MOSS: highlights from the first season

EMYA column regularly presented by Jesse Railo

Cristina Molero-Río and Belén Pulido

Can we bring together young mathematical talent so that everyone can benefit? MOSS makes it happen.

MOSS, the Mathematical Online Seminar Series, was created as a friendly and accessible space for young researchers to share their work, connect with others, and discover exciting areas of mathematics. What started as an idea quickly became a global seminar series with participants joining from all over the world.

EMYA,[1] the European Mathematical Society Young Academy, launched MOSS on February 2025.

MOSS includes presentations from leading young academics in mathematics from around the globe, which are accessible to a broad audience, no matter the mathematical subfield. This initiative is primarily intended to inspire the upcoming generation of young mathematicians, specially those who are working towards or have just completed a PhD in mathematics.

The origin of MOSS dates back to late 2024 during one of the EMYA monthly online meetings. The organizers by that time were the EMYA members Jelena Jankov Pavlović from the University of Osijek, Croatia, and Cristina Molero-Río from the University of Seville, Spain. Currently, Cristina continues and Belén Pulido, from the Universidad Nacional de Educación a Distancia (UNED), Spain, has taken over from Jelena. For more details, the reader is referred to [5].

The seminars are held entirely online every first Thursday of each month at 4 p.m. (CET), lasting approximately 45 minutes, followed by a 15-minute Q&A. They are recorded and are available at the EMS YouTube channel.[2] MOSS has also a mailing list[3] for those who would like to receive news.

The first season of MOSS occurred between February and June 2025. In what follows, we recap the speakers and their talks, as well as some metrics that illustrate the reception of this initiative by the mathematical community.

[1] https://euromathsoc.org/EMYA

[2] youtube.com/playlist?list=PLNDz3HuMo23DREzRlWkRPF6oQoLo3-tmZ

[3] docs.google.com/forms/d/e/1FAIpQLSfjXOc_H3IUqHTstGvEgYBYEwKqFd-UQVKgvf7mTzdshwckbw/viewform

Meet the speakers

In the first season of MOSS, all the speakers had obtained the EMS Prize of 2024,[4] which is awarded to young mathematicians under 35 for exceptional contributions to mathematics.

Cristiana De Filippis[5] is a professor at the University of Parma, Italy. She obtained her PhD in mathematics in 2020 at the University of Oxford, UK. She is an EMYA member of the first cohort (since 2023) and appeared at Forbes top 100 italian women.[6] She was awarded with the 2023 Bartolozzi Prize by the Italian Mathematical Union (UMI), the 2025 SIAM Early Career Prize in Partial Differential Equations and obtained an ERC Starting Grant in 2025. Her research interests focus on the regularity theory for elliptic and parabolic partial differential equations and on the calculus of variations.

Tom Hutchcroft[7] is a professor at the California Institute of Technology, USA. He obtained his PhD in mathematics in 2017 at the University of British Columbia, Canada. He has received prestigious awards, including the Canadian Mathematical Society Doctoral Prize in 2018, the Rollo Davidson Prize in 2019, and the Whitehead Prize in 2025, as well as the competitive Packard Fellowship in 2024, among others. His research interests lie mostly in probability theory and mathematical physics, with additional focus on group theory, ergodic theory, and metric geometry.

Adam Kanigowski[8] is a professor at the University of Maryland, USA. He obtained his PhD in mathematics in 2017 at the Institute of Mathematics of the Polish Academy of Sciences, Poland. He was honored with the Banach Prize in 2016 and the Polish Mathematical Society Prize for Young Mathematicians in 2016, among others, and has received competitive support including the Packard Fellowship in 2024. His research interests combine dynamical systems and ergodic theory, as well as their interactions with number theory, geometry and probability theory.

