Annual report

2010
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Cover photo: Maryke Devos
Photos in this report: Margareta Wiberg Roland, when nothing else is written.

Institut Mittag-Leffler
Auravägen 17
SE-182 60 Djursholm
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www.mittag-leffler.se 27 May 2011
Research programs

Programs 2010

- Dynamical Systems and PDEs, spring 2010
- Quantum Information Theory, fall 2010

During 2010 the Institute hosted 161 visiting researchers, who together spent 210 man-months working at the Institute.

The programs during the current 12-year period — past and future — are:

- Probability and Conformal Mappings, fall 2001 and spring 2002
- Partial Differential Equations and Spectral Theory, fall 2002
- Mathematical Control and Systems Theory, spring 2003
- Noncommutative Geometry, fall 2003 and spring 2004
- Queuing Theory and Teletraffic Theory, fall 2004
- Algebraic Combinatorics, spring 2005
- Wave Motion, fall 2005
- Algebraic Topology, spring 2006
- Moduli Spaces, fall 2006 and spring of 2007
- Stochastic Partial Differential Equations, fall 2007
- Complex Analysis of Several Variables, spring 2008
- Geometry, Analysis, and General Relativity, fall 2008
- Discrete Probability, spring 2009
- Mathematical Logic: Set theory and model theory, fall 2009

- Algebraic Geometry with a view to applications, spring 2011
- Complex Analysis and Integrable Systems, fall 2011
- Geometric and Analytic Aspects of Group Theory, spring 2012
- Hamiltonians in Magnetic Fields, fall 2012
- Inverse Problems and Applications, spring 2013
Activity report 2010

Institut Mittag-Leffler is an international research institute for mathematics with a Nordic basis. It was founded in 1916 by Professor Gösta Mittag-Leffler and his wife Signe, who donated their magnificent villa with its first-class library for the purpose of creating the Institute that bears their name.

The Institute is today an active international center for front-line research in the mathematical sciences, operating under the auspices of the Royal Swedish Academy of Sciences. It enjoys the economic support of national funding agencies from all the Nordic countries, as well as of some private foundations.

The main activities at the Institute are the research programs and the publication of two research journals.

The Institute conducts semester-long programs aimed at research in some area in pure or applied mathematics of current interest. Each research program is led by an organizing committee. Based on the recommendations of this committee the Institute invites senior and junior mathematicians to come and work together at the Institute. The senior participants are chosen among the internationally leading mathematicians in the given area. To the junior participants, typically recent Ph.D.s, we offer fellowships, open to everyone to apply for. Mathematicians from the Nordic countries are given a slight priority. We make, however, sure that scientific caliber and a good mixture of talents and backgrounds have top priority, to optimize the creative environment at the Institute.

Detailed reports and documentation on the 2010 programs can be found later in this report. See also our web pages at www.mittag-leffler.se.

An aspect of the programs that is emphasized is to provide good postdoctoral training to the junior participants. Special seminars and minicourses are given specifically for them. In addition to these area-specific research programs we have the RIP program (Research in Peace), which allows Nordic mathematicians to spend time at the Institute for independent research.
The Institute publishes two journals, *Acta Mathematica* (founded by Gösta Mittag-Leffler in 1882) and *Arkiv för matematik* (founded in 1903). Information about the journals is given later in this report, as well as on our web pages www.mittag-leffler.se/publications. *Acta Mathematica* is generally considered to be one of the leading international mathematics research journals. During 2010 we increased the number of pages of *Acta Mathematica* from 600 to 700 pages per year, in order to be able to publish more of the very excellent papers that are submitted to the journal.

Institut Mittag-Leffler is an active participant in international scientific life. It participates in international networks of mathematics research institutes. For instance, we belong to ERCOM (European Research Centers on Mathematics), a network of European sister institutes. We also belong to EPDI (European Post-Doctoral Institute), a collaboration between 9 institutes for jointly awarding postdoctoral fellowships to Europe’s most promising young mathematicians.

