driven learning with symbolic knowledge representation and logical inference. Yet the field remains without a unified theoretical foundation capable of formally characterizing what such systems can represent, infer, and learn and, critically, what they cannot.

This work argues that Mathematical Logic provides precisely this foundation. We show how core logical concepts, semantics, satisfiability, logical consequence, consistency, and provability, supply the formal apparatus necessary to bridge neural and symbolic computation in a principled way. Drawing on results from finite model theory, descriptive complexity, and abstract model theory, we demonstrate that the connections between logical formalisms and neural architectures are not analogies but structural correspondences: the expressive power of a neural model is determined by the logical fragment it inhabits, and its limitations are logical limitations. Grounding Neuro-Symbolic AI in Mathematical Logic thus transforms it from an empirically motivated engineering effort into a principled scientific discipline with formal tools for design, analysis, and verification.

The presentation concludes by identifying open problems at the intersection of logic and learning and proposes a research agenda for the next generation of formally and cognitively grounded intelligent systems.

Specification of the CAN protocol in Maude

Y. Gastouniotis and A. Fikiori

School of Applied Mathematics and Physical Sciences, National Technical University of Athens

This paper focuses on the modeling of the CAN communication protocol used in vehicles/machinery for the communication between individual Electronic Control Units (ECUs). All ECUs can send and read messages on the system's shared bus. The system's architecture allows for efficient, fault-tolerant, and low-cost communication. Due to the structure of CAN, the Maude programming language is well-suited for studying its operation and properties. Maude is based on rewriting logic and is used as a tool for studying distributed systems and communication

protocols. This work includes the modeling of messages (frames) and other CAN elements, the exchange of messages on the bus, as well as error detection. Indicatively, reference is also made to verifying CAN properties using Linear Temporal Logic (LTL), which is embedded in the language.

Probability and Statistics

Organizers

Cheliotis D. (National and Kapodistrian University of Athens)

Karlis D. (Athens University of Economics and Business)

Loulakis M. (National Technical University of Athens)

PROGRAM

PROBABILITY AND STATISTICS SESSIONS

	Monday June 29	**Tuesday June 30**	**Wednesday July 1**	**Thursday July 2**	**Friday July 3**
	NKUA, Γ31	**NTUA, ΣΗΜΜΥ, Room 7**	**NKUA, Γ31**		
12:30-13:05		I. Manolopoulou			
13:05-13:40		T. Papamarkou			
13:40-14:00		D. Lyberopoulos			
14:00-16:00	**Break**	**Break**	**Break**		
16:00-16:35	K. Panagiotou	E. Nestoridi	K. Dareiotis		
16:35-17:00	C. Panagiotis	M. Zazanis	A. Saplaouras		
17:00-17:30	A. Yannacopoulos		M. Louvaris		
17:30-18:00	**Coffee break**	**Coffee break**	**Coffee break**		
18:00-18:25	P. Tassopoulos	V. Chasiotis			
18:25-18:50	P. Zoubouloglou	A. Damoulaki			
18:50-19:15	A. Koutsibela	D. Karlis			
19:15-19:40	I. Vlachou	A. Nalpantidi			

A subsampling approach for variable selection and predictive modeling in big data

Vasilis Chasiotis, Lin Wang, Dimitris Karlis

Athens University of Economics and Business, Purdue University, Athens University of Economics and Business

In the context of large-scale data analysis, there is a growing demand for efficient methods to select representative subsets of data that enable accurate statistical inference while keeping computational costs manageable. Prior to subsampling, performing variable selection can be advantageous, as typically only a small fraction of the available variables significantly contribute to the model. We introduce a method tailored for scenarios where both the number of observations and variables are high. The approach first detects relevant variables using a technique inspired by random LASSO, and then applies leverage score–based sampling to construct a predictive model. Compared to existing approaches, including those relying on the full dataset, the proposed method improves both variable selection and predictive accuracy, while considerably lowering computational burden. Its performance is validated through simulation experiments and an application to real-world data.

Analytical Bounds on Posterior Inclusion Probabilities and Their Use in Variable Selection

Argyro Damoulaki & Ioannis Ntzoufras

Dept of Statistics, Athens University of Economics and Business

Bayesian model selection in high-dimensional settings is computationally challenging due to the exponential growth of the model space. Posterior inclusion probabilities typically require evaluation of up to 2^p models and are often approximated via MCMC methods. We introduce a deterministic variable screening framework based on analytically derived lower and upper bounds on posterior inclusion probabilities. Under a conjugate prior structure, we obtain tractable bounds that enable principled reduction of the model space. We study theoretical properties of the proposed bounds, including their tightness and implications for variable selection. The method remains effective in challenging settings, such as strong collinearity among predictors, while offering substantial computational gains over sampling-based approaches.

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Itô perspective on variance renormalisation

Konstantinos Dareiotis

University of Leeds

We show that the Itô solutions of the nonlinear stochastic heat equation

$$\partial_t u^\varepsilon - \Delta u^\varepsilon = \varepsilon^{3/4} g(u^\varepsilon)\nabla\xi_\varepsilon,$$

where ξ_ε denotes the mollification in space at scale $\varepsilon > 0$ of a space-time white noise ξ, converge in law, as $\varepsilon \to 0$, to the solution of the stochastic heat equation with right-hand side $cg'g(u)\xi$ with a constant $c > 0$. Since the noise $\nabla\xi$ is supercritical, the small prefactor is not unexpected to obtain a limit, but the exponent 3/4 is not predicted by naive scaling arguments. The case $g(u) = u$, modulo a Cole–Hopf transform, corresponds to the result of Hairer (2025) for the KPZ equation. Our argument is relatively short and relies solely on stochastic analytic techniques. This is joint work with M. Gerencsér.

Spatio-Temporal models for count data

Dimitris Karlis

Dept of Statistics, Athens University of Economics and Business

In many disciplines, observations are recorded as discrete counts across both spatial and temporal dimensions. Such data are prevalent in epidemiology, where disease occurrences are tracked across regions over time, criminology, where crime rates are analyzed within specific jurisdictions across successive periods, just to name few. This talk introduces a class of models designed to account for the discrete nature of these observations explicitly. By prioritizing the underlying discrete structure, these models offer better forecasting accuracy and deeper structural insights compared to traditional continuous approximations. We define a generalized spatio-temporal framework sing the idea of thinning that preserves the discrete nature of the data. We also erive its fundamental statistical properties. For parameter estimation, we employ a conditional maximum likelihood approach facilitated by an Expectation-Maximization (EM) algorithm. Furthermore, we discuss the development of robust forecasting procedures and validate the model's performance through extensive Monte Carlo simulation experiments. The practical utility of the proposed framework is demonstrated using a real-world application: the spatio-temporal progression of the COVID-19 epidemic in the Netherlands.

Scaling limits in interacting particle systems

Aggeliki Koutsibela

SEMFE (NTUA), AUEB

We establish a connection between tagged particles and size-biased empirical processes in interacting particle systems, in analogy to classical results on the propagation of chaos. In a mean-field scaling limit, the evolution of the occupation number on the tagged particle site converges to a time-inhomogeneous Markov process with non-linear master equation given by the law of large numbers of size-biased empirical measures. Joint work with Stefan Grosskinsky (University of Augsburg).

On the Einstein Relation for 1-d Mott random walk in random environment

Michalis Loulakis and Ioanna Vlachou

NTUA

We use a relative entropy approach to prove the Einstein relation for a one dimensional Mott random walk in a random environment given by an ergodic marked point process $(Z_k, E_k)_{k\in\mathbb{Z}}$ under the assumption of a finite first exponential moment $\mathbf{E}[e^{Z_0}] < \infty$. This extends the result of Faggionato, Gantert and Salvi.

Extreme eigenvalues and eigenvectors for finite rank additive deformations of non-Hermitian sparse random matrices

Michail Louvaris

Yale University

Consider an $n \times n$ sparse non-Hermitian random matrix X^n defined as the Hadamard product between a random matrix with centered independent and identically distributed entries and a sparse Bernoulli matrix with success probability K_n/n where $K_n \leq n$ (and possibly $K_n \ll n$) and $K_n \to \infty$ as $n \to \infty$. Let E^n be a deterministic $n \times n$ finite-rank matrix. We prove that the outlier eigenvalues of $Y^n = X^n + E^n$ asymptotically match those of E^n. In the special case of a rank-one deformation, assuming further that the sparsity parameter satisfies $K_n \gg \log^9 n$ and that the entries of the random matrix are sub-Gaussian, we describe the limiting behavior of the projection of the right eigenvector associated with the leading eigenvalue onto the right eigenvector of the rank-one deformation. In particular, we prove that the projection behaves as in the Hermitian case. To that end, we rely on the recent universality results of Brailovskaya and van Handel [1] relating the singular value spectra of deformations of X^n to Gaussian analogues of these matrices.

Our analysis builds upon recent framework introduced by Bordenave et.al. 2022 [2], and amounts to showing the asymptotic equivalence between the reverse characteristic polynomial of the random matrix and a random analytic function on the unit disc with explicit dependence on the finite-rank deformation.

References

[1] T. Brailovskaya and R. van Handel, “Universality and sharp matrix concentration inequalities,” Geometric and Functional Analysis, vol. 34, no. 6, pp. 1734–1838, 2024.

[2] C. Bordenave, D. Chafaï, and D. García-Zelada, “Convergence of the spectral radius of a random matrix through its characteristic polynomial,” Probability Theory and Related Fields,

pp. 1–19, 2022.

Hedonic models in official statistics

Demetrios P. Lyberopoulos

Aristotle University of Thessaloniki, Department of Mathematics

A fundamental, if not the main, problem that emerges when compiling price indices, particularly in the context of real estate statistics, lies in capturing the evolution of pure - in the sense that they are not affected by changes in the quality of the underlying good - *price changes*.

More precisely, let $\mathbb{T} \subset \mathbb{N} \times \mathbb{N}$ and let Y_t and $\mathbf{X}_t = (X_{1,t}, ..., X_{c,t}), t \in \mathbb{T}$, denote the price and the random vector of quality characteristics of a good at time t, respectively. A price index in its simplest form ideally would be given by the ratio $100Y_t(\mathbf{X}_s)/Y_t(\mathbf{X}_s)$ for some $s \in \mathbb{T}$. In practice, however it is only possible to compute ratios of the form $100Y_t(\mathbf{X}_t)/Y_s(\mathbf{X}_s)$ for $s, t \in \mathbb{T}$ with $s < t$, thereof comparability issues are raised since the prices may refer to goods with completely different quality characteristics. These issues are addressed by introducing in the compilation of price indices/ratios both nominal prices $Y_t(\mathbf{X}_t), t \in \mathbb{T}$, and some estimated ones $\tilde{Y}_t(\mathbf{X})$ referring to a common quality characteristics vector $\mathbf{X}$.

The latter prices are estimated by means of multiple regression models and re- lated methods also known as hedonic models/methods(see e.g. Hill et al. (2018)). In this work, an overview of some technical aspects of these methods will be provided together with a state of the art summary concerning their implementation for the production of housing price indices (see e.g. European Commission, Eurostat (2017)).

REFERENCES

European Commission, Eurostat (2017). Technical manual on Owner-Occupied Housing and House Price Indices.

Hill, R.J., Scholz, M., Shimizu, C. and Steurer, M. (2018). An evaluation of the methods used by European countries to compute their official house price indices. Economie et Statistique / Economics and Statistics 500-502, 221-238.

Combining confounded and unconfounded data in heterogeneous treatment effect modelling

Ioanna Manolopoulou

University College London

Building statistical models using non-randomly sampled data is a well-known challenge in statistics, and is especially challenging when any part of the statistical model is not fully identifiable. In causal inference, and in particular in the estimation of heterogeneous treatment effects, this arises when observational data are used which may be affected by unobserved confounding. One approach to correct for such confounding is to combine data with and without unobserved confounding. However, when the unconfounded data are not representative of the whole population, the effect of de-confounding will be poor for subsets of the population that fall outside the range of these data. Depending on the structure of the model and the nature of the prior distributions used within a Bayesian model, this will be addressed by borrowing information from other parts of the space. In this work, we highlight the importance of building models that can account for uncertainty due to unobserved confounding in regions where no de-confounding is possible. To this end, we embed a combination of data with and without unobserved confounding into Bayesian Causal Forests (BCF), and make use of a data-dependent tempered likelihood to harness as much reliable information from the unconfounded data as possible, without leading to over-confidence in regions of poor identifiability. We implement our methods on a set of simulated and real data examples. Joint work with Ilina Yozova and Nathan McJames

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On Modeling Multivariate Mixed-Type Time Series

Anna Nalpantidi and Dimitris Karlis

Athens University of Economics and Business

We develop a general framework for jointly modeling multivariate time series of mixed types, including continuous, count, ordinal, and binary data, using copula-based methods. To mitigate computational complexity in high dimensions while preserving flexible dependence structures, we propose approximating the full likelihood of the multivariate model by conditional pairwise likelihood. Estimation is carried out via a two-stage algorithm: first, the log-likelihood of each bivariate model is maximized separately, and then the resulting estimates are combined to obtain a unique parameter set. This synthesis can be performed either through simple averaging or through a weighted mean, where the weights are derived from the Hessian matrix of each bivariate model. Simulation studies demonstrate good asymptotic performance, with negligible differences between the two combination approaches. An application to real data illustrates the proposed methodology.

