The winners of Prizes of the 9ECM

During the opening ceremony of the congress, the European Mathematical Society has granted 14 prizes, recognizing the **most illustrious figures from the international mathematical landscape**. This includes the European 10 European Mathematical Society Prizes, the Felix Klein Prize, the Paul Lévy Prize, the Otto Neugebauer Prize and the Lanczos Prize. As Pavel Exner, chairman of the awards committee, said, "the EMS prizes have become very well known, and many of the winners have been also awarded with Fields Medals". In particular, "this year there have been many more nominees than in previous years, and this has been a great joy and also a frustration - we've seen **so great mathematics from young people**, but we had to make hard choices", he adds.

EMS Prizes

The European Mathematical Society Prizes are awarded every four years to **10 young mathematicians under the age of 35**, in recognition of exceptional contributions to mathematics. The winners must be of European nationality or have carried out their work in Europe. This year the winners are:

- **Tom Hutchcroft**, professor at the California Institute of Technology, has received the prize "for his revolutionary contributions to probability theory and geometric group theory, in particular to percolation theory on general graphs, using tools from geometry, operator theory, group theory and functional analysis." Hutchcroft studies the phase transitions in "percolation models in graphs". Instead of atoms moving chaotically, as in boiling water, these models consist of a network of interconnected "nodes" (like subway network of stations or the brain neurons).

Neighboring nodes are connected according to some probability; when it reaches a certain value the network suddenly changes its behavior. One of Hutchcroft's most celebrated works is the resolution of the so-called Schramm locality conjecture, which implies that, in many percolation models, one can understand the whole system by simply understanding what happens at very small scales (by zooming in).

- **Danylo Radchenko,** ukrainian mathematician, currently a researcher at the French CNRS, attached to the Paul Painlevé Laboratory of the University of Lille. The jury awarded him the prize "for the construction of optimal spherical designs and his seminal input in the new field of Fourier interpolation, as well as for his fundamental contributions to the theory of polylogarithms". Despite his youth, Radchenko has already made fundamental contributions to several areas of mathematics. He has dealt with the theory of polylogarithms, that have gone from relative curiosity to central concept in several areas of mathematics and physics, e.g. in new techniques to calculate what happens in particle accelerators. Radchenko became well-known for solving (with Andrii Bondarenko and Maryna Viazovska, Fields Medal 2022) the optimal sphere packing problem in dimension 24. Their solution is rather closely related to message encoding problems, and to the protocol that NASA used to communicate with the Voyager probes. The Radchenko's construction of optimal spherical designs, a special configuration of points on the sphere, is very useful in statistics, geometry and quantum computing.

- **Jessica Fintzen,** currently professor at the University of Bonn, has received the award "for her transformative work on the representation theory of p-adic groups, in particular for her spectacular proof that Yu's construction of supercuspidal representations is exhaustive". Fintzen studies the representations theory of p-adic groups. Her research is part of one of the most ambitious and profound projects in modern mathematics: the Langlands program, a network of conjectural relationships between geometry, harmonic analysis and number theory. Representation theory arises from the concept of symmetry (or transformation): it is about representing symmetries numerically, by means of tables of numbers with certain multiplication rules. In Fintzen's case, these tables do not contain everyday numbers but the so-called p-adic numbers. On the other hand, number theory arises from arithmetic: it studies objects such as prime numbers, systems of equations and their solutions. Between the two mathematical worlds, representation theory and number theory, apparently disconnected, Fintzen is discovering deep relationships, revealing an unexpected richness and unity in the mathematical universe.

- **Richard Montgomery,** currently professor at the University of Warwick, has been awarded the prize “for his solution of the Ringel tree packing conjecture, development of distributive absorption techniques with applications to graph embedding problems, and resolution of several classical conjectures of Erdős and others on cycle lengths in sparse graphs using the novel machinery of sublinear expanders". As an expert in combinatorics, Montgomery studies discrete structures, such as graphs, specifically extremal combinatorics, which seeks to understand how large these structures must be for certain patterns to emerge. His work aims to answer the question: can a network be decomposed into copies of simpler ones? Two examples are the Ringel tree packing conjecture, about decomposing complete graphs in trees, and the decomposition of graphs into cycles, which he has studied using a type of network called expander graph, now central in the area. These results have applications ranging from distributed computing to the design of experimental protocols.