An international evaluation\(^1\) of Swedish research in mathematics, sponsored by the Swedish Research Council (VR) and the Swedish Foundation for Strategic Research (SSF) was conducted in 2010. Institut Mittag-Leffler receives very positive mention. The importance of the Institute for Swedish mathematics is emphasized (see especially page 18 of the report), and the evaluation committee “most strongly recommends” VR and other Swedish and Nordic funding agencies to “act quickly to stabilize the current operating budget” (page 19).

The Institute staff does a wonderful job. Visitors from abroad often express their admiration how such a many-faceted operation can be run, and run so well, by so few individuals. At the end of 2010 Marie-Louise Koskull retired, after working 22 years at the Institute. For the last decade she has managed brilliantly the administration of the research programs. We welcomed her successor, Inger Halvarsson, who joined us at the Institute in December. Mikael Rågstedt was duly celebrated for having served as technical editor and librarian for 25 years.

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\(^1\) The report “Evaluation of Swedish research in mathematics”, VR and SSF, 2010, can be obtained at http://www.vr.se/download/18.287e63c12e07f2d51780001353/Evaluation+of+Swedish+research+in+mathematics.pdf
One of the scientific leaders of the spring program, Professor Jean Cristophe Yoccoz, was awarded the Erlander professorship by Vetenskapsrådet.

We were aided in the work of maintaining the historic main building by contributions from the Osher foundation (for maintenance of the old furniture) and from Professor Sigurdur Helgason (for new blackboards in the seminar room).

Institut Mittag-Leffler extends its warm gratitude to all organizations and individuals who via grants and contributions of various kinds have made the work of the Institute possible during the year 2010.

Anders Björner
Director
Contributors

The Institute is very grateful to the following organizations and individuals for contributions and support during 2010:

The Swedish Research Council, VR
Academy of Finland
Danish Agency for Science, Technology and Innovation
The Icelandic Mathematical Society
The Research Council of Norway

Acta Mathematicas fond
Erlanderprofessur, The Swedish Research Council (Jean-Christophe Yoccoz)
Fonden "Till bröderna Jacob och Marcus Wallenbergs minne"
KTH Royal Institute of Technology
Linköping University
Philip Leverhulme Trust via Andreas Winter
Professor Sigurdur Helgason, MIT
Stiftelsen G.S. Magnusons fond
The Anna-Greta and Holger Crafoord Fund

The first users of the new blackboards. September 2010. Made possible through a gift from Sigurdur Helgason
Dynamical Systems and PDEs

Scientific report 2010 spring

The program in Dynamical Systems and PDEs covered a large spectrum of the theory of modern dynamical systems ranging from chaotic behavior in low-dimensional systems over smooth and abstract ergodic theory to stability in PDEs and other infinite dimensional systems.

During almost every week two seminar talks were given each Tuesday and also each Thursday. Three weeks of more intensive seminar activities (“workshops”) were given during the program: one concentrated on ergodic theory in February, one on non-uniform hyperbolicity and interval exchange maps in the beginning of April, and one concentrated on KAM-theory, Schrödinger operators and PDEs in the end of May. J.-C. Yoccoz gave a course on “Non-uniformly hyperbolic horseshoes” during two months and A. Katok gave a mini-course on “KAM and rigidity”. The Gustafsson lectures by J. Bourgain also became a natural part of the activity though they took place at KTH.

The program gave rise to new collaborations or provided opportunity to continue existing ones. Many of these have already resulted in common works: Johansson, Pollicott and Öberg worked on Bernoulli g-mesures; Färm and Person studied dimension theory of baker-like skew-transformations of beta-transformations; Nicol and Persson studied smooth Livsic regularity of piecewise expanding maps; Burns and Hasselblatt gave a new proof of the Sharkovsky theorem; Aspenberg and Perez studied the growth of binomial recursion; Fan, Schmeling and Troubetzkoy worked on a multifractal mass transference principle for Gibbs measures; Khanin and Teplinsky finished a work on renormalization of circle diffeomorphisms with break. Baladi and Liverani worked on a project on exponential decay of correlations for piecewise hyperbolic contact flows which is now almost completed.