Cutoff for the Burnside process on the hypercube

Evita Nestoridi

Stony Brook University

S_n acts on the binary hypercube $\{0,1\}^n$ by permuting the coordinates. This action gives rise to a natural Burnside process. In joint work with Allan Sly, we prove that this Markov process exhibits worst-case total variation cutoff and we identify a Gaussian limit profile. The cutoff is controlled by the decay of a centered overlap with the initial configuration. This decay is asymptotically an i.i.d. stick-breaking product, and the cutoff window comes from the central limit theorem for this product.

Locality and analyticity for percolation on graphs of polynomial growth

Christoforos Panagiotis

University of Bath

In this talk, we will consider Bernoulli percolation on transitive graphs G of polynomial growth. Suppose that we do not know all of G, but only its ball of radius r for some large r. With only this partial, local knowledge of G, can we still say much about the behaviour of percolation on G? Based on joint work with Sébastien Martineau, the talk will be devoted to answering this question in a strong sense. Along the way, I will explain how one can show that the percolation density $\theta(p)$ of the infinite connected component is an analytic function of the parameter p in the supercritical regime, extending earlier joint work with Agelos Georgakopoulos.

Dispersion on the complete graph

Konstantinos Panagiotou

Ludwig Maximilian University Munich

We consider a synchronous process of particles moving on the vertices of a graph G. Initially, M particles are placed on a vertex of G. In subsequent time steps, all particles that are located on a vertex inhabited by at least two particles jump independently to a neighbour chosen uniformly at random. The process ends at the first step when no vertex is inhabited by more than one particle; we call this (random) time step the dispersion time.

In this talk we consider the case where G is a complete graph on n vertices and $M = cn$. In that case, the dispresion time undergoes a phase transition from logarithmic to exponential time when c crosses the value 1/2. We will investigate the fine details of this transition, and we will establish that there is a critical window of order $n^{1/2}$, where the dispersion time is also of that order. Moreover, we will derive very explicit descriptions of the distributions of various quantities, like the dispersion time and the total number of jumps.

This is joint work with U. De Ambroggio, T. Makai and A. Steibel.

Bayesian control for agentic AI systems

Theodore Papamarkou

SEMFE (NTUA) and Athena Research Center

Modern AI systems increasingly act through tool use, verification, refinement, and interaction rather than producing a single prediction. This creates a sequential decision problem under uncertainty. An agent must decide when to gather more evidence, when to refine an output, when to pay for verification, and when to stop. I will describe a Bayesian decision-theoretic view of agentic AI orchestration, in which the controller maintains posterior beliefs over task-relevant latent states and selects actions by expected utility. Coding agents provide a case study.

Candidate correctness is latent, critics provide noisy evidence, generators induce stochastic transitions, and verifiers are costly terminal actions. This perspective connects Bayesian statistics, sequential hypothesis testing, value of information, and partially observable Markov decision processes, and suggests a research direction for Bayes-consistent agentic AI systems.

The de La Vallée Poussin criterion under Young functions with enhanced properties

Alexandros Saplaouras

Department of Statistics and Actuarial - Financial Mathematics University of the Aegean

The classical lemma of de La Vallée Poussin provides a characterisation of a uniformly integrable family of random variables by means of Young functions. Many decades later, Meyer enhanced the properties the Young functions may possess, by allowing them to be of moderate growth. The aim of this work is to further refine the properties of Young functions appearing in the characterization of uniform integrability, by allowing them to be (at least) twice continuously differentiable and finally submultiplicative. The aforementioned set of properties is not exhaustive, as additional properties may be deduced, depending on the desired application. This strengthened de La Vallée Poussin criterion can be effectively applied within the framework of viscosity solution theory for second-order nonlinear integro–partial differential equations, yielding new, sharp analytic tools for the study of such problems.

The KPZ fixed point and Brownian motion share the same null sets

Pantelis Tassopoulos

University of Cambridge

We show that the increments of the KPZ fixed point started from arbitrary initial data are mutually absolutely continuous with respect to Brownian motion with diffusion parameter 2 on compacts, extending the one-sided Brownian absolute continuity relation of the KPZ fixed point established by Sarkar and Virag in 2021. As applications, we investigate geometric properties of the graph of the KPZ fixed point, obtaining a characterisation for the positivity of certain hitting probabilities thereof using a certain thermal capacity and compute essential suprema of Hausdorff dimensions of these random intersections. The arguments above can be extended to show that additive Brownian motion is absolutely continuous with respect to the centred Airy sheet on compacts, but it is not mutually absolutely continuous globally. This allows us to compute essential suprema of Hausdorff dimensions of images of subsets in the plane under the Airy sheet and give a condition for the positivity of their Lebesgue measure in terms of Bessel-Riesz capacity.

Stochastic PDEs involving the fractional Laplacian

Athanasios N. Yannacopoulos

(Department of Statistics, Athens University of Economics and Business

We present recent results on problems related to partial differential equations, involving the fractional Laplacian operator. In particular we study a stochastic parabolic PDE, involving the fractional Laplacian operator, with a nonlinear reaction term and stochastic driving terms involving the fractional Brownian motion. This model allows us to take into account long range correlations both in the spatial and the temporal domain. We present well posedness results for the model as well as asymptotic results regarding quenching of the solution.

This is joint work with N. Kavallaris and C. Nikolopoulos.

Limit Theorems for Superpostitions of Markovian ON/OFF Sources

Michael A. Zazanis, George Makatis and Dimitra Pinotsi

Department of Statistics, Athens University of Economics and Business

We examine superpositions of independent ON/OFF markovian sources and consider triangular arrays of stationary sources with unit transmission rate when a source is in the ON state. Assuming that the processes in each row are independent we obtain conditions under which the superposition processes resulting from each row converge in distribution to a stationary Gaussian process. Under these conditions, the limiting stationary covariance is a completely monotonic function. As a specific example, we consider a triangular array of parameters (λ_{jn}, μ_{jn}) (where all sources have ON rates μ_{jn} equal to μ. The nth row of the array has OFF rates $\lambda_{jn} = n^{-\alpha}\Lambda_j$ were $\{\Lambda_j\}$ are i.i.d. positive random variables with distribution F_Λ and $\alpha \in (0,1)$. Under appropriate conditions for the distribution F_Λ we establish the weak convergence of the sequence of superposition process (appropriately centered and normalized) to a stationary gaussian process with covariance $c(t) = \int_0^\infty e^{-(\mu+x)t} F_\Lambda(dx)$.

On the density of the supremum of nonlinear SPDEs

Pavlos Zoubouloglou

University of Münster

We study the one-dimensional stochastic partial differential equation

$$\frac{\partial u}{\partial t}(t,x) = -\kappa \frac{\partial^4 u}{\partial x^4}(t,x) + \rho \frac{\partial^2 u}{\partial x^2}(t,x) + b(u(t,x)) + \sigma(u(t,x))\,\dot{W}(t,x),$$

posed on a bounded spatial domain, where u is understood in the random field sense. Depending on the value of κ, this equation includes the nonlinear stochastic heat equation with Dirichlet or Neumann boundary conditions, as well as the linearized stochastic Cahn–Hilliard equation with Neumann boundary conditions. We prove that the supremum of the solution admits a density with respect to the the Lebesgue measure. Our approach is based on Malliavin calculus, and

in particular on the version of the Bouleau–Hirsch criterion for suprema developed by Nualart and Vives. One of the main difficulties lies in the analysis of the argmax set of the solution and in showing that the Malliavin derivative is almost surely nondegenerate on this set. As a byproduct of our arguments, we also establish Hölder continuity properties for the Malliavin derivative of the solution as an L^2-valued process in the regimes considered in this work.

This is joint work with G. Karali, A. Stavrianidi, and K. Tzirakis.

Operations Research

Organizers

Dimitriou I. (University of Ioannina)

Georgiou A. (University of Macedonia)

Mourtos I. (Athens University of Economics and Business)

PROGRAM

OPERATIONS RESEARCH SESSIONS

	Tuesday, June 30	**Tuesday, June 30**	**Friday, July 3**
	NTUA, ΣΗΜΜΥ, Room 1	**NTUA, ΣΗΜΜΥ, Room 2**	**NKUA, A32**
12:30-13:00	K. Nikolopoulos		E. Thanassoulis
13:15-13:35	M. Benioudakis, A. Bournetas, D. Zisis, G. Ioannou	K. Fountoulakis	13:00-13:15 M. Michali
13:35-13:55	A. Burnetas, A. Economou, A. Manou	I. Avgerinos	13:15-13:30 K. Petridis, A. Emrouznejad
13:55-14.15	I. Dimitriou, I. Adan	A. Georghiou	13:30-13:45 G. Koronakos, Jose H. Dula
			13:45-14:00 A. Berahas
14:00-16:00	**Break**		**Break**
16:00-16:20	K. Bekios, A. Burnetas	N. Dimou	16:00-16:15 A. C. Georgiou
16:20-16:40	A. Pasiouras, K. Bekios, A. Burnetas	A. Ktenidis	16:15-16:30 N. Chatzistamoulou
16:40-17:00	M. Deligiannis, M. Scarsini, X. Venel		16:30-16:45 E. Stergiou, N.Rigas, G. Ferrara, K.E. Kounetas
			16:45-17:00 C. Zacharias, P. Zervopoulos
17:30-18:00	**Coffee break**		**Coffee break**
18:00-18:30	A. Papavasileiou		
18:45-19:15	M. Vlassiou		

Semi-plenary: Stochastic processes on interacting networks

Maria Vlasiou

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Many systems in science and engineering can be viewed as collections of stochastic processes that interact through dynamic networks. Classical approaches typically assume fixed structures or independent components, but contemporary systems—ranging from communication platforms and service ecosystems to mobility networks and biological systems—*evolve* while operating. Their behaviour emerges from feedback between random flows, changing topologies, and state-dependent interactions.

This lecture surveys recent developments in stochastic processes on interacting networks. I will discuss models that capture how randomness, dependence, and network evolution shape collective dynamics, highlighting tractable results on stability, scaling limits, and approximation methods. Rather than proposing a single framework, the aim is to outline a research programme. By modelling systems as stochastic processes on interacting networks, we obtain models that are closer to modern applications and pose new mathematical questions.

Revenue Sharing and Channel Structure in Dual-Channel Service Systems with Strategic Customers

Myron Benioudakis[1], Apostolos Burnetas[2], Dimitris Zissis[3], George Ioannou[3]

[1]*Department of Mathematics, University of Patras, Patras, Greece, (benioudakis.myron@ac.eap.gr),* [2]*Department of Mathematics, National and Kapodistrian University of Athens (NKUA), Athens, Greece,* [3]*Department of Management Science & Technology, Athens University of Economics & Business, Athens, Greece*

We study a queueing model with a service provider that may operate through a direct (dine-in) channel, an indirect (delivery) channel via a platform, or both channels simultaneously (omni-channel), in a setting with strategic customers who are sensitive to both prices and delays. Customers arrive according to a Poisson process and endogenously select their preferred channel based on utility functions that depend on prices and expected waiting times within an M/M/1 queueing framework.

Delivery customers are subject to an additional service stage that captures logistics-related delays. Customer delay sensitivity is differentiated, with customers exhibiting greater sensitivity to delays in the direct channel than in the indirect channel.

We first establish the existence and uniqueness of equilibrium arrival rates and determine threshold prices that separate the dine-in only, delivery only, omni-channel, and no-service operating regimes.

Next, we examine a Stackelberg game under a revenue-sharing contract, in which the platform chooses the revenue-sharing rate and the service provider optimally sets the delivery price. For low, medium, and high dine-in price ranges, we derive the platform's optimal sharing policy and the corresponding equilibrium outcomes, highlighting the effects of operating costs and delay sensitivities on the feasibility and attractiveness of each channel configuration.

Our findings offer managerial insights into the conditions under which omni-channel operation is beneficial, when delivery becomes the dominant mode, and how revenue-sharing agreements shape channel coexistence and overall profitability.

Revenue and Social Welfare Maximization in Service Systems: Independent vs. Grouped Customers

Apostolos Burnetas, Antonis Economou, Athanasia Manou

Department of Mathematics, National and Kapodistrian University of Athens (NKUA), Athens, Greece, aburnetas@math.uoa.gr

The revenue maximization problem in service systems with strategic customers is a fundamental topic in the Rational Queueing literature. The standard assumption is that customers make joining decisions independently, leading to a game-theoretic interaction between individual customers and the service provider. In this setting, the provider determines an optimal admission price while anticipating the equilibrium joining behavior of self-interested customers.

In this work, we consider an alternative setting in which customers cooperate and their decisions are coordinated by a common leader. The resulting problem becomes a game between the service provider and the customers' leader, who acts on behalf of the entire customer population. We investigate how such collusive behavior affects optimal pricing policies and equilibrium outcomes in the join-or-balk problem for an unobservable single-server Markovian queue. In particular, we compare the provider's optimal pricing decisions under independent and coordinated customer behavior and examine the corresponding effects on customer participation, social welfare, and provider revenue. Our analysis highlights the extent to which customer coordination alters the balance between profitability and system efficiency.

Vector-Valued Functional Equations with Multiple Recursive Terms

Ioannis Dimitriou[1], Ivo Adan[2]

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[2]*Department of Industrial Engineering and Innovation Sciences, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, the Netherlands*

We develop a general method for solving vector-valued functional equations with multiple recursive terms. Such equations arise naturally in the analysis of vector-valued multiplicative Lindley-type recursions, reflected autoregressive processes, and semi-Markovian queueing models. The main object is a vector transform satisfying a recursive equation in which a matrix-valued kernel couples the background states, while coordinate projections route different components through different contraction mappings.