- **Adam M. Kanigowski,** professor at the University of Maryland, has been awarded "for his outstanding contributions to the spectral classification and the mixing properties of slowly chaotic dynamical systems." Kanigowski is an expert in dynamical systems, focused on differential equations on surfaces, which model systems whose state at each instant of time is determined by two parameters. These equations appear naturally when studying the motion of planets, magnetic fields in plasmas, or electrons in a metal. He has shed light on slowly chaotic systems: those in which the famous butterfly effect occurs, but slowly. One of the questions that Kanigowski has solved is how to detect whether mixing processes will occur in these slowly chaotic systems - in particular, that the system will eventually reach almost every possible state as time goes by.

- **Jacek Jendrej,** researcher at the French CNRS at the Sorbonne University, receives the award “for his groundbreaking proofs of the soliton resolution conjecture and two-soliton collision problem for equivariant wave maps, developing new approaches using ideas from the theory of dynamical systems to describe the behavior of solutions near a multi-soliton configuration.” Jendrej studies nonlinear partial differential equations that describe the propagation and interaction of waves, whose type of solutions (the so-called solitons) are observed in many natural phenomena. Based on experiments and computer simulations, many experts in the field believe that the emergence of solitons is typical in many nonlinear wave equations - this is the “soliton resolution conjecture” Jendre has worked on.

- **Nina Holden,** professor at the Courant Institute of Mathematical Sciences of New York University, has won the EMS prize “for her profound contributions to probability theory and its applications to statistical physics, including results linking Liouville quantum gravity, the Schramm-Loewner evolution, and random triangulations.” Holden works at the boundaries of mathematical physics, complex analysis, and probability, in a very active area connected to statistical physics and quantum field theory. The central problem of her work is to develop a mathematically rigorous theory of random surfaces, whose notion is central to physicists' attempts at reconciling Einstein’s gravity with quantum mechanics, and where she has proved important results.

- **Frederick Manners,** professor at the University of California, wins the prize “for his remarkable contributions to additive combinatorics and related areas, in particular to the foundations of higher-order Fourier analysis, as well as for miscellaneous other results such as the solution of the pyjama problem." Manners is interested in the idea of pseudorandomness: whether a certain object seems to be formed by chance, or whether, on the contrary, there is some structure, an underlying order that allows us to analyze it. Talking about the pyjama problem, the idea is to determine whether, by rotating this striped pattern of a pyjama several times and superimposing the result, you can cover the image entirely in black. Manners proved this to be true, no matter how thin the original pattern of stripes, with techniques from the theory of dynamical systems and from p-adic analysis.

- **Cristiana de Filippis,** researcher at University of Parma, has won the prize “for her outstanding contributions to elliptic regularity, in particular Schauder estimates for non-uniformly elliptic equations and non-differentiable variational integrals, and minima of quasiconvex integrals". De Filippis is an expert in the calculus of variations and in elliptic partial differential equations, which describe the equilibrium states of classical physical systems, such as the electric field created by a distribution of electric charges. The solutions to equations of classical physics minimize or maximize a certain magnitude called the action, as if nature was performing an optimization exercise behind the scenes. We can picture all the potential behaviors of a physical system as an abstract landscape, where each behaviour would be a region, and think of the action the height of the corresponding region. The calculus of variations, of which De Filippis is an expert, studies how to find the peaks and valleys, that is, the maximum and minimum values of the action, in this territory. He is mainly interested in properties of regularity.