[4] https://euromathsoc.org/list-ems-prizes-history

[5] https://sites.google.com/view/cristianadefilippis/home

[6] https://forbes.it/2023/07/18/donne-successo-classifiche-forbes-2023

[7] https://www.its.caltech.edu/~thutch/

[8] https://akanigow.math.umd.edu/publications/

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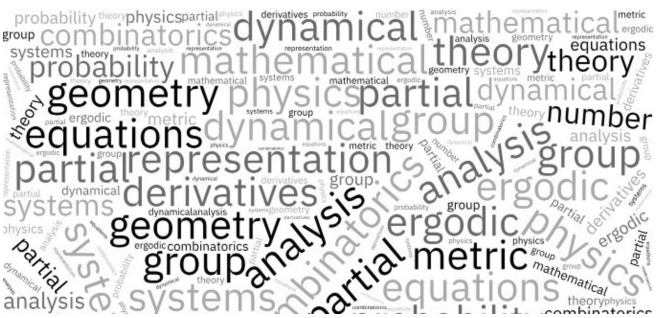
Jessica Fintzen[9] is a professor at the University of Bonn, Germany. She obtained her PhD in mathematics in 2016 at Harvard University. She was awarded with the Association for Women in Mathematics (AWM) Dissertation Prize in 2018, the Whitehead Prize of the London Mathematical Society in 2022 and the Frank Nelson Cole Prize in Algebra in 2024, among others. She also obtained different grants from the US National Science Foundation (NSF) and an ERC Starting Grant in 2022. Her research interests are related to number theory and representation theory, specially focused on p-adic groups and the Langlands program.

Richard Montgomery[10] is a professor at the University of Warwick, UK. He obtained his PhD in mathematics in 2015 at the University of Cambridge. He received several awards such as the European Prize in Combinatorics in 2019, the Philip Leverhulme Prize in 2020 and the London Mathematical Society (LMS) Whitehead Prize in 2025. He also obtained an ERC Starting Grant in 2020. His research interests are mostly related to extremal and probabilistic combinatorics.

What we learned

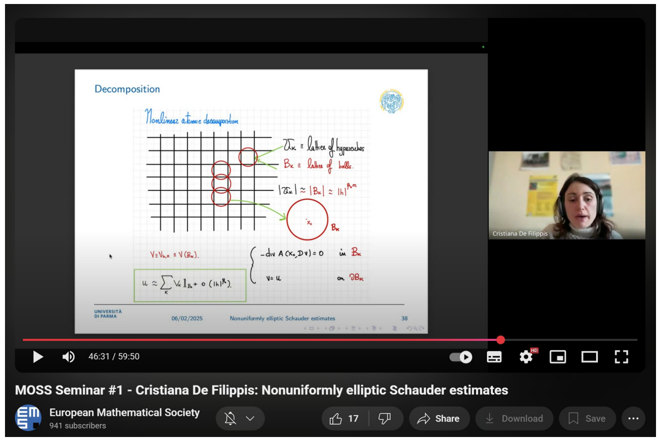


The first talk of the season was given by *Cristiana De Filippis* on *'Nonuniformly elliptic Schauder estimates.'*

Schauder estimates are a fundamental tool in the study of elliptic and parabolic partial differential equations (PDEs), as they ensure that solutions inherit the regularity of the coefficients. They play a crucial role in various contexts, including establishing higher regularity of solutions to elliptic problems, handling free boundary issues, implementing bootstrap arguments, or proving existence theorems, among others.

In the linear case, Schauder estimates are classical, with foundational results dating back to the 1920s. Over the years, new proofs have been developed using different techniques, such as function space methods, convolution approaches, blow-up techniques, and nonlinear extensions.

All these classical results focus on uniformly elliptic operators and fundamentally rely on perturbation methods, which involve



Nonuniformly elliptic Schauder estimates – Cristiana de Filippis, February 2025. (EMS YouTube channel)

freezing the coefficients and comparing the original solution to one with constant coefficients. However, these techniques fail in the nonuniformly elliptic setting, where homogeneous a priori estimates are lost and standard iteration arguments break down.

In this talk, Cristiana proposes a solution to the long-standing problem of extending Schauder estimates to nonlinear, nonuniformly elliptic problems. This approach introduces a novel method for obtaining a priori gradient bounds that does not rely on perturbation techniques, even in the presence of non-differentiable problems.