Under commutativity and contraction assumptions on the recursive arguments, we obtain a convergent series representation for the solution. The convergence mechanism relies on the fact that the polynomial growth of the multi-index expansion is dominated by the geometric decay induced by the contractions. The framework is illustrated through Markov-modulated reflected autoregressive and queueing models.

Learnability of Algorithms

Kimon Fountoulakis

Department of Computer Science, University of Waterloo

This talk examines when and how machine learning models can learn to execute algorithms. Such reasoning underpins core tasks such as arithmetic and sorting, which are often used as testbeds for algorithmic reasoning. I present both lower and upper bound results. On the negative side, I show that end-to-end training can be inefficient for learning algorithms, while step-by-step supervision enables efficient learnability. On the positive side, I demonstrate that neural networks can be trained to execute algorithms and general computer instructions exactly. Finally, I quantify their ensemble complexity, which provides a lower bound on the number of independent training runs required to achieve zero error. These results indicate when algorithmic behavior is learnable in practice and when structural barriers make it provably hard.

Decomposition and Lower Bounds for Flexible Flowshop Scheduling

Ioannis Avgerinos, George Zois, Ioannis Mourtos

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An extended variant of the Hybrid Flexible Flowshop scheduling (HFFS) problem is studied, where resource allocation plays a central role not only as a constraint but also as a decision variable that determines the processing times of operations. In this setting, jobs are processed across multiple stages, each consisting of several identical parallel machines, while some jobs may skip certain stages. Processing times depend on the amount of workforce assigned to each job at every stage. The model further incorporates transportation times between machines and limited-capacity buffers before and after each stage. A Constraint Programming (CP) formulation is developed together with a Logic-Based Benders Decomposition (LBBD) framework that exploits the structure of the problem. Since CP methods may yield weak lower bounds, several valid lower bounds are derived; in particular, a strong bound is obtained via a reduction to a malleable scheduling problem, leveraging structural properties of the processing time functions. Computational experiments are conducted on benchmark instances adapted from recent instance generators, with sizes reaching up to 400 jobs, 8 stages, and 10 parallel machines per stage. The results indicate competitive optimality gaps and strong scalability, even on instances that significantly extend the scope of existing HFFS literature. Overall, the study highlights the interplay between scheduling, resource allocation, and decomposition-based optimization methods for complex manufacturing environments.

Optimization Problems under Uncertainty with Decision-Dependent Information Discovery

Angelos Georghiou

Department of Business and Public Administration University of Cyprus

In multi-stage decision-making problems affected by uncertainty, it is usually assumed that the uncertain parameters can be observed for free and that the sequence in which they are revealed is independent of the decision-maker's actions. Yet, these assumptions fail to hold in many real-world applications where the time of information discovery is decision-dependent and the uncertain parameters only become observable after an often costly investment has been made. In this work we consider optimization problems under uncertainty (in particular robust optimization problems) in which part of the decision variables control the time of information discovery. Thus, information available at any given time is decision-dependent and can be discovered (at least in part) by making strategic exploratory investments in previous stages. In this talk, I will present the basic concepts between the classical (decision free) setting and the proposed approach, and discuss applications where this modelling approach is particularly useful.

Learning and Optimization in Multi-Armed Bandit Models with Delayed Observations

Konstantinos Bekios, Apostolos Burnetas

Department of Mathematics, National and Kapodistrian University of Athens (NKUA), Athens, Greece, kmpekios@gmail.com

We study a general stochastic multi-armed bandit problem with delayed feedback and multiple simultaneous plays, motivated by applications such as adaptive clinical trials and other sequential experimentation settings. We consider a collection of arms whose rewards follow parametric distributions with unknown parameters endowed with independent prior distributions. Observations are subject to random delays: once an arm is selected, it remains active and unavailable for reselection until its reward is observed, with completion times modeled as independent exponential random variables. Consequently, both the set of available arms and the number of arms selected at each decision epoch evolve randomly over time.

Within this setting, we develop a modified Thompson sampling policy that operates at the completion times of individual arms. Whenever a reward is observed, the posterior distribution of the corresponding arm is updated and the current leader arm is identified based on the available information. The policy then samples parameters from the posterior distributions of the available arms and selects those whose sampled mean rewards exceed that of the current leader. In this way, the algorithm balances exploration and exploitation through an explicit comparison mechanism while naturally accommodating delayed feedback and arm unavailability. The resulting multi-play strategy progressively concentrates experimentation effort on the most promising alternatives.

We introduce an appropriate notion of regret and investigate its asymptotic behavior under the proposed policy, establishing asymptotic optimality. Numerical experiments confirm the effectiveness of the approach and illustrate its learning performance across a range of scenarios.

The proposed methodology provides a unified reinforcement-learning framework for delayed and resource-constrained sequential experimentation problems, with adaptive clinical trials representing a particularly important application domain.

Polya-Gamma methods for Bayesian Learning in Contextual Multi-Armed Bandits

Alexandros Pasiouras, Konstantinos Bekios, Apostolos Burnetas

Department of Mathematics, National and Kapodistrian University of Athens (NKUA), Athens, Greece, apasiour@math.uoa.gr

We study a contextual Bernoulli multi-armed bandit problem with latent user contexts and Bayesian learning. We consider a finite set of users, each associated with an unknown context value drawn from a known discrete set. A finite collection of Bernoulli arms is available, and the success probability of each arm depends on the user's context through a logistic model with unknown parameters. At each decision epoch, the identity of the arriving user is observed, but the corresponding context remains unknown. The decision maker must simultaneously learn the latent user contexts, estimate the reward model, and select the arm (or arms) to play.

To address this problem, we develop a Bayesian learning framework that combines Pólya–Gamma data augmentation for efficient inference in logistic models with Thompson sampling policies for context estimation and arm selection. The resulting algorithm balances exploration and exploitation while accounting for uncertainty in both the latent contexts and the reward parameters. In contrast to standard contextual bandit models, learning must proceed simultaneously at two levels: inferring the hidden contexts of recurring users and estimating the context-dependent reward structure of the arms.

We establish convergence properties of the proposed methodology and evaluate its performance through simulation experiments. The results demonstrate its effectiveness in learning both user contexts and reward models while achieving low regret. The proposed framework provides a tractable approach to contextual bandit problems with latent heterogeneity and has potential applications in personalized recommendation systems, adaptive experimentation, and other sequential learning environments.

Dynamic Wholesale Pricing under Censored-Demand Learning

Michalis Deligiannis, Marco Scarsini, and Xavier Venel

Department of Economics and Finance, University of Luiss, Milano, Italy, mdeligiannis@luiss.it

We study a finite-horizon dynamic wholesale-price contract between a manufacturer and a retailer who both observe only sales rather than true demand. When the retailer stocks out, unmet demand is unobserved, so both parties update a common posterior over the demand distribution using sales data. In each period, the manufacturer sets the wholesale price, the retailer chooses an order quantity, and the public belief state is updated. We characterize Markov perfect equilibria as functions of this public belief. Our main results are as follows. For Weibull demand, we extend the well-known scaling approach to this strategic learning setting, prove the existence

of an equilibrium, and reduce computation to a standardized one- parameter recursion. For exponential demand, we show that the equilibrium is unique and can be computed via a simple backward recursion. Our numerical analysis reveals several distinctive features of the dynamic equilibrium. First, equilibrium wholesale prices increase strictly along feasible public-belief paths, even after censored transitions, whereas myopic wholesale prices increase only weakly. Second, at a given wholesale price, the retailer's forward-looking order can be either lower or higher than the myopic order, because the marginal continuation value of additional information can be negative. Even so, the equilibrium order remains above the myopic equilibrium order, since the manufacturer sets a lower wholesale price early in the horizon to encourage learning. Third, channel efficiency shows a strong nonlinear horizon effect: decentralization losses fall quickly as the horizon lengthens and then level off for long horizons.

On the Equivalence of Zero-Sum Games and Conic Programs

Nikolaos Dimou

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We prove the almost equivalence of the minimax theorem and the strong duality theorem for a large class of games and conic programs. The previous fundamental results of von Neumann, Dantzig, Adler and von Stengel, on the equivalence of linear programming and two-player zero-sum games with simplex-strategy sets are extended to Banach spaces, and a comprehensive framework unifying two-player zero-sum games and conic linear programs is established. Specifically, we show that for every zero-sum game with a bilinear payoff function and strategy sets that represent bases of convex cones, the minimax equality holds and its game value and Nash equilibria can be found by solving a primal-dual pair of conic programs. Conversely, the minimax theorem for the same class of games "almost always" implies strong duality of conic linear programming. In fact, we give a game-dependent characterization of strict feasibility, and show that minimax is equivalent to a generalized version of Ville's theorem of the alternative. Several well-established game classes are embedded in the introduced model, including (i) semi-infinite; (ii) semidefinite; (iii) quantum; (iv) time-dependent; and (v) polynomial games, as well as (vi) the mixed extension of any continuous game with compact strategy sets.

Next Generation Algorithms for Stochastic Optimization with Constraints

Albert Berahas, Raghu Bollapragada, Frank E. Curtis, Michael O'Neill, Daniel P. Robinson, Jiahao Shi and Baoyu Zhou

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Stochastic gradient and related methods for solving stochastic optimization problems have been studied extensively in recent years. It has been shown that such algorithms and much of their convergence and complexity guarantees extend in straightforward ways when one considers problems involving simple constraints, such as when one can perform projections onto the feasible region of the problem. However, settings with general nonlinear constraints have received less attention, and many of the approaches that have been proposed for solving such problems resort

to using penalty or (augmented) Lagrangian methods, which are often not the most effective strategies. In this work, we propose and analyze stochastic optimization algorithms for deterministically constrained problems based on the sequential quadratic optimization (commonly known as SQP) methodology. We discuss the rationale behind our proposed techniques, convergence in expectation and complexity guarantees for our algorithms, and present numerical experiments that we have performed.

When Learning Meets Constraints: Reinforcement Learning for Scalable Scheduling Optimization

Andreas Ktenidis, George Zois, Ioannis Mourtos

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Typical scheduling problems require the allocation and sequencing of operations over limited resources while satisfying precedence, capacity, machine-eligibility, and due-date constraints. As the number of jobs, machines, and operational restrictions increases, the search space grows rapidly, making large-scale and dynamic instances difficult to solve efficiently with exact methods alone. Learning-guided optimization methods are developed as a way to address this challenge, with particular emphasis on the integration of Reinforcement Learning and Constraint Programming. Classical optimization methods provide strong mathematical modeling capabilities and feasibility guarantees, while learning-based methods can exploit repeated structural patterns across problem instances to support faster decision making. Their combination leads to hybrid architectures in which learning is used for decomposition, schedule construction, warm-start generation, and search guidance. AL and mathematical optimization can therefore be viewed as complementary: Reinforcement Learning contributes adaptability, pattern recognition, and scalable guidance, while Constraint Programming contributes feasibility, constraint reasoning, and systematic solution refinement. This perspective is particularly relevant for industrial scheduling environments where high-quality decisions must be produced under limited computational time.

Semi-plenary: Applications of OR in Energy

A. Papavasileiou

Department of Electrical and Computer Engineering, National Technical University of Athens

The energy sector is one of the most fertile domains of applications of operations research, both for the purpose of optimizing operations as well as for the purpose of analyzing market interactions. In this presentation we offer an overview of applications of operations research in the sector of power system planning and electricity market design. We discuss various domains of operations research and how they are applied in different contexts in energy systems: (I) Stochastic programming and its application in long-term power system capacity expansion planning. (II) Dynamic programming and its application in hydrothermal planning. (III) Variational inequalities and their application in the analysis of market power and imperfect market designs. (IV) Integer programming and its application in unit commitment problems. (V) Chance-constrained optimization and machine learning, and their application to the dimension-

ing of reserves in power systems. (VI) KKT conditions and their application in the pricing of electricity in power market auctions. An outlook is offered on the promise of high performance computing for our sector and emerging applications. All of the applications described in this talk are based on collaborations with industry, and highlight how OR can be fruitfully applied for real problems. Our industry collaborators include the Joint Research Center (JRC) of the European Commission, the European Network of Transmission System Operators for Electricity (ENTSOE), the Agency for the Cooperation of Regulators of Energy Regulators of the European Commission (ACER), power grid operators (Svk in Sweden and ELIA in Belgium), N-SIDE and the Single Day-Ahead Coupling (SDAC).

Semi-plenary: The Theta Method (and other Time series Benchmarks)

K. Nikolopoulos

Durham University Business School

The Theta Method, originally proposed by Assimakopoulos and Nikolopoulos (2000), is widely regarded as one of the most successful univariate time series forecasting method of the past three decades. Its success was first demonstrated by topping the M3 Competition — the largest forecasting competition in the world at the time — and has since been confirmed across a broad range of applications in demand forecasting, finance, economics, and healthcare where consitently is the top benchmark. The intuitive core of the method lies in the decomposition of a time series based on its local curvature, achieved through the application of a theta coefficient (θ) to the second differences of the data. The resulting "theta lines" are extrapolated independently and then recombined to produce point forecasts for the original series. In the M4 Competition, the Theta Method again performed commendably, outperforming all standard forecasting benchmarks — including the celebrated ETS method and ARIMA variants — across all series, while also being computationally efficient - to the extent that is used form UBER. Alongside Damped Trend Exponential Smoothing, the Theta Method has emerged as one of the two key benchmarks that any new forecasting method must surpass in order to prove its worth. This talk provides a comprehensive overview of the Theta Method, from its theoretical foundations and properties (including unit root processes and multivariate extensions) to its practical implementation. The speaker will also survey the broader landscape of time series benchmarks, discuss the lessons learned from empirical forecasting competitions, and reflect on what makes a method both robust and operationally useful across diverse real-world settings, including comparisons versus AI, GenAI and HI-judgemntal offerings.

