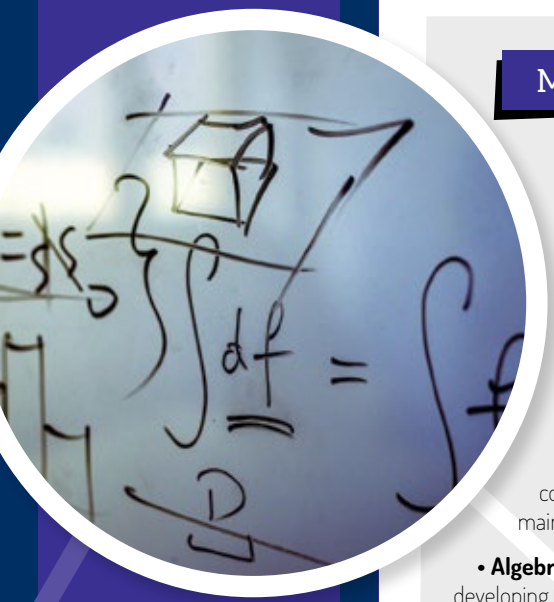

Major studies and research projects

Key research conducted at the Faculty includes, on the one hand, areas of study originating from mathematical analysis practiced in Kraków at a high level over a long period of time and, on the other hand, disciplines lying on the border between mathematics and computer science.

- **Functional Analysis.** A Polish specialty since the time of Stefan Banach, this area includes research on infinite-dimensional linear spaces equipped with additional structures. We explore objects that can be applied both in mathematics and theoretical physics, especially in quantum mechanics: operators in Hilbert, Krein, and Banach spaces; Banach and von Neumann algebras.

- **Complex Analysis.** The roots of this discipline lie in 19th-century studies on natural numbers. Currently, in addition to research conducted in traditional areas of the function theory of several complex variables, we work on its new branches that can be applied in physics and geometry. The main tool here is the Monge-Ampère equation, widely studied by mathematicians.

- **Algebraic Geometry.** Originated in studies on polynomial equations, this is one of the most intensively developing fields in modern mathematics. The research concerns Calabi-Yau manifolds, mathematical objects that play a key role in physical superstring theory. Inspired by this theory, the Mirror Symmetry Conjecture predicts that each manifold has its mirror partner. The relationship between them verified in many explicit examples is not yet fully understood.

- **Analytical Computer Science.** This discipline explores algorithms. The results obtained here are of both theoretical (computational complexity) and practical (development of software) nature. For instance, the scientists have found algorithms that recognise license plates of moving vehicles. Ongoing studies investigate the possibility of using similar techniques in medical diagnostics.

- **Computational Mathematics.** Research in this field focuses on numerical analysis of dynamical systems through the use of topology and interval arithmetic. In particular, this allows for the detection of chaos. The results obtained up to this point include a library comprising more than 60,000 lines of code for the rigorous analysis of the behaviour of solutions to differential equations. The library is used by researchers around the world.

Academic research and doctoral training are inseparable. During the past few years, many of the Faculty's PhD students have participated in three large projects: the international PhD programme "Geometry and Topology in Physical Models," the National PhD Studies on Mathematical Sciences, and the interdisciplinary PhD studies "Society-Environment-Technologies."

Collaboration

Research in mathematical sciences has a more individual character than in other scientific fields; thus, collaboration with other centres is rarely of an institutional nature.

Proof of a lively exchange between scholars from the Faculty and the world's leading scientists are the papers written in collaboration with mathematicians, physicists and computer scientists from top (according to the world rankings) universities, including Princeton, Paris 6, Texas A&M, Georgia Institute of Technology, Rutgers, Tel Aviv, Colorado, Paris 7, Pennsylvania, Toronto, Illinois, TU Berlin, Vanderbilt, Hannover, and many others, as well as numerous visits by computer scientists and mathematicians from the Faculty at leading universities around the world.

Scholars

Prof. Sławomir Kołodziej – the most important results of his research pertain to the existence of singular solutions of Monge-Ampère equations. They allow for the construction of spaces with prescribed Ricci curvature including Kähler-Einstein metrics, which play an important role in theoretical physics. The world's leading mathematicians, including Simon Donaldson (Imperial College London), who is a recipient of the Fields Medal, and Gang Tian (Princeton University), have used these results to demonstrate long-lasting conjectures in complex geometry. He was awarded the 2014 Stefan Bergman Prize by the American Mathematical Society.

Prof. Wojciech Kucharz – conducts research in real algebraic and analytic geometry. His most important findings concerning algebraic models of smooth manifolds and bundles over algebraic manifolds have been used by outstanding scientists in the field, including János Kollár (Princeton University), Selman Akbulut (Michigan State University), and Henry C. King (University of Maryland). His current research establishes new directions in the studies on phenomena described by the continuous rational function.

Prof. Marian Mrozek – gained worldwide recognition as a co-author of the first computer-assisted proof of the existence of chaos in the famous Lorenz equations. This started the research – still carried out today – on the use of computers in rigorous analysis of dynamics. His research team is a global leader in this field. He is one of the few scholars for whom a song has been composed. The lyrics for the song "Motyliada" (Butterfliad) were written by the poet Michał Zabłocki, while the music was composed by a leading Polish singer, Grzegorz Turnau, who performed the song several years ago.

Prof. Jan Stochel – is an expert on theory of unbounded operators in Hilbert spaces. The most important results of his research, obtained in collaboration with Franciszek H. Szafraniec, concern unbounded subnormal operators, a complex momentum problem, unitary dilations of contractions, and orthogonal polynomials. In recent years he has been investigating weighted shifts on directed trees.

Specialisation

- Functional Analysis
- Nonlinear Analysis
- Complex Analysis
- Differential Geometry
- Analytical Computer Science
- Computational Mathematics
- Applied Mathematics
- Algebraic and Analytic Geometry
- Dynamical Systems
- Approximation Theory

Achievements

Recently, outstanding results have also been achieved by junior members of the Faculty. Sławomir Dinew, PhD, who is investigating the Monge-Ampère equation, showed – in particular – the uniqueness of its solution. He also proved the Calabi-Yau theorem for a wider class of Hessian equations. Studies on Calabi-Yau manifolds conducted by Michał Kapustka, PhD, turned out to be of particular importance for the Mirror Symmetry Conjecture originating from physical superstring theory. The results obtained by Marcin Kozik, PhD, on the computational complexity of satisfiability problems provided information about operation time of computer programs used in studies on artificial intelligence and databases.

The 6th European Congress of Mathematics, organised in 2012, became the most significant event of the decade for promoting Kraków as an important centre for mathematical sciences. The very high reputation of the Faculty of Mathematics and Computer Science is due in part to its students' achievements in the ACM International Collegiate Programming Contests (ICPC) – gold medal in 2006; bronze medals in 2011 and 2013 – as well as to individual and team results (main awards received five times) earned at the International Mathematics Competition for University Students (IMC-US). These successes place the Faculty firmly among the leading European institutions educating young computer scientists and mathematicians.

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