The reader is referred to [2], for instance.

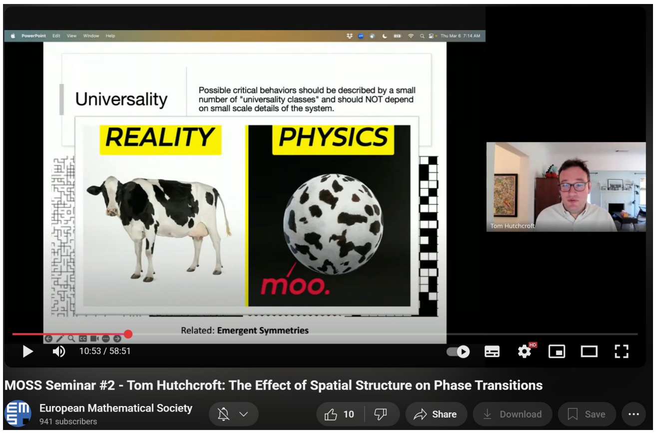
The second talk of the season was given by *Tom Hutchcroft* on *'The effect of spatial structure on phase transitions.'*

An important and fascinating feature of many large, complex systems in mathematics, physics, and other fields is that they undergo phase transitions.

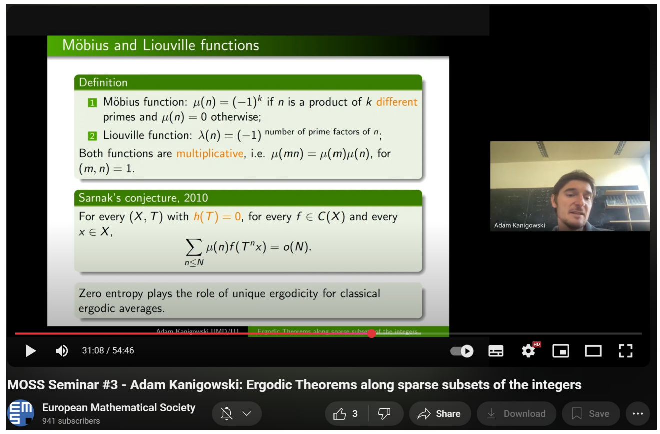
Mathematically, phase transitions usually appear in a specific way. Consider a system with many individual components, possibly arranged according to some spatial structure. Each component interacts with its neighbors in a manner governed by certain parameters, such as temperature, which we can vary continuously. A phase transition occurs when a small change in one of these parameters, crossing a special value called the critical value, causes a sudden, qualitative change in the system's behavior on a macroscopic scale.

We are all familiar with the solid/liquid/gas transitions from everyday life. However, phase transitions also appear in many other large systems unrelated to physics. Examples include the formation of traffic jams, the average-case computational complexity of optimization problems, and the spread of a novel disease through a population, a topic that has become particularly relevant recently. Understanding when, how, and why these systems undergo phase transitions is crucial for both theoretical insights

[9] https://www.math.uni-bonn.de/people/fintzen/
[10] https://rhmontgomery.warwick.ac.uk



The effect of spatial structure on phase transitions – Tom Hutchcroft, March 2025. (EMS YouTube Channel)



Ergodic theorems along sparse subsets of the integers – Adam Kanigowski, April 2025. (EMS YouTube channel)

and practical applications. Interestingly, the underlying mathematical principles are often very similar across these diverse situations, making the study of phase transitions a rich source of beautiful and deep mathematics beyond its original practical motivations.

The simplest models of phase transitions are called mean-field models, where every particle interacts equally with every other particle, ignoring any geometric arrangement. In this talk, Tom provides an introductory overview of what happens when geometry is introduced to these models, particularly how critical phenomena depend on spatial dimensions. He also briefly discusses some recent progress on these questions.

The reader is referred to [3], for instance.