Semi-plenary: Theory and Application of Data Envelopment Analysis in the field of Regulation of Network Industries

Emmanuel Thanassoulis

Aston University Business School

Regulatory systems have developed in tandem with the privatisation of previously publicly

owned utilities such as water, electricity, gas, telecommunications etc. Privatisations are generally intended to reinforce market competition. However, competition between utilities is not perfect. Water mains, electricity grid and gas mains are long lived assets. Users are usually only connected to one network and so the provider or transmission network operator enjoys a de facto local monopoly. This creates the need for regulation to protect the consumer. The presentation will review how the Linear Programming based method of Data Envelopment Analysis (DEA) has been used in Regulatory systems for water, gas and electricity in the United Kingdom, Germany and the Netherlands. Regulators have used DEA to ascertain the scope for efficiency savings in the operations of regulated companies. That scope is then reflected in the price or revenue caps regulators impose periodically on regulated companies. The talk will also illustrate how integer linear programming in the framework of DEA can be used to create incentive mechanisms to promote efficient behaviour by regulated organisations.

On Modelling Undesirable Outputs via Inverse Transformation in Data Envelopment Analysis

M. Michali[1], Ali Emrouznejad[2], Gholam Reza Amin[3]

[1] *University of Bristol, UK* , [2] *University of Surrey, UK,* [3] *University of New Brunswick, Canada*

In many cases, the production of desirable outputs results in the joint generation of undesirable outputs, such as waste or emissions. In the Data Envelopment Analysis (DEA) literature, different methods and assumptions are used to account for undesirable outputs. A very common approach is using the inverted undesirable output as a desirable output instead of the actual undesirable output in the formulation of the constraints. In this paper, we discuss that this formulation of the production possibility set (PPS) might not reflect the true production process. An alternative formulation of the PPS is introduced, where the inverse of the convex combination of undesirable outputs is used instead. This results in a nonlinear programming (NLP) DEA model. An iterative procedure with a linear rate of convergence is suggested to solve this NLP, and its computational efficiency is demonstrated through Monte Carlo simulations. The suggested approach and the iterative algorithm are implemented to assess the efficiency of raw material flows in the EU-27, where emissions and waste are considered undesirable outputs. Under the variable returns to scale (VRS) assumption, our approach provides a more favorable efficiency assessment for DMUs.

Dimensionality Reduction for Efficiency Analysis: A Rank-Correlation-Guided Elimination Approach

Konstantinos Petridis [1], Ali Emrouznejad [2],

[1] *Department of Business Administration, Athens Univesity of Economics and Business,* [2] *Surrey Business School, University of Surrey*

Data Envelopment Analysis (DEA) is known to suffer from a curse of dimensionality: as the number of inputs and outputs grows relative to the number of decision-making units (DMUs), discriminatory power erodes and efficiency scores become inflated and unstable. This paper

introduces a rank-preserving backward elimination procedure that prunes the variable set one factor at a time, retaining at each step the configuration that best preserves the Kendall-τ ordering of DMUs relative to the full-specification model. We evaluate the method against four established baselines, correlation filtering, principal component analysis, LASSO, and gradient-boosted trees (XGBoost), over six experimental settings with sample sizes ranging from 800 to 5,000 DMUs. The proposed approach attains Pareto-dominant performance on both reconstruction error (RMSE) and rank fidelity across every configuration tested, delivering RMSE reductions of as much as 40% under high compression. The result is a more interpretable, discriminating, and robust efficiency model obtained at substantially lower dimensionality.

Operation Counts for DEA: Modeling Workload and Algorithmic Performance

G. Koronakos[1], José H. Dulá[2]

[1]*Department of Informatics, University of Piraeus, Greece* , [2]*Department of Information Systems, Statistics, and Management Science, University of Alabama, U.S.A*

This study revisits the computational analysis of Data Envelopment Analysis (DEA) by introducing a machine-independent approach that departs from traditional time-based comparisons and models workload through the adoption of Operation Counts (OC). This quantifies the computational effort of DEA algorithmic procedures by counting the number of linear programs (LPs) and tracking their size. Solving LPs is the dominant computational task in DEA, yet execution-time comparisons obscure the true optimization burden due to dependence on implementations and solvers. OC enables the formulation of best and worst case scenarios that illustrate the behaviors of the examined procedures and explains their performance.

Recent extensions and developments in DEA-Markovian models - Models for transition and cyclicity

A. Georgiou[1], Emmanuel Thanassoulis[2], Georgios Tsaples[1], Konstantinos Kaparis[1]

[1]*Quantitative Methods and Decisions Analysis Lab, Department of Business Administration, University of Macedonia, Thessaloniki, Greece,* [2]*Aston University, Aston Business School, Birmingham, UK*

The emergence of Manufacturing as a Service (MaaS) ecosystems introduces new challenges for decision-making in dynamic environments where resources, service providers, products, and demand patterns evolve over time. Understanding and guiding such evolution requires analytical frameworks capable of combining performance assessment with stochastic system dynamics. This paper presents recent extensions and developments of DEA–Markovian models that enhance their ability to support strategic decision-making in evolving socio-technical systems characterized by transition and cyclicity. The proposed framework introduces a Dual-Frontier formulation in which intervention policies and aspirational targets are simultaneously modelled and co-designed. In addition to the conventional efficiency frontier, target structures form their own convex frontier, enabling the identification of efficient policy–target combinations that satisfy

Markovian balance relations while reflecting long-term strategic objectives. This allows decision makers to distinguish between attainable and desirable development pathways and to evaluate trade-offs between intervention effort, transition speed, and target attainment. The methodology is particularly relevant for MaaS environments, where service composition, provider networks, resource allocation, remanufacturing activities, and ecosystem evolution must be coordinated under uncertainty. By integrating efficiency analysis with stochastic transition dynamics, the proposed DEA–Markovian framework supports the evaluation of alternative intervention strategies and their impact on system evolution over time. Furthermore, the framework accommodates cyclic processes that are increasingly important in circular economy settings, where products, materials, and resources repeatedly move across multiple states and value-creation stages. The resulting models provide a versatile decision-support tool for analysing transitions and cyclical behaviours in complex systems, with potential applications ranging from Manufacturing as a Service ecosystems and circular value networks to workforce planning, healthcare systems, and the transition towards electrification. The framework contributes to the growing literature on dynamic efficiency analysis and supports the broader twin-transition agenda linking digitalisation, sustainability, and system transformation.

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The Technological Foundations of Energy Efficiency in Europe: Critical Green Technologies, Endogenous Innovation Dynamics, and the Twin Transition

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Laboratory of Economics of Strategy, Innovation and Sustainability-LENS, Department of Economics, University of Patras, Greece

This study examines the role of critical green technological capabilities in shaping energy efficiency across the EU-27 and the United Kingdom over the period 2010-2022. Positioned within the broader European twin-transition agenda, the paper conceptualizes energy efficiency not merely as a function of technological adoption, but as an outcome of countries' underlying capabilities to develop and sustain critical climate-mitigation technologies. Drawing on Technological Innovation Systems (TIS) theory and the socio-technical sustainability transition literature, the study argues that strategic technological autonomy based on the development of critical green technologies constitutes a foundational mechanism through which decarbonization and energy transition pathways are conditioned.

Energy efficiency is measured using a slack-based Data Envelopment Analysis (DEA) framework under an input-oriented Variable Returns to Scale (VRS) specification, allowing for the estimation of relative efficiency performance while accounting for input excesses. The empirical framework focuses on two distinct categories of critical green technologies and explicitly models their dynamic interdependence. To account for endogenous technological co-evolution and feedback mechanisms between the two technology domains, the paper employs a recursive Conditional Mixed Process (CMP) estimation strategy. The main specification adopts a fractional probit model for energy efficiency with two predetermined endogenous regressors, jointly estimated within a system of equations that captures lagged cross-domain technological interactions.

By integrating efficiency analysis with endogenous technological capability formation, the paper contributes to the emerging debate on technological sovereignty and the uneven capacity of European economies to translate innovation capabilities into sustainability outcomes. More broadly, the study advances a dynamic perspective on the energy transition by linking technological specialization, innovation-system interactions, and energy efficiency performance within a unified empirical framework.

Acknowledgements

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Rebound effect-A Sisyphean effort or a Chimera? Evidence from transient, persistent and energy efficiency in European Industries

Eirini Stergiou[1], Nikos Rigas [2], Giancarlo Ferrara[3], Konstantinos E. Kounetas[1]

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The energy efficiency paradox refers to the phenomenon in which the adoption of energy efficient technologies is offset by behavioral and systemic responses that increase energy use and diminish energy savings. The European manufacturing industries are in need of re- ducing their energy consumption and adapting to structural reforms. This study employs a stochastic frontier energy demand framework to 11 manufacturing industries from 27 European countries over the period 1995 to 2022, examining substitution elasticities among key production inputs and distinguishing between transient and persis- tent inefficiencies. In addition, the rebound effect of energy efficiency improvements is evaluated in order to capture if the expected en- ergy savings are offset by increased production or energy use. Our results in efficiency analysis indicate that improvements in industrial energy performance require long-term structural reforms and targeted investments in technological advancement, rather than short-lived pol- icy interventions. Furthermore, analysis of the rebound effect reveals that energy efficiency gains do not fully translate into proportional reductions in energy consumption, as there are partial rebound ef- fects. Finally, complementarity and substitutability analysis reveals 1 that energy–labor substitutability is prevalent in most industries, ex- cept the Mining and Chemical industries. In conclusion, Europe’s pathway to energy efficiency, industrial decarbonization and climate neutrality requires a dual approach: addressing long-term structural inefficiencies through sustained capital renewal and regulatory reform, while simultaneously mitigating short-term rebound effects through complementary fiscal and regulatory instruments.

A Kernel Bayesian Data Envelopment Analysis Approach for Bias Correction of Efficiencies

Constantinos Zacharias[1], Panagiotis Zervopoulos [2]

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This study introduces a kernel Bayesian approach to correct the bias of data envelopment analysis (DEA) efficiency estimates. This approach yields consistent estimates for convex sets. The prior distribution of this Bayesian method is “non- informative” in a relative sense as no distributional assumptions are made, like in theoretical Bayesian approaches, and the parameters of DEA efficiency distributions are not used to obtain bias-corrected estimates, as in alternative computational or hybrid Bayesian techniques for statistical inference to efficiencies. Specifically, various kernel distributions, such as Epanechnikov, Biweight, Triweight, and Gaussian, are tested for the prior distribution. In addition, we deploy least cross validation (LCV), rule of thumb (RoT), and least-squares cross validation (LSCV) as bandwidth selection methodologies for every kernel distribution function. Bias correction draws on the ratio of a posterior truncated normal distribution, with μ and σ the respective kernel values, and the above prior kernel distributions with LCV, RoT, and LSCV as bandwidth selection mechanisms. Using scaled samples of 30, 50, 80, and 100 units, the mean square error (MSE) and mean absolute error (MAE) of this Bayesian approach's estimates are as low as 6.45 × 10–3 and 6.4 × 10–2, respectively. Based on real-world data, we show that the new Bayesian method performs better than extant computational bias-correction techniques for DEA efficiencies. At the same time, the MSE and MAE decrease gradually as the sample size increases.

Theoretical Computer Science

Organizers

Achlioptas D. (National and Kapodistrian University of Athens)

Pagourtzis A. (National Technical University of Athens)

Raptopoulos Chr. (University of Patras)

PROGRAM

THEORETICAL COMPUTER SCIENCE SESSIONS

	Monday June 29	**Tuesday June 30**	**Wednesday July 1**	**Thursday July 2**	**Friday July 3**
	NKUA, Γ22	**NTUA, ΣΗΜΜΥ, Amf. 4**	**NKUA, Γ22**	**NTUA, ΣΗΜΜΥ, Amf. 4**	**NKUA, Γ22**
12:30-13:10		C. Caramanis		P. Mertikopoulos	A. Kiayias
13:10-13:30		T. Lianeas		G. Mitropoulos	D. Balla
13:40-14:00		E-V. Vlatakis-Gkaragkounis		C. Fragkoudi	V. Zikas
14:00-16:00	**Break**	**Break**	**Break**	**Break**	**Break**
16:00-16:40	L. Kirousis	M. Kyropoulou	E. Terzi	A. Sgouritsa	E. Markakis
16:40-17:00	A. Chalki	C. Santorinaios	A. Kalavasis	V. Kouni	G. Papasotiropoulos
17:00-17:40	E. Kranakis	S. Kontogiannis	D. Fotakis	I. Panageas	17:00-17:20 T. Tolias 17:20-17:40 E. Anastasiadi
17:40-18:00	**Coffee break**	**Coffee break**	**Coffee break**	**Coffee break**	**Coffee break**
18:00-18:40		L. Georgiadis	C. Zaroliagis	C. Efthymiou	G. Christodoulou
18:40-19:00		S. Kanellopoulos	V. Pollatos	K. Zampetakis	A. Hellander
19:00-19:40		C. Pergaminelis	A. Mouzakis		K. Tsakalidis

PSPACE hardness of the reachability problem for register machines

Elli Anastasiadi

Aalborg University

Register machines are finite automata equipped with a finite set of memory in the form of registers which can be written on, outputted, and copied between eachother. They cannot however be tested for values, meaning that all operations (and therefore runs) of the machine are completely data independent. In this type of machine a reachability question concerns a starting configuration given as a pair of a machine state and an array of register values, and a target configuration of the same form. In this talk I will present a new reduction from the n-DFA intersection problem showing that this problem is PSPACE hard, despite its very regular form.