Other collaborations will likely produce interesting results in the future: Eliasson and Matheus made progress on their work on the perturbation theory for the KP-equation and had occasion to discuss their approach with the one of Yuan; Kuksin and Kappeler exchanged their different points of view on the Birkhoff- coordinates for KdV; Eliasson, Fayad and Krikorian made progress on their work on Herman’s problem and was able to give an infinitely differentiable counter-example to Herman’s conjecture; Marmi and
Yoccoz continued their work on interval exchange maps and so did Benedicks and Rodrigues on double standard maps.

The program was followed by more than 90 participants from US, Canada, Brazil, China and different European countries - the participants from Sweden and France were particularly numerous. A number of postdocs and a few other participants stayed for the whole period. Most senior participants were able to stay for a month, but we noticed an important difficulty for many of them to stay for a month without interruption. In general the participants were extremely pleased and impressed by the facilities and the ambiance of the Institute.

On the non-mathematical side, the organizers arranged a trip to Uppsala at Walpurgis, a boat trip to Sandhamn end of May, and several parties during the semester. By initiative of some participants ice-swimming (at Hellasgården) and a weekend sailing trip in the Stockholm archipelago were organized. In May and June common barbecues were frequent by those living at the institute.

Organizing committee:
Michael Benedicks, KTH Royal Institute of Technology, Stockholm
Håkan Eliasson, University Paris-Diderot
Jörg Schmeling, Lund University
Jean-Christophe Yoccoz, Collège de France
### Dynamical Systems and PDEs

**Participants 2010 spring**

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## Dynamical Systems and PDEs

### Preprints 2010 spring

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11
17 Renormalization horseshoe and rigidity theory for circle diffeomorphisms with breaks
Konstantin Khanin, Alexey Teplinsky

18 A Multifractal Mass Transference Principle for Gibbs Measures with Applications to Dynamical Diophantine Approximation
Ai-Hua Fan, Joerg Schmeling, Serge Troubetzkoy
Dynamical Systems and PDEs

Seminars 2010 spring

Maria Saprykina, KTH, Stockholm
Examples of Hamiltonian systems with Arnold diffusion

Boris Hasselblatt, Tufts University and European Doctoral College
Legendrian knots and nonalgebraic contact Anosov flows on 3-manifolds (with Patrick Foulon)

Jean-Christophe Yoccoz, Collège de France, Paris
COURSE: Non-uniformly hyperbolic horseshoes(continuation)

Jean Bourgain, IAS, Princeton
Toral eigenfunctions and distribution of lattice points on spheres

Michael Björklund, Jerusalem
Multiplicative combinatorics and dynamics

Artur Avila, Université Paris 6
KAM, Lyapunov exponents and the spectral dichotomy for one-frequency Schrödinger operators

Jean-Christophe Yoccoz, Collège de France, Paris
COURSE: Non-uniformly hyperbolic horseshoes(continuation)

Yakov Pesin, Penn State University
Stable Ergodicity of Partially Hyperbolic Diffeomorphisms: The Dissipative Case

Pierre Berger, Université Paris 13
Abundance of one dimensional non-uniformly hyperbolic attractors for surface endomorphisms

Jean-Christophe Yoccoz, Collège de France, Paris
COURSE: Non-uniformly hyperbolic horseshoes(continuation)

Wei-min Wang, Université Paris Sud 11
Supercritical NLS: quasi-periodic solutions and almost global existence

Rafael de la Llave, University of Texas, Austin
Periodic and almost periodic breathers in Hamiltonian lattice systems

Artur Avila giving a lecture
David Damanik, Rice University, Houston
What determines the spreading of a wavepacket?

Anders Szepessy, KTH, Stockholm
How accurate is molecular dynamics?