The third talk of the season was given by *Adam Kanigowski* on *'Ergodic theorems along sparse subsets of the integers.'*

In the study of dynamical systems, a central question is how a system evolves over time. To capture this, mathematicians often consider ergodic averages, which measure the long-term average of a function along the orbit of a point under a transformation.

When the system is ergodic, these averages converge to a limit independent of the starting point, linking local orbit behavior to global properties of the system.

A more recent development studies ergodic averages along sparse subsets of the integers, such as the prime numbers or values of polynomials with integer coefficients. These sparse averages raise subtle questions about convergence and distribution, requiring a combination of ideas from number theory and ergodic theory.

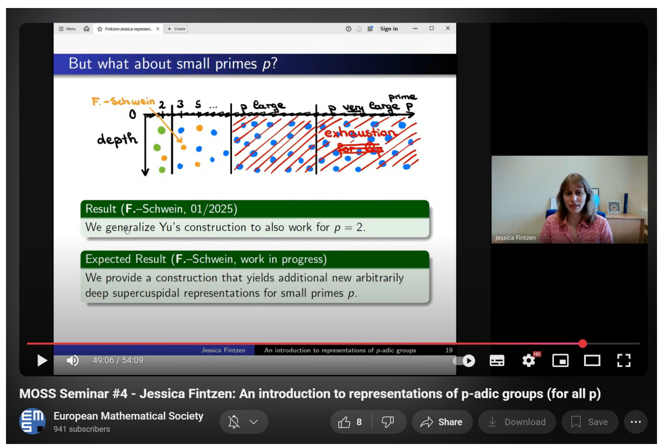
In his talk, Adam focuses on precisely these kinds of sparse ergodic averages, and examines how they behave. He recalls some classical results, mentions some recent developments and highlights some interesting open problems.

The reader is referred to [4], for instance.

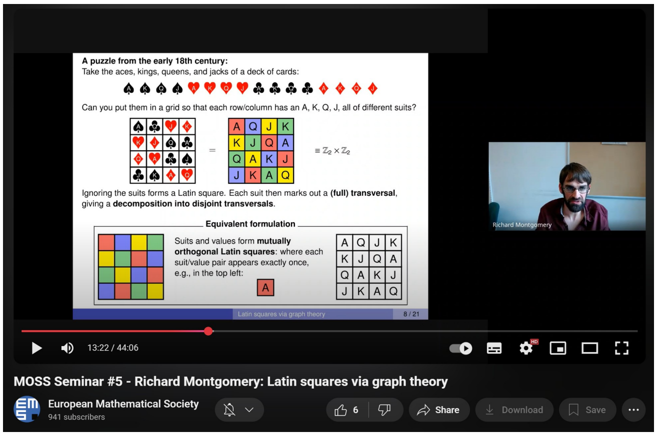
In May 2025, *Jessica Fintzen* delivered the talk titled *'An introduction to representations of p-adic groups (for all p).'*

An explicit understanding of the category of all smooth, complex representations of p-adic groups provides an important tool not only within representation theory. It also has applications to number theory and other areas, and in particular enables progress on various different forms of the Langlands program.

The talk introduces p-adic groups and provides an overview of what is known about the representation theory of these groups, including developments from the last ten months. In particular, it surveys the construction of all so-called supercuspidal representations, which are the building blocks for all representations. For more than 20 years, it remained an open problem to extend a general construction to the case $p = 2$. The talk explains what makes this case so special and how the obstacles were finally overcome in recent joint work with David Schwein. See [6] for more details.



An introduction to representations of p-adic groups (for all p) – Jessica Fintzen, May 2025. (EMS YouTube channel)



Latin squares via graph theory – Richard Montgomery, June 2025. (EMS YouTube channel)

The last talk of the season was given by *Richard Montgomery* on *'Latin squares via graph theory.'*

Latin squares have been studied in combinatorics since the pioneering work of Euler in the 1780s. More recently, significant progress has been made from the perspective of graph theory, allowing modern graph-theoretic tools to be applied to an equivalent formulation using edge-colored graphs. The lecture explored the study of transversals in Latin squares through this approach, with particular attention to the following questions:

1. How large a partial transversal can be found in any Latin square?
2. How many disjoint transversals are likely to be found in a random Latin square?