Revisiting Linkable Ring Signatures with Logarithmic Verification Complexity

Danai Balla

National Technical University of Athens & Archimedes, Athena RC

Ring Signatures allow a user to sign on behalf of an ad-hoc set of public keys, while hiding their identity inside that set. Linkable Ring Signatures (LRS) add the functionality of detecting signatures originating from the same signer. They have found many applications in anonymous transactions and e-voting.

The LLRing family of linkable ring signature schemes by Hui and Chau (ESORICS 2024) is one of the more efficient LRS schemes. However, we show that it has an unlinkability vulnerability, meaning an adversary can create more unlinkable signatures than the number of secret keys they own. The vulnerability is caused by the introduction of unwanted structure to base elements used in proofs. We also find a similar attack against the Threshold Ring Referral (TRR) scheme of Ta, Hui, and Chau (Security and Privacy 2025), rendering it unsound.

We show how to achieve strong linkability with logarithmic verification complexity in the pairing based setting by first reverting the unsafe construction of base elements, and by also adjusting the arguments of knowledge used in order to maintain efficiency. Concretely, by modifying the Dory argument to fit our scheme we are able to match the performance of LLRing-P. We separate the design and analysis of the scheme from the instantiation of the knowledge arguments, which helps prevent unwanted interactions between the two, and can provide easier upgrades to more efficient proof systems.

link: `https://eprint.iacr.org/2025/1375`

Linear Regression with Unknown Truncation

Constantine Caramanis

The University of Texas at Austin

In truncated linear regression, samples (x, y) are shown only when the outcome y falls inside a certain survival set S. Ignoring this truncation can completely destroy the quality of the solution. Much recent work has focused on the setting where this survival set is precisely known a priori. Learning S from data is a challenge related to the classical problem of positive-only PAC learning. In this talk we will outline our recent results showing that assuming the features follow a subgaussian distribution, the problem can be solved efficiently. These results are joint work with Alexandros Kouridakis, Anay Mehrotra and Alkis Kalavasis.

The complexity of deciding characteristic formulas

Aggeliki Chalki

Reykjavík University

Formal verification is the process of mathematically checking that the behavior of a system satisfies a given property. Two widely used techniques in formal verification are equivalence checking and model checking. In these approaches, the system is represented as a formal model, while the property to be verified is expressed either as another formal model or as a logical formula, respectively. In this context, characteristic formulas give a complete logical description of the behaviour of models: a characteristic formula for a model can be seen as its 'fingerprint'. These formulas are exactly the ones that allow the reduction of equivalence checking and model checking to each other.

In this talk, we will introduce characteristic formulas and discuss the complexity of determining whether a formula is characteristic for a model.

Fair and Truthful Allocations on Graphs

Giorgos Christodoulou

Aristotle University of Thessaloniki & Archimedes, Athena RC

We will discuss allocation problems where a set of indivisible goods need to be allocated to a set of agents. We will discuss "fair" allocations using various notions of fairness. We study settings where valuations can be represented via a graph of arbitrary size where vertices correspond to agents and edges to items. An item (edge) has zero marginal value to all agents (vertices) not incident to the edge. We will also focus on truthful mechanisms, where the goal is also to provide incentives to participants to report truthfully their valuations.

On sampling two spin models using the local connective constant

Charilaos Efthymiou

The University of Warwick

This work establishes novel optimum mixing bounds for the Glauber dynamics on the Hard-core and Ising models. These bounds are expressed in terms of the local connective constant of the underlying graph G. This is a notion of effective degree for G. Our results have some interesting consequences for bounded degree graphs:

(a) They include the max-degree bounds as a special case.

(b) They improve on the running time of the FPTAS considered in [Sinclair, Srivastava, Štefankonič and Yin: PTRF 2017] for general graphs.

(c) They allow us to obtain mixing bounds in terms of the spectral radius of the adjacency matrix and improve on [Hayes: FOCS 2006].

We obtain our results using tools from the theory of high-dimensional expanders and, in particular, the Spectral Independence method [Anari, Liu, Oveis-Gharan: FOCS 2020]. We explore a new direction by utilising the notion of the k-non-backtracking matrix $H_{G,k}$ in our analysis with the Spectral Independence. The results with $H_{G,k}$ are interesting in their own right.

Online Resource Allocation via Static Bundle Pricing

Dimitris Fotakis

National Technical University of Athens & Archimedes, Athena RC

In algorithmic mechanism design, we aim to allocate resources (or goods) to self-interested agents in a way that guarantees dominant-strategy incentive compatibility (a.k.a. truthfulness), social efficiency (at least approximately) and computational efficiency. We focus on posted-price mechanisms, where the agents arrive online and are offered take-it-or-leave-it prices either for individual resources or for bundles of resources. We will start with a brief introduction to the prophet inequality, its extensions and its applications to posted-price mechanisms in the Bayesian setting, where the agent valuations are drawn as independent samples from known distributions. Next, we will present a unified bundle pricing framework for single-minded combinatorial auctions and network routing. We will analyze the competitive ratio of our mechanisms in the Bayesian setting and present information theoretic lower bounds on the best possible competitive ratio of any online algorithm for single-minded combinatorial auctions.

Compression for learning

Christina Fragouli

UCLA

Compression is a classical, very well researched topic, dating back to Shannons famous source coding theorem and before. In this talk, I will argue that there still exist interesting and novel research directions in exploring compression, and sometimes these explorations may lead to results of independent interest, especially as we consider applications in distributing learning or generally learning under resource constraints. In particular, I will present two results on compression for learning, one related to Multi-Armed Bandits (MABs), and the other to Large Language Models (LLMs). The first result establishes a reduction that converts every stochastic contextual linear bandit instance to a linear bandit instance, implying that in distributed settings we do not need to convey the context at all (0 bits compression); while the second result presents a novel framework that leverages outlier statistics to design an efficient index coding scheme for outlier-aware weight-only quantization in LLMs that outperforms the state of the art solutions at the very low bits regime (< 4 bits per weight).

Computing k-Connected Components in Static and Dynamic Graphs

Loukas Georgiadis

University of Ioannina

Computing k-edge- and k-vertex-connected components is a fundamental problem in graph algorithms, with applications in network reliability, fault tolerance, and structural graph analysis. In this talk, we will survey recent advances on the computation of k-connected components in directed graphs. We will consider several algorithmic settings, including static graphs, dynamic graphs, and sensitivity models, highlighting both the main techniques and the challenges that arise in each case. We will conclude by discussing key open problems and promising directions for future research.

Fisher Markets with Approximately Optimal Bundles and the Need for a PCP Theorem for PPAD

Alexandros Hollender

University of Oxford

We study the problem of computing a competitive equilibrium with approximately optimal bundles in Fisher markets with separable piecewise-linear concave (SPLC) utility functions, meaning that every buyer receives a $(1 - \delta)$-optimal bundle, instead of a perfectly optimal one. We establish the first intractability result for the problem by showing that it is PPAD-hard for some constant $\delta > 0$, assuming the PCP-for-PPAD conjecture. This hardness result holds even if all buyers have identical budgets (competitive equilibrium with equal incomes), linear capped utilities, and even if we also allow ε-approximate clearing instead of perfect clearing, for any

constant $\varepsilon < 1/9$. Importantly, we show that the PCP-for-PPAD conjecture is in fact required to show hardness for constant δ: showing PPAD-hardness for finding such approximate market equilibria in a broad class of markets encompassing those generated by our hardness result would prove the conjecture. This is the first natural problem where the conjecture is provably required to establish hardness for it.

Based on joint work with Argyrios Deligkas, John Fearnley, and Themistoklis Melissourgos.

https://arxiv.org/abs/2604.27276

Learning Mixture Models beyond Moment-Based Methods

Alkis Kalavasis

Yale University

We give a poly(d, k) time and sample algorithm for efficiently learning the parameters (i.e., the means and the mixture weights) of a mixture of k spherical distributions in d dimensions. Our method succeeds whenever the component distributions have a characteristic function with sufficiently heavy tails. Unlike all previous methods, our techniques apply to heavy-tailed distributions and include examples that do not even have finite covariances.

Even for the special case of Laplace distributions, we prove that any moment-based algorithm must necessarily use a super-polynomial number of samples (while our algorithm achieves polynomial time complexity). Our algorithm is based on a new approach to learning mixture models via efficient high-dimensional noisy sparse Fourier transforms and adds to a short list of techniques that circumvent the limitations of the method of moments.

Finite Pinwheel Scheduling: the k-Visits Problem

Sotiris Kanellopoulos

National Technical University of Athens & Archimedes, Athena RC

Pinwheel Scheduling is a fundamental scheduling problem, in which each task i is associated with a positive integer d_i, and the objective is to schedule one task per time slot, ensuring each task perpetually appears at least once in every d_i time slots. Although conjectured to be PSPACE-complete, it remains open whether Pinwheel Scheduling is NP-hard (unless a compact input encoding is used) or even contained in NP.

We introduce k-Visits, a finite version of Pinwheel Scheduling, where given n deadlines, the goal is to schedule each task exactly k times. While the 1-Visit problem is trivial, we prove that 2-Visits is strongly NP-complete. We further extend our strong NP-hardness result to a generalization of k-Visits ($k \geq 2$) in which the deadline of each task may vary throughout the schedule, as well as to a similar generalization of Pinwheel Scheduling.

Additionally, we prove that 2-Visits can be solved in linear time if all deadlines are distinct, rendering it one of the rare natural problems which exhibit the interesting dichotomy of being in P if their input is a set and NP-complete if the input is a multiset. We also show an FPT

algorithm for 2-Visits parameterized by a value related to how close the input deadlines are to each other, as well as a linear-time algorithm for instances with up to two distinct deadlines.

The Mathematics of Large Scale Consensus

Aggelos Kiayias

University of Edinburgh & IOG

The design and analysis of consensus protocols occupy a special place in theoretical computer science. It is a deceptively simple problem, with myriad variations and solution attempts that have spanned decades of arduous work. The recent development and deployment of large-scale permissionless consensus protocols has brought to the forefront a number of mathematical techniques and perspectives that have no precedent in prior analytical methods. These include random walks, martingales, and fine-grained computational complexity. In this talk, we will review these developments, highlight recent results, and point to future research directions.

The Lovász Local Lemma and acyclic graph colorings

Lefteris Kirousis

National and Kapodistrian University of Athens

The Lovász Local Lemma (LLL) is a powerful tool in Combinatorics, used, among other things, to show the existence of combinatorial objects with given desired properties. It was first published in 1975 (with Erdős). The original proof was simple, but non-constructive. In this lecture, I will sketch the basic ideas behind a variation of the first algorithmic proof, given much later (in 2008 and 2009) by A. Moser and G. Tardos. Naturally, the algorithmic proof leads to constructive proofs of existence. I will also discuss an application of LLL to coloring graphs in a way that avoids bichromatic cycles. The lecture will be given in Greek.

Recent Advancements on LP-based Approaches to Approximate Bimatrix Nash

Spyros Kontogiannis

University of Patras

The polynomial-time construction of approximate Nash Equilibrium (NE) points in bimatrix games is a fundamental problem in algorithmic game theory, with deep connections to the complexity class TFNP. Almost all the proposed algorithms in the literature, from the very first lines of attack back in 2006 to the most recent breakthrough achievements, have actually exploited the power of linear programming tractability, with a continuously increasing level of sophistication in the verification of the approximation guarantees.

In this work we review some of the most characteristic LP-based algorithms for approximating NE points in bimatrix games. We also discuss the challenge of constructing really hard instances for these algorithms, and of pushing the observed worst-case approximations to their theoretical bounds. Consequently, we review a recent unifying approach, which decomposes all these algorithms in two distinct phases: the search phase which attempts to provide promising candidate strategies for the players, mainly based on human innovation; and the mixing phase that tries to create a profile, from this space of candidate strategies per player, that minimizes the resulting regrets. Interestingly, the mixing phase can be interpreted as a univariate constraint optimization problem. Moreover, the resulting profile (the "optimal mix") from this automated mixing process comes with a provable approximation guarantee for the entire algorithm's performance. This quite powerful feature of the mixing phase has triggered a novel algorithmic framework that exploits the power of large language models (LLMs) to explore (essentially LP-based) candidate search-phase algorithms at scale, based on the worst-case approximation guarantees provided by the automated mixing phase for them. This framework has managed to reproduce the humanly-proven approximation bounds of all the LP-based approximation algorithms in the literature, within seconds and without any human intervention.