Yakov Pesin, Penn State University
Thermodynamics of Towers of Hyperbolic Type

Benoit Grebert, Université de Nantes
KAM for the semilinear quantum harmonic oscillators

Artur Avila, Université Paris 6
Absence of critical energies for typical one-frequency Schrödinger operators

Thomas Kappler, Universität Zürich
On the asymptotics of the Birkhoff map

Walter Craig, McMaster University, Hamilton
Lagrangian invariant tori for Hamiltonian systems with infinitely many degrees of freedom

Alexander Bufetov, Institute of Mathematics, Moscow, and Rice University, Houston
Limit theorems for translation flows

Margaret Beck, University of Boston
Time-periodic parabolic PDEs on unbounded spatial domains: a method for understanding the linear non-autonomous operator and the full nonlinear dynamics

Håkan Eliasson, Universitè Paris 7
KAM for the KP equation

Jean-Paul Thouvenot, CNRS and UPMC, Paris
Another proof of the norm convergence of nonconventional ergodic averages for commuting transformations

Sergei Kuksin, CNRS and Ecole Polytechnique, Paris
Perturbed KdV: results and open problems

Jean-Christophe Yoccoz, Collège de France, Paris
COURSE: Non-uniformly hyperbolic horseshoes(continuation)

Anatole Katok, Penn State University
Anatole Katok's Course: KAM and rigidity - Lecture 6: Setting up of the KAM scheme for the parametric local differentiable rigidity of the unipotent action of R2 on SL(2,R)\times SL(2,R)/Gamma. Application of cocycle rigidity, and tame splitting

Bassam Fayad, Université Paris 13
Transitive dynamics in the solid torus

Nicolas Gourmelon, Université de Bordeaux
"Pathwise" perturbations of linear cocycles, and new examples of wild dynamics

Anatole Katok, Penn State University
Anatole Katok's Course: KAM and rigidity - Lecture 5: Cocycle rigidity and tame splitting for the unipotent action of R2 on SL(2,R)\times SL(2,R)/Gamma

Dario Bambusi, Università Statale di Milano
On dispersion of small energy solutions of the nonlinear Klein Gordon equation with a potential. (Joint work with Scipio Cuccagna(Modena))
Xiaoping Yuan, Fudan University, Shanghai
KAM theory for unbounded perturbation with application to PDEs

Anatole Katok, Penn State University
Anatole Katok's Course: KAM and rigidity - Lecture 4: Unitary representation of SL(2,R) and solution of cohomological equations for the horocycle flow

Anatole Katok, Penn State University
Anatole Katok's Course: KAM and rigidity - Lecture 3: Realization of the KAM scheme for local differentiable rigidity for actions by commuting partially hyperbolic automorphisms of the torus

Michael Yampolsky, University of Toronto
Parabolic renormalization

Jean-Christophe Yoccoz, Collège de France, Paris
COURSE: Non-uniformly hyperbolic horseshoes(continuation)

Anatole Katok, Penn State University
Anatole Katok's Course: KAM and rigidity - Lecture 2: Local differentiable rigidity for actions by commuting automorphisms of the torus: 1. Hyperbolic case. A priori regularity of structural stability. 2. Partially hyperbolic case: setting up the KAM scheme

Nalini Anantharaman, Orsay
Semiclassical measures for the Schrödinger equation II : the case of negative curvature

Kostya Khanin, University of Toronto
Nonrigidity for circle maps with breaks

Anatole Katok, Penn State University
Absolutely continuous invariant measures for actions of higher-rank abelian groups

Kristian Bjerklöv, KTH, Stockholm
Quasi-periodic perturbations of some unimodal maps

Michael Benedicks, KTH, Stockholms
Moser's theorem on commuting circle diffeomorphisms. Two introductory lectures to the course of A. Katok

Anatole Katok, Penn State University
Anatole Katok's Course: KAM and rigidity - Lecture 1: Survey of rigidity properties for smooth actions of abelian groups: hyperbolic, partially hyperbolic, elliptic and parabolic. Methods used for establishing various flavors of rigidity. Cocycles, cohomological equations and time changes. General scheme of the KAM method for actions of higher-rank abelian groups

Michael Benedicks, KTH, Stockholms
Moser's theorem on commuting circle diffeomorphisms. Two introductory lectures to the course of A. Katok

Sylvain Crovisier, Université Paris 13, Villetaneuse
Strong homoclinic intersections inside hyperbolic attractors

Raphael Krikorian, Université Paris 6
Cocycles not homotopic to the identity

Jean-Christophe Yoccoz, Collège de France, Paris
Non-uniformly hyperbolic horseshoes.(Continuation of J.-C. Yoccoz' course)
Corinna Ulcigrai, University of Bristol
A Gauss map for symbolic sequences in the regular octagon