A Latin square of order n is defined as an $n \times n$ grid filled with n symbols so that every symbol appears exactly once in each row and each column. A *partial transversal* of a Latin square of order n is a collection of cells in the grid that share no row, column, or symbol, while a *transversal* is a partial transversal with n cells. Not every Latin square contains a transversal; however, when n is large, every large Latin square has a partial transversal extremely close to a full transversal. In a "typical" Latin square, much more can be expected. Recent work has shown that in a random Latin square it should be possible to decompose the structure into disjoint transversals.

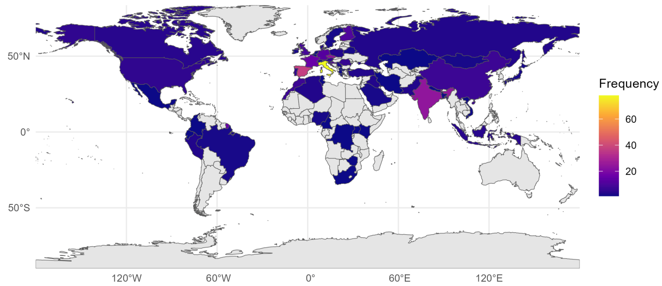
This research is based in part on joint work with Candida Bowtell, that can be found in [1].

Spreading the word

MOSS talks have attracted a wide range of participants, from students at different stages of their careers to professionals from industry and others with a general interest in the topics.

Regarding attendance, the average number of live participants connected at the time of each talk was around 33. Beyond the live audience, the recordings on YouTube have reached a much broader community, with an average of 375 views per talk. This shows the continuing interest in the material even after the sessions have taken place.

The map appearing below shows the countries where people are subscribed to MOSS mailing list, with colors indicating how many members come from each place. This gives a clear picture of the diversity of the audience and shows how MOSS has reached people across Europe, Asia, Africa, and America.



The MOSS community.

Finally, new people continue to sign up month after month, which highlights the growing interest in the seminar series and its international appeal.

What's next?

The MOSS adventure continues! The next season will start in February 2026 and will bring together outstanding young researchers from different countries, covering many different areas of mathematics.

Those interested in the talks can join the MOSS mailing list to receive updates and information about upcoming sessions. This will provide an opportunity to stay connected with the young mathematician community and follow the new MOSS season.

References

[1] C. Bowtell and R. Montgomery, Almost every Latin square has a decomposition into transversals. arXiv:2501.05438v1 (2025)

[2] C. De Filippis and G. Mingione, Nonuniformly elliptic Schauder theory. *Invent. Math.* **234**, 1109–1196 (2023)

[3] T. Hutchcroft, Dimension dependence of critical phenomena in long-range percolation. arXiv:2510.03951v1 (2025)

[4] A. Kanigowski, M. Lemańczyk and M. Radziwiłł, Prime number theorem for analytic skew products. *Ann. of Math. (2)* **199**, 591–705 (2024)

[5] E. Schlitzer, *MOSS: the mathematics online seminar series by EMYA*. European Mathematical Society News (2025) https://euromathsoc.org/news/moss-the-mathematics-online-seminar-series-by-emya-133

[6] J. Fintzen and D. Schwein, Construction of tame supercuspidal representations in arbitrary residue characteristic. arXiv:2501.18553v2 (2025)

Cristina Molero-Río is a postdoctoral researcher at the University of Seville, Spain, where she earned her PhD in mathematics in 2022. Her research combines the disciplines of operations research and artificial intelligence, contributing to the fields of mathematical optimization and machine learning, respectively.

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Belén Pulido is an assistant professor at the Universidad Nacional de Educación a Distancia (UNED), Spain. She earned her PhD in mathematical engineering from the Universidad Carlos III de Madrid, Spain, in 2024. Her research focuses primarily on statistics, with particular interest in functional data analysis and its software implementation.

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