The shades of adversarial robustness: from unfolding networks to frame-based attacks

Vicky Kouni

Paris Dauphine - PSL University

We study adversarial robustness, i.e., resilience of neural networks to small input perturbations, in the context of unfolding and frame theory. In the first part of the talk, we examine unfolding networks, which emerge from reformulating outputs of iterative algorithms as neural networks outputs, to solve inverse problems. As such, unfolding networks are applied in critical domains, e.g., medical imaging, where robustness is crucial to prevent catastrophic failures. We provide the first adversarial generalization error bounds for unfolding networks, perturbed during training and test times, highlighting how the network architecture ripples out to its generalization ability. Our experimental results conform with our derived theory and showcase the beneficial role of overparameterization to the network robustness. In the second part of the talk, we introduce a methodology for creating structured adversarial attacks, that highly hurt robustness, even of adversarially trained networks. Our approach hinges upon tools from frame theory – in particular, overcomplete spatial-frequency transforms, which are popular tools for image processing tasks. By representing the attacks with respect to these transforms, we improve their effectiveness, even across unseen, target models. We assess the quality of our method on standardized datasets and models, with results showcasing that our proposed attack outperforms the examined baselines and exposes vulnerabilities even of defended models, while highly preserving visual structure.

Impact of Communication in Search with Autonomous Mobile Agents

Evangelos Kranakis

Carleton University

We address a fundamental question in distributed computing: How does communication between autonomous mobile agents affect the competitive ratio when searching for a target in a given search domain? The trajectories of the searchers are within a continuous "linear" search domain (e.g., infinite real line, perimeter of a disc, or generalizations thereof). Proposed algorithms take into account the impact of the knowledge the searchers (modelled as autonomous mobile agents) have as well as their behaviour in order to obtain an optimal competitive ratio. The approach emphasizes agent co-operation and distributed algorithm design principles. We give a survey of recent results and propose open problems.

Optimal Interventions and Strategic Debt Operations in Financial Networks

Maria Kyropoulou

University of Essex

A financial system can be represented as a network, where nodes correspond to banks and directed labelled edges correspond to debt contracts between banks. The structure of these interconnections captures complex financial dependencies, where local changes may significantly affect the financial well-being and stability of the entire system. We study central interventions and strategic debt operations in financial networks, focusing on mechanisms such as allocating bailout funds to selected banks, forgiving debt obligations to help institutions avoid costs related to default, and performing debt transfer operations that allow banks to transfer debt claims to their lenders.

We consider bailouts, debt forgiveness, and debt transfers in both centralized and distributed (game-theoretic) settings. First, from a centralized optimization perspective, we investigate the computational complexity of finding optimal intervention policies, and study approximation guarantees of natural heuristic approaches such as greedy bailout policies. We also examine financial networks from a game-theoretic standpoint, focusing on settings where banks can strategically forgive or transfer debt claims. We formally define the resulting games and prove theoretical and empirical results concerning the existence and quality of pure Nash equilibria, as well as the computational complexity of relevant problems.

Facility Location for Congesting Commuters and Generalizing the Cost-Distance Problem

Thanasis Lianeas

University of West Attica

In Facility Location problems there are agents that should be connected to facilities and locations where facilities may be opened so that agents can connect to them. We depart from Uncapacitated Facility Location and by assuming that the connection costs of agents to facilities are congestion dependent, we define a novel problem, namely, Facility Location for Congesting (Selfish) Commuters. The connection costs of agents to facilities come as a result of how the agents commute to reach the facilities in an underlying network with cost functions on the edges. Inapproximability results follow from the related literature and thus approximate solutions is all we can hope for. For when the cost functions are nondecreasing we employ in a novel way an approximate version of Caratheodory's Theorem to show how approximate solutions for different versions of the problem can be derived. For when the cost functions are nonincreasing we show how this problem generalizes the Cost-Distance problem and provide an algorithm that for this more general case achieves the same approximation guarantees.

Algorithms for Constrained Fair Division Problems

Evangelos Markakis

Athens University of Economics and Business & Archimedes, Athena RC

In this talk, we will provide an overview of recent research on fair division of indivisible resources in the presence of constraints. In contrast to the classic fair division setting, we will discuss two variations of the problem where constraints are imposed on the set of feasible allocations. The first one has to do with cardinality constraints on the bundle size assigned to each agent, motivated by assigning shifts or forming equally sized teams. The second one concerns incompatibilities among items and is modeled by a conflict graph, with the meaning that any two items connected by an edge in the graph cannot be given to the same agent. For both of these models we will discuss the existence and computation of allocations that satisfy fairness criteria such as EF1 and EFX (and their appropriate adaptations in these settings).

The long-run behavior of stochastic gradient descent in non-convex landscapes

Panayotis Mertikopoulos

National and Kapodistrian University of Athens & Archimedes, Athena RC

Even though stochastic gradient descent (SGD) was introduced more than 75 years ago, it remains the method of choice for training modern machine learning models and deep learning architectures. Still, despite the method's phenomenal success, we know surprisingly little about its long-run behavior—for example, which minimizers are more likely to be observed in the long run, or how long until it reaches a global minimum (if at all).

In this talk, I will outline an approach to study the long-run behavior of SGD based on the theory of large deviations and randomly perturbed dynamical systems. Using this approach, we show that the limiting distribution of SGD follows the Boltzmann-Gibbs law of equilibrium thermodynamics with temperature equal to the method's step-size and energy levels determined by the problem's objective and the statistics of the noise. In particular, we show that, in the long run, (a) the iterates of SGD spend an exponentially small amount of time away from the problem's critical region; (b) any given critical point (or manifold thereof) is visited with probability that is exponentially proportional to its energy; (c) minimizers are visited exponentially more often than non-minimizers; and (d) SGD becomes exponentially concentrated around the problem's "ground state" (which does not always coincide with the minimum of the objective). If there is time, I will also describe a tight characterization of the global convergence time of SGD via matching upper and lower bounds which quantify the most "costly" set of obstacles that SGD may need to overcome to reach a global minimizer from a given initialization.

Approximation schemes for selecting closest sum subsets

Giorgos Mitropoulos

LIP6, Sorbonne Université

The Subset Sum Ratio problem (SSR) asks, given a multiset A of positive integers, to find two disjoint subsets of A such that the largest-to-smallest ratio of their sums is minimized. In this work, we study the k-version of SSR, namely k-Subset Sum Ratio (k-SSR), which asks to minimize the largest-to-smallest ratio of sums of k disjoint subsets of A. We develop an approximation scheme for k-SSR running in $O(n^{2k}/\varepsilon^{k-1})$ time, where $n = |A|$ and ε is the error parameter. To the best of our knowledge, this is the first FPTAS for k-SSR for fixed $k > 2$.

We also study the k-way Number Partitioning Ratio (k-PART) problem, which differs from k-SSR in that the k subsets must constitute a partition of A; this problem in fact corresponds to the objective of minimizing the largest-to-smallest sum ratio in the family of Multiway Number Partitioning problems. We present a more involved FPTAS for k-PART, also achieving $O(n^{2k}/\varepsilon^{k-1})$ time complexity. Notably, k-PART is also equivalent to the Minimum Envy-Ratio problem with identical valuation functions, which has been studied in the context of fair division of indivisible goods. Thus, for the case of identical valuations, our FPTAS represents a significant improvement over the $O(n^{4k^2+1}/\varepsilon^{2k^2})$ bound obtained by Nguyen and Rothe's FPTAS [Trung Thanh Nguyen and Jörg Rothe, 2014] for Minimum Envy-Ratio with general additive valuations.

Lastly, we propose a second FPTAS for k-SSR, which employs carefully designed calls to the first one; the new scheme has a time complexity of $\tilde{O}(n/\varepsilon^{3k-1})$, thus being much faster when $n \gg 1/\varepsilon$.

Robust Statistical Estimators with Bounded Empirical Sensitivity

Argyris Mouzakis

University of Waterloo and UT-Austin

We introduce a new measure of robustness for statistical estimators, which we call *empirical sensitivity*. An estimator $\hat{\theta}$ has bounded empirical sensitivity if, with high probability over a dataset $X = (X_1, \ldots, X_n) \sim \mathcal{D}^{\otimes n}$, for any dataset Y obtained by modifying at most ηn points in X, we have that $\hat{\theta}(Y)$ is close to $\hat{\theta}(X)$.

We study bounds on this quantity for the prototypical problem of Gaussian mean estimation. We prove new lower bounds, showing that for any estimator $\hat{\mu}$ which achieves an optimal ℓ_2-error bound of $O(\sqrt{d/n})$, the empirical sensitivity is at least $\Omega(\eta + \sqrt{\eta d/n})$. The two terms arise due to obstructions on the mean and variance (via an Efron-Stein argument) of such an estimator. We show that this bound is tight up to logarithmic factors, by employing recent results for robust empirical mean estimation.

The Computational Landscape of Avoiding Saddle Points: From Dynamics to Complexity

Ioannis Panageas

University of California, Irvine

The escape from undesirable strict saddle points has been a central challenge in non-convex optimization for over a decade, particularly within the context of training modern machine learning models. While earlier research focused on establishing that first-order methods almost always avoid such points (mainly in unconstrained settings), the exact computational complexity of finding second-order stationary points (SOSPs) has remained a nuanced problem. This talk bridges the gap between the dynamics of local search and the formal complexity classes of TFNP. We present recent results showing that finding an ε-SOSP over polytope constraints is PLS-complete. This result is surprising, as it holds even for remarkably simple domains, such as the 2-dimensional unit square $[0, 1]^2$. Crucially, we establish a fundamental barrier: unless PLS $\subseteq$ PPAD, there can be no deterministic, iterative algorithm with a computationally efficient, continuous update rule for finding approximate SOSPs in constrained settings. This stands in stark contrast to finding first-order KKT points, a task known to be CLS-complete and one where Gradient Descent is guaranteed to succeed. We will discuss the implications of this "discreteness" in the complexity of second-order optimization and what it means for the future of continuous local search algorithms.

Participatory Budgeting Rules: The Bad, the Good, and the Better

Georgios Papasotiropoulos

University of Warsaw

Participatory Budgeting is the democratic process where citizens are empowered to decide, through voting, which projects their municipality should fund within a given budget. Hundreds of cities run such processes annually, almost all using simple greedy methods—an approach that can lead to highly unfair outcomes. The Method of Equal Shares (MES) is a recent breakthrough in the Computational Social Choice literature that manages to ensure fair treatment of voters and has already been applied in real-world cases. After identifying certain drawbacks of MES, we propose the Method of Equal Shares with Bounded Overspending (BOS), a robust variant that addresses these issues and achieves a better balance between proportionality and efficiency.

Based on the paper "Method of Equal Shares with Bounded Overspending" (EC'25), Papasotiropoulos, G., Pishbin, S. Z., Skibski, O., Skowron, P., Wąs, T.

Hardness, Tractability and Density Thresholds of finite Pinwheel Scheduling Variants

Christos Pergaminelis

National Technical University of Athens & Archimedes, Athena RC

The k-Visits problem is a finite version of Pinwheel Scheduling. Given n tasks with deadlines, the goal is to find a schedule of length kn in which every task is executed exactly k times and no deadline is missed between two executions of the same task.

We present new results on the complexity of this problem. We prove that 2-Visits remains strongly NP-complete even when every deadline appears at most twice, resolving an open question. We also show that 2-Visits is in RP when the number of distinct deadlines is constant.

Finally, we study density thresholds for k-Visits: for 2-Visits we prove a lower bound of 0.9142, while for large k the threshold approaches 5/6, matching the known threshold behavior of Pinwheel Scheduling. This work will be presented at ICALP 2026.

The Computational Complexity of Avoiding Strict Saddle Points in Constrained Optimization

Vasilis Pollatos

National and Kapodistrian University of Athens & Archimedes, Athena RC

While first-order stationary points (FOSPs) are the traditional targets of non-convex optimization, they often correspond to undesirable strict saddle points. To circumvent this limitation, recent attention has shifted towards finding second-order stationary points (SOSPs). In the unconstrained setting, as it has recently been established by Kontogiannis et al. (ICML 2024), the problem of finding approximate SOSPs is PLS-complete. Notably, this problem is as hard as finding approximate unconstrained FOSPs with the latter also been recently showed to be PLS-complete by Hollender and Zampetakis (COLT 2023, Math. Program. 2025). That said, the complexity of finding SOSPs in constrained settings has remained notoriously unclear and has been highlighted as an important open question by both the works of Hollender and Zampetakis and Kontogiannis et al. In particular, under one strict definition of constrained second-order stationarity, even verifying whether a point is an approximate SOSP is NP-hard as shown by Murty and Kabadi (Math. Program. 1987). Under another widely adopted, relaxed definition where non-negative curvature is required only along the null space of the active constraints—the problem lies in TFNP, and algorithms with $O(\text{poly}(1/\epsilon))$ running times have been proposed by Lu et al. (NeurIPS 2020).

In this paper, we settle the complexity of constrained SOSP by proving that computing an ϵ-approximate SOSP under the tractable definition is PLS-complete. We demonstrate that our hardness result continues to hold in domains as simple as the 2-dimensional unit square $[0,1]^2$, and remarkably, even when promised that all stationary points are isolated at a distance of $\Omega(1)$ away from the domain's boundary. Our result establishes a fundamental barrier: unless PLS $\subseteq$ PPAD (which in turn would imply that PLS = CLS), no deterministic, iterative algorithm with a computational efficient, continuous update rule can exist for finding approximate SOSPs. This comes in stark contrast to the complexity of its constrained first-order counterpart, for which the celebrated work of Fearnley, Goldberg, Hollender and Savani (STOC 2021, JACM 2022) showed that finding an approximate KKT point drops to CLS-complete. Furthermore, to the best of our knowledge, our result yields the first problem defined in a compact domain to be shown PLS-complete—beyond the canonical PLS-complete problem Real-LocalOpt (Daskalakis and Papadimitriou, SODA 2011).