Lorenzo Diaz, PUC, Rio de Janeiro
C¹-robust cycles

Carlos Matheus Santos, Collège de France, Paris
Axiom A versus Newhouse phenomena for Benedicks-Carleson toy models

Nalini Anantharaman, Ecole Polytechnique, Palaiseau
Semiclassical measures for the Schrödinger equation on the torus

Jean-Christophe Yoccoz, Collège de France, Paris
Non-uniformly hyperbolic horseshoes

Sylvain Crovisier, Université Paris 13, Villetaneuse
Partial hyperbolicity far from homoclinic tangencies

Ian Melbourne, University of Surrey, Guildford
Convergence of fast-slow ODEs to stochastic differential equations

Jean-Christophe Yoccoz, Collège de France, Paris
Non-uniformly hyperbolic horseshoes

Lorenzo J. Diaz, PUC, Rio de Janeiro
Porcupine-like transitive sets

Henk Bruin, University of Surrey, Guildford
Dynamics of some interval translation maps

Giovanni Forni, University of Maryland, College Park
The Kontsevich-Zorich exponents beyond the canonical measures

Keith Burns, Northwestern University, Evanston
Ergodicity of the Weil-Petersson flow

Corinna Ulcigrai, University of Bristol
Mixing time-changes of parabolic flows

Stefano Marmi, Scuola Normale Superiore, Pisa
Linearization of generalized Interval Exchange Maps

David Damanik, Rice University, Houston
Dynamical aspects of the spectral analysis of Schrödinger operators

Magnus Aspenberg, Gothenburg
Perturbations of rational Misiurewicz maps

Raphael Krikorian, Ecole Polytechnique, Paris
On a problem of Michel Herman

Mark Pollicott, University of Warwick, Coventry
Large circles on surfaces

Carlos Matheus Santos, Collège de France, Paris
Lyapunov spectrum of Kontsevich-Zorich cocycle over SL(2,R) orbits of square-tiled cyclic covers
Alexey Teplinsky, National Academy of Sciences of Ukraine, Kiev
Hyperbolic horseshoe for renormalizations of circle diffeomorphisms with a break

Viviane Baladi, ENS. Paris
Anisotropic Sobolev spaces adapted to piecewise hyperbolic dynamics

Mark Pollicott, University of Warwick, Coventry
Factors of measures for shifts

Tomas Johnson, Uppsala University
Dynamics of the universal area-preserving map associated with period doubling I: Hyperbolicity

Denis Gaidashev, Uppsala University
Dynamics of the universal area-preserving map associated with period doubling II: Stability

Marco Martens, Stony Brook University
Henon renormalization II

Claire Chavaudret, Université Paris VII
Reducibility and almost reducibility of quasi-periodic cocycles

Marco Martens, Stony Brook University
Henon renormalization

Alexey Teplinsky, National Academy of Sciences of Ukraine, Kiev
Smooth conjugacy of circle diffeomorphisms

Sergey Dobrokhotov, A. Ishlinski Institute for Problems in Mechanics of Russian Academy of Sciences and Moscow Institute of Physics and Technology
Explicit asymptotics of localized solutions to linear hyperbolic systems

Rafael de la Llave, University of Texas, Austin
Invariant objects in coupled map lattices

Francois Ledrappier, University of Notre Dame
Entropies for covers of compact Riemannian manifolds Part I

Francois Ledrappier, University of Notre Dame
Entropies for covers of compact Riemannian manifolds Part II

Manfred Denker, Universität Göttingen
Erdös-Renyi Laws for Dynamical Systems

Andreas Knauf, Friedrich-Alexander-Universität, Erlangen
Hamiltonian motion in (non-)random potentials

Margaret Beck, University of Boston
Understanding metastability using invariant manifolds

Mike Todd, University of Boston
Transience in dynamical systems

Ana Rodrigues, Universidade do Porto
Background, kneading theory and quasisymmetric conjugacy