- **Maria Colombo,** professor at the École Polytechnique Federale de Lausanne, has received the award “for breakthrough results in fluid dynamics, optimal

transport and kinetic theory, and for her impact on analysis more broadly." In the broad field of mathematical analysis, Colombo is an exceptionally prolific and versatile mathematician. A recurring theme in her work is the study of irregular solutions to nonlinear partial differential equations, which describe both physical processes and geometric problems. In particular, she has developed new techniques for the study of irregular or "rough" flows, which appear in everyday phenomena that still remain little understood, such as the movement of turbulent fluids.

Felix Klein Prize

The winner of the Felix Klein Prize is **Fabien Casenave**, a researcher at the French multinational technology company Safran, specialized in the design and manufacture of aerospace machinery, such as airplanes and rockets. He develops AI techniques to improve simulations of physical processes. To find the best design for a machine, it is necessary to iteratively simulate its physical behavior under different conditions, but computational models of the machines have so many variables, that this iterated simulation is prohibitively expensive, when not impossible. The AI techniques developed by Casenave make it possible to systematically find "reduced models", with fewer variables, and to control the error one has to pay with these simplifications. Casenave has applied his techniques to problems of great practical importance, such as estimating the durability of turbines.

The Felix Klein Prize is awarded to young mathematicians under the age of 38 "for using sophisticated methods to give an outstanding solution, which meets with the complete satisfaction of industry, to a concrete and difficult industrial problem." It's named after the German geometer and analyst Felix Klein (1849-1925).

Paul Lévy Prize in Probability Theory

Paul Lévy Prize in Probability Theory has been granted to **Jeremy Quastel**, professor at the University of Toronto, who uses probability theory to understand the large-scale behavior of interacting many-particle systems. For example, the partial differential equations describing liquids, gases or plasmas emerge from the approximately one hundred sextillions of equations that describe the motion of their individual particles. Recently, he has focused on the study of the KPZ equation (by Kardar-Parisi-Zang), which models growth and aggregation processes, such as those of a tumor, a city, or a crystal that captures atoms from its surroundings. These processes have their laws and patterns, but also a component of randomness, which is why the equations that describe them are called stochastic differential equations. Stochastic equations such as KPZ are a challenge for mathematicians. Quastel and his collaborators were the first to find an exact solution to this equation.

The Paul Lévy Prize named after the French mathematician of the same name (1886-1971) was created by the European Mathematical Society, the École Polytechnique and Paul Lévy's family, with the financial support of BNP Paribas.

Otto Neugebauer Prize

Reinhard Siegmund-Schultze, German historian of mathematics at Adger University, Kristiansand, Norway, is the winner of the Otto Neugebauer Prize awarded by the EMS "for highly original and influential work in the field of history of mathematics that enhances our understanding of either the development of mathematics or a particular mathematical subject in any period and in any geographical region." Siegmund-Schultze studied mathematics at the Martin Luther University of Halle-Wittenberg, and did a PhD at the University of Leipzig, on the history of the branch of mathematics known as functional analysis. He is especially renowned for his historical research on the emigration of European mathematicians during Nazism.

The Prize is named after Otto Neugebauer (1899-1990), an Austrian-American mathematician and historian, who laid the foundations of our current understanding of the mathematical knowledge of Mesopotamia, Egypt, and Greece.

Cornelius Lanczos EMS/ECMI Prize for Mathematical Software

Cornelius Lanczos EMS/ECMI Prize for Mathematical Software has been granted to **MUMPS** software library, developed by researchers Patrick Amestoy, Jean-Yves L'Excellent and Chiara Puglisi. MUMPS is able to solve systems of linear equations with speed and accuracy. The numerical simulation of many processes, from geophysical to quantum, involves solving enormous systems of millions of linear equations and millions of unknowns. This step is often the most expensive part, where the bottleneck of numerical simulation is found, in terms of speed and data storage. The company that manages this software says that "the time spent solving linear systems usually reaches 80% of the total simulation time."

The Lanczos Prize was established in 2023 by the EMS and the European Consortium for Mathematics in Industry (ECMI). It is named after Cornelius Lanczos (1893-1974), mathematician of Hungarian origin, pioneer in the development and implementation of numerical algorithms in digital computers.