Efficient Computation and Best-Response Dynamics in Anonymous Two-Action Games with Linear Utilities

Christodoulos Santorinaios

Athens University of Economics and Business & Archimedes, Athena RC

The computational complexity of anonymous games has been a central theme in algorithmic game theory, with foundational contributions by Daskalakis and Papadimitriou [2015], Goldberg and Turchetta [2017], and Cheng et al. [2017] establishing that the landscape of equilibrium computation admits a PTAS. In this paper, we investigate the class of n-player anonymous games with linear utilities and two actions. While finding an equilibrium in anonymous games is PPAD-hard for arbitrary utility functions—even with a constant number of actions [Chen et al., 2015]—we show that this linear structure allows for significant algorithmic improvements. Exploiting the fact that payoffs depend solely on the first moment of the players' strategy distribution, we provide the first algorithm for computing exact Nash equilibria that runs in time polynomial in the number of players n. We achieve this by establishing a novel combinatorial characterization of the Nash equilibria. Finally, we establish a novel connection between Nash equilibria in these games and non-convex non-concave min-max optimization. Despite the technical challenges posed by this structural property, we design a sequential best-response dynamic that provably converges to an ε-Nash equilibrium in $O(1/\varepsilon)$ steps.

Fair allocations of indivisible goods on graphs

Alkmini Sgouritsa

Athens University of Economics and Business & Archimedes, Athena RC

We investigate the problem of "fairly" allocating indivisible goods among agents, specifically focusing on the notion of envy-freeness. However, in the case of indivisible goods, eliminating envy completely is impossible: consider the scenario of a single valuable good; whoever gets it is envied by the others. Thus, we turn our attention to relaxations of envy-freeness, with the most prominent and well-studied being the envy-freeness up to any good (EFX). We study EFX existence in a structured setting where agent valuations are represented by an arbitrary graph: vertices denote agents and edges denote goods. A good (edge) provides zero marginal value to any agent (vertex) not incident to it.

We first demonstrate that if allocations are restricted to edge orientations, EFX existence is not guaranteed even in simple graphs. On the positive side, we prove that EFX allocations always exist in simple graphs when this restriction is lifted. We further extend our existence results to multigraphs and specific classes of multi-hypergraphs.

Online Combinatorial Optimization via OCO

Evimaria Terzi

Boston University

Submodular maximization is a true workhorse of data science. Numerous applications spanning important scientific and industrial domains can be cast as submodular maximization problems. These include recommender systems, caching and paging problems, summarization and exemplar clustering, team formation, and influence maximization, to name a few. In such problems, one seeks to optimize a combinatorial selection: examples include, e.g., a set of items to recommend to an online user, content stored in a network cache to serve incoming demand, a team to put together to complete a future task, etc.

In real-life applications, this prior knowledge may not be readily available when a selection is made. This has motivated the study of Online Submodular Maximization (OSM). In this setting, submodular reward functions are revealed over several rounds: in each round, a decision maker first commits to a set; subsequently, a reward function is revealed and evaluated over this set. OSM lifts all distributional assumptions, allowing for an arbitrary sequence of rewards, without having access to (or even assuming the existence of) a prior distribution.

In this talk, we will give examples, where we can significantly simplify algorithms for OSM by using the arsenal of techniques developed in Online Convex Optimization (OCO). We will also discuss variants of the original OSM problem that can be solved using such techniques. Finally, we will identify the advantages and the limitations of this framework and directions for future work.

A Polylogarithmic Competitive Algorithm for Stochastic Online Sorting

Thanos Tolias

National Technical University of Athens & Archimedes, Athena RC

In *Online Sorting*, an array of n initially empty cells is given. At each time step t, an element $x_t \in [0,1]$ arrives and must be irrevocably placed in an empty cell without knowledge of future arrivals. We aim to minimize the sum of absolute differences between pairs of elements placed in consecutive array cells, seeking an online placement strategy that results in a final array close to a sorted one. An interesting multidimensional generalization, referred to as the *Online Traveling Salesperson Problem*, arises when the request sequence consists of points in the d-dimensional unit cube and the objective is to minimize the sum of Euclidean distances between points in consecutive cells. Motivated by the recent work of (Abrahamsen, Bercea, Beretta, Klausen and Kozma; ESA 2024), we consider the *stochastic version* of Online Sorting (*resp.* Online TSP), where each element (*resp.* point) x_t is an i.i.d. sample from the uniform distribution on $[0,1]$ (*resp.* $[0,1]^d$). By carefully decomposing the request sequence into a hierarchy of balls-into-bins instances, where the balls to bins ratio is large enough so that bin occupancy is sharply concentrated around its mean and small enough so that we can efficiently deal with the elements placed in the same bin, we obtain an online algorithm that approximates the optimal cost within a factor of $O(\log^2 n)$ with high probability. Our result comprises an exponential improvement over the previously best known competitive ratio of $\tilde{O}(n^{1/4})$ for Stochastic Online Sorting due to (Abrahamsen et al.; ESA 2024) and $O(\sqrt{n})$ for (adversarial) Online TSP due to (Bertram, ESA 2025).

Computational Geometry: Algorithms & Data Structures

Konstantinos Tsakalidis

University of Liverpool

We visit the state-of-the-art in static and dynamic data structures and algorithms for geometric range searching and point location, highlighting open algorithmic problems and directions for practical implementations with applications in machine learning and artificial intelligence.

Central Limit Theorem meets John Nash

Emmanouil Vasileios Vlatakis Gkaragkounis

UW Madison

Modern learning and artificial intelligence systems increasingly operate in environments where many agents interact strategically, such as in networks, markets, and autonomous decision-making systems. In such settings, it is no longer enough to know that an algorithm "converges" to an equilibrium; it is equally important to understand how reliable and stable this behavior is

in the presence of noise and uncertainty.

In this talk, we will present recent results on the stochastic dynamics of Follow-the-Regularized-Leader (FTRL) learning algorithms, which are a fundamental tool in the theory of online learning and in multi-agent systems. When these algorithms operate with a constant learning rate, the random fluctuations do not vanish but instead persist over the long run around the equilibria of the game.

We will explain how tools from probability theory, geometry, and dynamical systems make it possible to describe these fluctuations quantitatively, by means of central limit theorems and Gaussian approximation results. These results pave the way for statistical inference and uncertainty quantification in modern multi-agent learning systems.

Revisiting the k-SAT uniqueness threshold

Kostas Zampetakis

TU Dortmund

We prove that for any $k > 2$, for clause/variable ratios up to the Gibbs uniqueness threshold of the corresponding Galton-Watson tree, the number of satisfying assignments of random k-SAT formulas is given by the so-called “replica symmetric solution” predicted by physics methods [Monasson, Zecchina: Phys. Rev. Lett. (1996)]. Furthermore, while the Gibbs uniqueness threshold is still not known precisely for any k, we derive new lower bounds on this threshold that improve over prior work [Montanari and Shah: SODA (2007)]. The improvement is significant particularly for small k.

Time-Dependent Route Planning

Christos Zaroliagis

University of Patras

Computing optimal paths in real-world spatio-temporal networks that exhibit a time-dependent arc-cost metric is a core algorithmic task for numerous applications, with route planning in road networks being a prime example. The time-dependent route planning poses several hard challenges both theoretically and in practice. In this talk, some recent theoretical advances in developing time-dependent oracles are presented that exhibit subquadratic preprocessing time and space, and query time sublinear on the network size or the actual Dijkstra rank of the query at hand. In addition, some heavily engineered variants of these oracles are presented that demonstrate an impressive query performance in practice, both in quality (relative error less than 0.3%) and in the query-response time (less than 0.67 msec) even for continental size networks.

Pseudo-Equilibria, or: How to Stop Worrying About Crypto and Just Analyze the Game

Vassilis Zikas

Georgia Tech

We revisit the problem of a game theorist analyzing a game that uses cryptographic protocols. Ideally, the game theorist should be able to ignore all implementation details of the cryptographic protocols and abstract them as ideal, implementation-independent primitives, in a way that conclusions in the "ideal world" can be faithfully transferred to the "real world," where real protocols are implemented by cryptography. Achieving this goal is crucial, as the game theorist cannot — and should not be expected to — grapple with the full complexity of cryptographic implementations. This is particularly relevant in the era of Web3, where the widespread adoption of distributed ledgers has created a pressing need for a common language that bridges cryptography and game theory.

We propose a new solution concept: the *pseudo-Nash equilibrium*. Informally, a (poly-time) strategy profile is a pseudo-Nash equilibrium if no (poly-time) player observes a noticeable, i.e., non-negligible, (expected) utility gain by playing a different (poly-time) strategy. Pseudo-Nash is substantially simpler and more accessible to game theorists than any existing notion that attempted to address the mismatch in the (asymptotic) cryptographic method and game theory. We prove, in a very general sense, that Nash equilibria in games that use idealized, unbreakable cryptography correspond naturally to pseudo-Nash equilibria when idealized cryptography is instantiated with actual protocols (under state-of-the-world assumptions). Our translation is not only conceptually simpler than existing approaches, but also more general: it does not require tuning or restricting utility functions in the game with idealized cryptography to accommodate idiosyncrasies of cryptographic implementations. In other words, pseudo-Nash equilibria allow us to separately and seamlessly study game-theoretic and cryptographic aspects.

Geometry and Topology

Organizers

Kodokostas D. (National Technical University of Athens)

Prassidis E. (National and Kapodistrian University of Athens)

Savas-Chalilaj A. (University of Ioannina)

PROGRAM

GEOMETRY AND TOPOLOGY SESSIONS

	Monday June 29	**Tuesday June 30**	**Wednesday July 1**	**Thursday July 2**	**Friday July 3**
				NTUA, ΣΗΜΜΥ, Room 7	**NKUA, Γ31**
12:30-13:00				I. Androulidakis	N. Kechagias
13:00-13:30				N. Eptaminitakis	P. Batakidis
13:30-14:00				K. Zemas	C. Neofytidis
14:00-16:00				**Break**	**Break**
16:00-16:30				S. Lampropoulou	P. Dimakis
16:30-17:00				G. Tsapogas	I. Gkeneralis
17:00-17:30				I. Platis	R. Tsiamis
17:30-18:00				**Coffee break**	**Coffee break**
18:00-18:30					S. Garoufalidis
18:30-19:00					
19:00-19:20					
19:30-19:50					

Maximal hypoellipticity and the Helffer-Nourrigat conjecture

Iakovos Androulidakis

Thursday 2/7 - 18:00-18:30

Helffer-Nourrigat conjecture, linear PDEs

The Helffer-Nourrigat conjecture (1979) characterizes the existence of smooth solutions of linear PDEs, including singularities. The characterization is given by the behaviour of an appropriate symbol on arestricted number of representations, which are computable. In this talk we will present the proof of the conjecture, in collaboration with Omar Mohsen and Robert Yuncken.

Topological and Delzant-type classification of quaternionic torus actions

Panagiotis Batakidis

Friday 3/7 - 13:00-13:30

quaternionic torus, quaternionic toric geometry, tetraplectic geometry, toric fibration, Arnold-Liouville theorem, quaternionic Delzant theorem

Let $Q = S^3$ be the quaternionic torus. We first discuss local Q^n actions on 4n-manifolds and the obstruction to global existence. We then classify such actions via a combinatorial and a cohomological invariant. In the second part of the talk, quaternionic toric geometry is related to tetraplectic geometry, a generalization of symplectic geometry, via lagrangian toric fibrations. For this we use a quaternionic version of the Arnold-Liouville theorem and finally we classify orbit spaces via a quaternionic Delzant theorem. This is joint work with I. Gkeneralis.

The conformal limit for Nakajima quiver varieties

Panagiotis Dimakis

Friday 3/7 - 16:00-16:30

Higgs bundle, Nakajima quiver variety, Simpson's conjecture, Bialynicki-Birula slice

Inspired by Gaiotto's conformal limit construction for Higgs bundles we introduce and study a conformal limit construction for Nakajima quiver varieties. We prove that the conformal limit is indeed a limit of a one-parameter family of points inside a specified quiver variety and that it gives a biholomorphic map between holomorphic Lagrangian submanifolds foliating two related quiver varieties. Finally, we introduce the analog of Simpson's conjecture on the completeness of these holomorphic Lagrangian submanifolds and provide a complete proof under a genericity assumption. Central to both proofs is the existence of a Bialynicki-Birula slice associated to fixed points of a natural circle action.

Tensor Tomography on Asymptotically Hyperbolic Surfaces

Nikolaos Eptaminitakis

Thursday 2/7 - 13:00-13:30

geodesic X-ray transform, asymptotically hyperbolic surfaces

In this talk we will discuss the geodesic X-ray transform on symmetric tensor fields in the geometric setting of asymptotically hyperbolic surfaces, which are non-constant curvature generalizations of Poincaré disk. This setting is interesting in part due to its connections to theoretical physics, specifically the AdS-CFT Correspondence. The geodesic X-ray transform on symmetric tensors of positive rank has a natural nullspace, implying that such a tensor field cannot be uniquely recovered from its X-ray transform. On asymptotically hyperbolic surfaces we propose gauge representatives (modulo the nullspace of the transform) to be reconstructed from the data, by proving a "transverse traceless-conformal-potential" decomposition. We then use our tensor decompositions to provide range characterizations of the geodesic X-ray transform in the special case of 2-dimensional hyperbolic space, as well as to develop reconstruction procedures. Based on joint work with François Monard and Yuzhou Zou.