Michael Benedicks, KTH, Stockholm
Quasiconformal perturbations and Teichmüller theory. Extensions to k-fold standard maps
Boris Kruglikov, University of Tromsø
Dynamics of piece-wise affine maps and applications

Simon Kristensen, University of Aarhus
Rotations revisited

Carlangelo Liverani, Universita degli studi di Roma, Tor Vergata
Something I learned from Dolgopyat (he claims is Varadhan's)

Ale Jan Homburg, University of Amsterdam
Forced circle diffeomorphisms

Klaus Schmidt, University of Vienna
Entropy and periodic points

Mark Pollicott, University of Warwick, Coventry
Asymptotic escape rates for subshifts

Anatole Katok, Penn State University, University Park
From Pesin theory to measure rigidity to Zimmer's program

Carlangelo Liverani, Universita degli studi di Roma, Tor Vergata
Concerning the derivation of the Fourier Law

Henk Bruin, University of Surrey, Guildford
Monotonicity of entropy for families of polynomials on the interval

Giovanni Forni, University of Maryland, College Park
Mixing for reparametrizations of Heisenberg nilflows

Feliks Przytycki, IMPAN, Warsaw
Analyticity of pressure for rational maps and maps of the interval

Ana Rodrigues, IUPUI, Indianapolis and Universidade do Porto
Simple conjugacy invariants for braids

Anders Öberg, Uppsala University
Uniqueness, mixing and Bernoullicity of g-measures

Viviane Baladi, ENS, Paris
Linear response for generic nonuniformly hyperbolic unimodal maps

Andreas Knauf, Friedrich-Alexander-Universität, Erlangen
Topological and geometric ideas in scattering theory

Matthew Nicol, University of Houston
Borel-Cantelli lemmas for nonuniformly expanding maps

Jeff Steif, Chalmers, Gothenburg
The very many different faces of the T T-inverse process

Francois Ledrappier, University of Notre Dame, Indiana
Entropies of covers for compact manifolds

José Alves, Universidade do Porto
From mixing rates to recurrence times
Jairo Bochi, PUC, Rio de Janeiro
Nonuniform hyperbolicity, global dominated splittings and generic properties of volume-preserving diffeomorphisms

Manfred Einsiedler, ETH, Zürich
An ergodic proof of Duke's theorem

Anders Karlsson, KTH, Stockholm and University of Geneva
Noncommutative ergodic theorems

Michael Melgaard, Dublin Institute of Technology/Uppsala University
Recent results on models of Quantum Chemistry, I

Mattias Enstedt, Uppsala University
Recent results on models of Quantum Chemistry, II

Reiner Lauterbach, Universität Hamburg
Some open problems in equivariant dynamics

Hiroki Takahasi, Kyoto University
Prevalent dynamics at the first bifurcation of the Henon family

Matthew Nicol, University of Houston
Extreme value theory and hitting time statistics for dynamical systems with some degree of hyperbolicity

Neil Dobbs, KTH, Stockholm
Phase transitions in unimodal dynamics

Masato Tsujii, Kyushu University, Fukuoka
Functional analytic methods in smooth ergodic theory (second lecture)

Masato Tsujii, Kyushu University, Fukuoka
Functional analytic methods in smooth ergodic theory (third lecture)

Ramona Anton, Mathématiques Jussieu, Paris
Global existence for Gross-Pitaevskii equation on three dimensional exterior domains

Evelina Shamarova, Universidade do Porto
Solutions of Navier-Stokes and Burgers equations via forward-backward SDEs (joint work with Ana Bela Cruzeiro)

Masato Tsujii, Kyushu University, Fukuoka
Functional analytic methods in smooth ergodic theory(a series of three lectures)

Niklas Brännström, University of Helsinki
Slow dynamics of a slow-fast Hamiltonian system

Joerg Schmeling, University of Lund
On the dimension of iterated sumsets

Tomas Persson Warsaw
Dimension of piecewise hyperbolic attractors with overlaps

Daniel Schnellmann, KTH, Stockholm
Absolutely continuous limit distributions of sums of point measures
Quantum Information Theory

Scientific Report 2010 fall

The fall, 2010 program on quantum information theory was intended to provide an extended and intensive opportunity for cross-fertilization between quantum information scientists and mathematicians, particularly those working on operator algebras, operator spaces, operator systems, and free probability. For this reason, the seminars held most Tuesdays and Thursdays included expository talks, as well as reports of recent research results and work in progress.

