Mathematical Institute, Utrecht University

Presentation
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1. Positioning of the institute

Over the past decades, Utrecht was the home of mathematicians of world renown, such as Hans Duistermaat, Richard Gill, Tonny Springer and Henk van der Vorst. The department consistently received excellent scores in research assessment exercises. Three of our current staff members belong to the Dutch Royal Society.

About 120 freshmen study mathematics at Utrecht each year, of which about 60 in combination with (theoretical) physics.

About 1/3 of the departmental budget consists of external research funding.

Our international, dedicated staff currently comprises around 25 tenured scientists.

1.1 Positioning within the Faculty and University

The Institute is part of the research focus area *Structures and Patterns* of the Science Faculty. It consists of two sections:

- *Fundamental Mathematics*,
- *Mathematical Modeling*.

Existing research links within the university are presently to theoretical physics and mathematical aspects of medical science (in particular, infectious diseases), and to applied physics and life sciences (notably computational physics, geology and medical imaging).

1.2 Positioning within The Netherlands

Dutch research in mathematics is (in part) supported by NWO in four broad programs, called *clusters.* Of these, pure mathematics at Utrecht plays a leading role in the "Geometry and Quantum Theory" (GQT)-cluster, and members also participate in the DIAMANT-cluster (Discrete, Interactive and Algorithmic Mathematics, Algebra and Number Theory). Applied mathematics at Utrecht is part of NDNS+ (Nonlinear Dynamics of Natural Systems) and members also participate in STAR (Stochastics - Theoretical and Applied Research).

1.3 Societal positioning - Relevance of Mathematics

We view mathematics both as a *foundational discipline*, through unexpected applications at the basis of most of today's most dramatic technological advances; and at the same time as a *spider in the web of science*, as a source of consultancy for science and industry (for example, we have worked on hart pumps, cabin crew rostering, computer chip design, greenhouse optimization, MRI-scanning and options-pricing, etc.).

In education, mathematics teaches abstract concepts of structure, information and space. These attract the most ambitious and talented students from The Netherlands and abroad; in recent years, we have seen an increased inflow of students with experience in various mathematics olympiads. At Utrecht we offer a very attractive

combined degree in mathematics and theoretical physics. We provide a constant outflow of highly qualified, broadly trained scientists into society. We believe this is a very relevant task, that serves Dutch society and the world at large, and we want to continue to do this at the highest possible output level. At masters level, we provide an honours track for ambitious students, the “Utrecht Geometry Centre”.

2. Research groups

2.1 Fundamental Mathematics

For centuries, the subject of pure mathematics has been roughly divided into Algebra, Geometry and Analysis, which we describe through large clouds:

- *Algebra*: commutative and noncommutative algebra, group theory, representation theory, field theory, Lie algebras, algebraic number theory, algebraic geometry, arithmetic geometry, (higher) category theory, mathematical logic, model theory, algebraic theory of differential equations, modular forms, automorphic forms, analytic number theory, algebraic topology, links with cryptography, coding, security, discrete mathematics, physics.
- *Geometry*: including algebraic geometry, arithmetic geometry, differential geometry, symplectic geometry, noncommutative geometry, geometric analysis, Lie groups, (higher) category theory, topology, algebraic topology, graph theory, links with theoretical physics, string theory, computer science.
- *Analysis*: classical real and complex analysis, functional analysis, harmonic analysis, geometric analysis, classical mechanics, integrable systems, noncommutative geometry, ergodic theory, Lie theory, automorphic forms, analytic number theory, partial differential equations, links with theoretical physics, applied analysis, dynamical systems.

Obviously, not all aforementioned subjects can be present at a comparatively small institute such as ours. Our current focus points are:

- *Number Theory,* including algebraic number theory, analytic number theory, automorphic forms, relations with mathematical physics
- *Algebraic Geometry*, including arithmetic geometry, relations with mathematical physics
- *Differential Geometry and topology,* including symplectic geometry, algebraic topology, higher categories, relations with mathematical physics
- *Mathematical Physics,* including integrable systems, Lie theory, string theory, gravity, methods of noncommutative geometry
- *Geometric analysis,* including partial differential equations, Lie theory, automorphic forms, modular forms, noncommutative geometry, ergodic theory
- *History of Mathematics*, including cultural and societal aspects

2.2 Research Group Mathematical modeling

The subject of applied mathematics comes in three broad clouds:

- *Stochastics*: stochastic processes, stochastic differential equations, random geometry, statistics, ergodic theory, statistical mechanics, quantum statistical mechanics, percolation, combinatorics, discrete mathematics, graph theory, optimisation, applications in the sciences
- *Dynamical Systems:* ordinary and partial differential equations, bifurcation theory,

ergodic theory, mathematical methods of population dynamics and infectious diseases, applications in the sciences
- *Mathematics of Computation*, scientific computing, numerical linear algebra, finite element methods, parallel and distributed computing, algorithms, digital security, cryptography, coding, industrial mathematics, mathematical methods of computational biology and physics, applications in the sciences

Our current focus points are:
- *Discrete Mathematics*: combinatorics, (random) graph theory, percolation, random geometry - linked to computer science, physics
- *Scientific computing:* finite element methods, parallel computing, algorithms, industrial mathematics - linked to industry, applications in the sciences, especially "Mathematics of Planet Earth"
- *Mathematics for Life Sciences:* mathematical methods of population dynamics and infectious diseases, computational biology, and problems of radiation - linked to theoretical biology and Utrecht Centre for Infection Dynamics
- *Mathematical methods in Applied Physics*: computational physics, (quantum) statistical mechanics - linked to theoretical condensed matter physics
- *Ergodic Theory:* including applications to number theory and geometric analysis - linked to fundamental mathematics
- *Bifurcation Theory:* including applied and algorithmic bifurcation theory - linked to the sciences

2.3 Interaction between the research groups in mathematics

The boundaries between the research groups are rather fluid, as should be clear from the multiple occurrences of the same subject in the above specifications. And indeed, in the past, Utrecht mathematics has fared well by implementing a special combination of pure and applied research. We also search for talented people with *dual capacities*. This duality maximizes excellence in mathematics and relevance to other subjects. (For example, we had successful combinations in linear algebra + chemical computation, functional analysis + epidemiology, stochastics + quantum statistical mechanics, algebraic geometry + string theory, number theory + theoretical physics, geometric analysis + mechanics, etc.).

2.4 Members of the department in 2015

2015 permanent faculty with research interests

see http://www.uu.nl/en/organisation/mathematical-institute/research/faculty-with-topics

In addition, Ieke Moerdijk will join in 2016 as Distinguished University Professor.

Graphical representation of the research groups