From knots to Habiro cohomology

Stavros Garoufalidis

Thursday 2/7 - 16:30-17:00

knot, 3-manifold, topological quantum field theory, skein theory, Habiro cohomology

I will give a gentle and quick introduction to the classical subject of knots and their connection with 3-manifolds, topological quantum field theories, skein theories, and the recently arithmetically defined Habiro cohomology. Joint work (in several parts) P. Scholze, C. Wheeler and D. Zagier.

Equivariant and topological rigidity of moment-angle manifolds

Ioannis Gkeneralis

Friday 3/7 - 16:30-17:00

moment-angle manifolds, equivariant topological rigidity, surgery theory, Farrell-Jones conjecture, Borel Conjecture

In this talk we investigate rigidity phenomena for real, complex and quaternionic moment-angle manifolds from both equivariant and non-equivariant perspectives. For complex and quaternionic moment-angle manifolds, we study equivariant topological rigidity under locally linear torus actions. By reducing the classification problem to the equivariant rigidity of the associated quasitoric (respectively, quoric) quotients together with the classification of the corresponding principal bundles, we establish new rigidity results. In particular, we prove that complex

moment-angle manifolds are equivariantly rigid: any locally linear manifold that is equivariantly homotopy equivalent to such a manifold is in fact equivariantly homeomorphic to it. In the quaternionic setting, we obtain full equivariant rigidity in dimension four (at the level of quoric quotients), and a primary rigidity result in higher dimensions governed by degree-4 characteristic classes. As a consequence, these manifolds are equivariant strong Borel manifolds, meaning that their equivariant homotopy type determines their equivariant homeomorphism type. In contrast, for real moment-angle manifolds associated to flag simplicial complexes, we establish (non-equivariant) topological rigidity. Using the cubical geometry arising from the Davis construction, we identify the universal cover with the Davis complex and show that it admits a CAT(0) metric. This implies that the fundamental group satisfies the Farrell-Jones conjecture. By applying surgery theory, we deduce that real moment-angle manifolds of dimension at least five associated to flag complexes satisfy the Borel Conjecture. Finally, we explain why this rigidity phenomenon is specific to the real case and does not extend to the complex and quaternionic settings.

Homotopy groups of spheres and other curiosities

Nondas Kechagias

Friday 3/7 - 12:30-13:00

algebraic topology, homotopy groups of spheres

The geometric objects of interest in algebraic topology can be constructed by fitting together spheres of varying dimensions. The homotopy groups of spheres describe the ways in which spheres can be attached to each other. From the viewpoint of algebraic topology, detailed knowledge of these groups would lead to a classification of geometric objects. Smoothly and avoiding technical details we will describe up to date results.

Bonded knots, the bonded braid monoid and some applications

Sofia Lambropoulou

Thursday 2/7 - 16:00-16:30

bonded knots, bonded knotoids, bonded braids, bonded braidoids

We present the theory of bonded knots and bonded knotoids, and their algebraic counterparts, the bonded braids and bonded braidoids. We shall discuss the structure of the bonded braid monoid and its relation to the pure braid group and the singular braid monoid. Then, the topological passage from bonded knots/knotoids to bonded braids/braidoids. We will conclude by pointing to some applications to the topological modelling of proteins.

A topological interpretation of numbers

Christoforos Neofytidis

Friday 3/7 - 13:30-14:00

degree of a map, closed manifold

I will explain how an arbitrary finite set of numbers containing zero can be understood with topology, namely, as the set of degrees of maps between two closed manifolds in any dimension greater than two.

Notions of curvature in 3D Lie groups with a CR structure

Ioannis Platis

Thursday 2/7 - 17:00-17:30

Gauss curvatures, mean curvatures, Lie group, CR structure, Heisenberg group, Affine-Additive group

By using a Riemannian approximation scheme, we introduce notions of horizontal Gauss and mean curvatures of surfaces embedded into a 3-dimensional Lie group endowed with a CR structure. In particular, we provide full classification of certain types of surfaces embedded in the Heisenberg group and in the Affine-Additive group.

Ideal Hyperbolic Structures on 2-dimensional Complexes and Thurston's Asymmetric Metric

Georgios Tsapogas

Thursday 2/7 - 18:30-19:00

Teichmuller space, punctured surface, Thurston's asymmetric metric

We will discuss the Teichmuller space of punctured surfaces of finite type and new ways of computing Thurston's asymmetric metric on it which allow the extension of Thurston's foundational results from punctured surfaces to 2-dimensional complexes.

Scalar curvature and sharp systolic inequalities for Kähler manifolds

Raphael Tsiamis

Friday 3/7 - 17:00-17:30

2-systole, Kähler manifold, Spin-c manifold, Fubini-Study metric, Gromov width

We establish sharp inequalities for two-dimensional systolic invariants of metrics with positive scalar curvature: the 2-systole and the spherical 2-systole of compact Kähler manifolds, and the stable 2-systole of Riemannian metrics on a general class of Spin-c manifolds and their products. These bounds attain equality precisely for complex projective space $\mathbb{CP}^n$ equipped with the Fubini-Study metric. Moreover, we prove an algebraic characterization of manifolds admitting Kähler metrics with non-negative total scalar curvature, which implies a conjecture of Gromov for Kähler metrics. Finally, we obtain uniform bounds for the Gromov width, volume, and higher stable systoles of Kähler manifolds in terms of their scalar curvature.

Global minimality of the Hopf map in the Faddeev-Skyrme model with large coupling constant

Konstantinos Zemas

Thursday 2/7 - 13:30-14:00

Hopf map, Faddeev–Skyrme energy, quantum field theory, topological solitons.

The Faddeev-Skyrme model is a by now classical nonlinear $O(3)$-sigma model which has proved very successful in quantum field theory, in particular in detecting topological solitons. A prototype mathematical model for fields $u : S^3 \to S^2$ consists of the harmonic map energy together with its symplectic variant acting as a singular perturbation. We prove that, modulo rigid motions, the Hopf map is the unique minimizer of the Faddeev–Skyrme energy in its homotopy class, for an explicit sufficiently large range of the coupling constant. This is joint work with A. Guerra (University of Cambridge) and X. Lamy (University of Toulouse).

Mathematical Education

Organizers

Kalavasis Fr. (University of the Aegean)

Moutsios-Rentzos A. (National and Kapodistrian University of Athens)

Psycharis G. (National and Kapodistrian University of Athens)

Description: The session on Mathematics Education addresses a shared yet often antagonistic pursuit: both mathematicians and mathematics educators seek to maintain the continuity and quality of mathematics education while ensuring equitable and inclusive learning environments. In contexts of rapid and radical socioecological and technological transformations (including AI, interactive provers, and mixed learning environments), this common aspiration becomes a site of tension, as differing epistemologies, priorities, and practices come into contact. Moving from the presentation of current research towards a panel discussion, the session asks how such a pursuit might become collaborative rather than antagonistic.

PROGRAM

MATHEMATICS EDUCATION SESSIONS

	Monday June 29	**Tuesday June 30**	**Wednesday July 1**	**Thursday July 2**	**Friday July 3**
			NKUA, A22		
16:00-16:30			G. Psycharis		
16:30-16:50			P. Kalogeropoulou, I. Rizos, J. Russo		
16:50-17:10			A. Nikolidaki		
17:10-17:30			E. Rachmanidi, C. Misailidou		
17:30-18:00			**Coffee break**		
18:00-19:40			G. Psycharis S. Kafoussi D. Diamantidis M. Karavakou A. Moutsios - Rentzos		

Digital and Non-Digital Mathematical Games: A Cross-National Comparison of Primary Teachers' Preferences in Australia and Greece

Penelope Kalogeropoulos (Monash University), Ioannis Rizos (University of Thessaly), James Russo (Monash University)

Mathematical games are widely recognized as valuable pedagogical tools in primary mathematics education. While much research has examined the effectiveness of game-based learning, as far as we know few studies have explored teachers' preferences for different game modes and the reasons supporting these choices. This paper contributes to the improvement of mathematics education by examining teachers' preferences for digital and non-digital games in classroom practice. Drawing on data from a larger cross-national study involving eight countries, it focuses on responses from Australia and Greece. The study integrates quantitative and qualitative data, using survey results to contrast national differences in preferences, alongside teacher descriptions of their favourite mathematics game and its classroom use. Findings reveal clear contextual differences. Quantitative results show that Australian teachers demonstrate a strong preference for non-digital games, whereas Greek teachers exhibit a more balanced distribution, with the largest proportion expressing neutral positions and similar proportions favouring digital and non-digital games. Qualitative data further illuminate these trends: Australian teachers emphasise accessibility, adaptability, and student interaction, while Greek teachers highlight practical and affective benefits of digital games, particularly ease of access, set-up, and their capacity to engage students. Sensory richness and instant feedback were also noted as supporting mathematical learning. To deepen understanding, two illustrative examples drawn from teacher responses are presented. A non-digital game described by two Australian teachers is analysed using a framework of reasons for preferring non-digital games, while a digital game described by a Greek teacher is examined using the corresponding framework. These analyses demonstrate how pedagogical and contextual factors shape teachers' choices and support effective game-based learning in mathematics.

From quantum computing to analytic geometry: conic sections via Grover's algorithm

Aikaterini Nikolidaki

1st Model High School of Athens-Gennadeio

This paper proposes a two-hour instructional scenario for 11th-grade Mathematics (B' Lyceum), connecting Analytic Geometry with Quantum Information Science. The central claim is that three conic sections of the Greek secondary curriculum emerge as direct algebraic consequences of the geometric structure of Grover's quantum search algorithm, each derivable using only curriculum-level algebra and the Pythagorean identity. The scenario is structured around the "Reversed Bridge" methodology, where a contemporary scientific problem creates the mathematical necessity before the formal theory is introduced. Students first encounter the algorithm as a concrete search problem, then discover each conic through guided inquiry: they observe a numerical invariant in a data table, formulate a conjecture, and construct the algebraic proof themselves. The circle arises from the Pythagorean identity applied to the algorithm's state representation ($\varepsilon = 0$). The parabola emerges from the relationship between classical and quantum

computational complexity, with eccentricity $\varepsilon = 1$. The rectangular hyperbola appears through the quantum speedup index, with eccentricity $\varepsilon = \sqrt{2}$. The ellipse is deliberately excluded, as no analogous rigorous derivation exists. Differentiated instruction is supported through multiple entry points: numerical pattern recognition, algebraic proof, and geometric visualization via a purpose-built interactive HTML tool that includes an eccentricity explorer.

Using AI for Designing an Inclusive Mathematics Learning Environment

Eirini Rachmanidi, Christina Misailidou

National and Kapodistrian University of Athens

The study presented here investigates the role of Artificial Intelligence (AI) in promoting an inclusive approach to teaching and learning primary school mathematics. Specifically, it introduces FractionsCoach, a digital dialogic tool designed to support the learning of fractions, incorporating limited and pedagogically controlled AI features. The tool aims to promote the meaningful involvement of all learners through multiple representations, graduated scaffolding and immediate formative feedback. FractionsCoach is not designed to function merely as an answer-generating system. Instead, it provides adaptive feedback based on students' responses, opportunities for reflection and self-correction and targeted support for revisiting and reconstructing mathematical meaning. The use of multimodal representations aims to reduce barriers to understanding and broaden access to mathematical reasoning for students with diverse learning needs and profiles. Inclusion is therefore conceptualized not simply as a classroom practice but as an equitable access to mathematical sense-making. The study adopted a mixed-methods approach, drawing on pre- and post-assessment data, system log data, student work, and field notes. The findings suggest that a carefully designed AI-supported digital environment can foster more equitable, participatory and inclusive mathematics teaching. Consequently, the educational value of AI appears to be maximized when it is embedded in a clear pedagogical framework oriented towards formative support and inclusion.

Round table: Mathematics Education in a digitalised learning environment: epistemological foundations, inclusive and critical perspectives, and systemic collaboration

Discussants: Georgios Psycharis (National and Kapodistrian University of Athens), Sonia Kafoussi (University of the Aegean), Dimitris Diamantidis (Ministry of Education), Myrto Karavakou (University of the Aegean and National and Kapodistrian University of Athens), Andreas Moutsios-Rentzos (National and Kapodistrian University of Athens)

In contexts of rapid technological and socioecological transformations, this panel examines how digitalised learning environments reshape mathematics education. Bringing mathematicians and mathematics educators into dialogue, it approaches this shared yet contested terrain not as a competition between communities but as an invitation to systemic collaboration, addressing questions across three interconnected dimensions:

- Technological affordances and disruptions: How do digital technologies –including AI, algorithmic approaches, interactive provers, and mixed/hybrid learning environments– create new opportunities and challenges for mathematical thinking and learning? What disruptions do these technologies introduce to established practices, epistemologies, and relationships within and across educational settings? How might the priorities of formal, disciplinary mathematics –proof, rigour, and formalisation, increasingly mediated by interactive provers and algorithmic tools– align or come into tension with the educational priorities of access, meaning-making, and inclusion?

- Inclusive and critical perspectives: How do different communities –including marginalized groups differentiated by disability, migration status, socioeconomic position, and language– experience and engage with digitalised mathematics education? What is the role of families in supporting mathematical learning in digital environments, and how can critical perspectives illuminate issues of equity, access, and epistemological justice?

- Systemic collaboration within and across learning environments: How can different educational actors –teachers, students, families, community members, policymakers, and institutional leaders– collaborate to create inclusive, equitable, and meaningful digitalised mathematics learning? What structures and practices enable collaboration within schools and across the boundaries between schools, homes, communities, and educational institutions?

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