During the first month participants represented a broad range of interests, from entanglement theory to quantum lattice systems to random matrices and convex geometry. Starting in Oct. there was more emphasis on quantum Shannon theory and during Nov.-Dec. about half the participants were experts on some aspects of the operator structures mentioned above. However, these divisions were not rigid and diverse interests were represented throughout the semester.

Interactions between different groups enabled some participants to use new ideas to finish or improve existing work. In other cases, new collaborations were formed with plans to continue to work after the program.

One of the highlights was a pair of visits and talks by M. Musat who spoke about her work with U. Haagerup on factorizable maps, and its implications for the so-called “quantum Birkhoff conjecture” which they showed is false. The first talk generated so much excitement that questioning went on for over an hour, with enthusiastic longer discussions for the rest of Musat’s stay. Some participants found connections to earlier results on quantum channels. During her second visit, she announced some additional results including an example that showed that a conjecture with implications for Connes’ embedding problem was false, as well as a new reformulation of this problem. Further discussions led to additional results and new collaborations, which are still going on.

Several reformulations of Connes' embedding problem, including a connection to Tsirelson's problem, were discussed at various times. Most participants outside of operator algebras were not even familiar with these problems prior to the program. These reformulations are exciting; although the problem is still open, we now have several new approaches and people with different viewpoints interested in this long-standing question.
In contrast to classical information theory, most of the many types of capacity encountered in quantum information theory are not “additive” for memoryless channels (represented by tensor products) because entanglement can increase the capacity. In 2009, a long-standing group of conjectures regarding “additivity” was shown to be false by Hastings using a subtle extension of the standard concentration of measure argument. In 2010, G. Auburn, S. Szarek and E. Werner used an improvement of Dvoretzsky’s theorem in high dimensional convex geometry to resolve this conjecture in a different way. G. Aubrun gave an expository talk on this work followed by a talk by P. Hayden about ongoing work demonstrating its application to other problems in quantum information theory. I. Bjelaković and J. Nötzel found this useful in their work on quantum capacity of varying channels. Several participants explicitly mentioned their appreciation of exposure to this powerful new tool which they expect to use in future work.

Later in the program, B. Collins and I. Nechita gave a series of lectures on their approach to violations of additivity based on free probability (which D. Petz provided an introduction to early in the program) and a new graphical calculus. Earlier work on additivity used random unitary channels; their methods can be applied to arbitrary channels by choosing the matrix associated with the Stinespring representation randomly. They are still trying to improve some of their bounds on the size of violations. M. Fukuda, a postdoc, began to collaborate on this during the program and is continuing to do so. All of the above methods give only existence theorems. M. Horodecki and M.B. Ruskai began a program to construct explicit counter-examples using dual Young diagrams for representations of the symmetric group, and benefited from discussion with Aram Harrow about this.

Perhaps the most important new result of the program was a proof by F. Brandao, M. Christandl and J. Yard giving a lower bound to a quantity known as “squashed entanglement”. This resolved a long-standing question about this entanglement measure, showing that it has a unique combination of several desirable properties not known to hold simultaneously for any other quantity. These properties also lead to several new results in entanglement theory and quantum complexity. This includes shedding some light on the structure of states which almost satisfy equality in the strong subadditivity of quantum entropy, with important implications for complexity theory.

During the program, G. Aubrun showed that under certain conditions a typical bipartite random state has the so-called PPT property, i.e., its partial transpose is positive semi-definite. This result is surprising because it is well-known that the proportion of states which are entangled states increases rapidly with dimension (or, conversely, the volume of separable states decreases faster than exponentially). Thus, G. Aubrun’s result implies that although entangled states dominate in high dimensions, most of them have the property that no entanglement can be distilled. It is a long-standing open question whether or not states which do not have the PPT property always have distillable entanglement. This can be reformulated as a question about 2-positivity of tensor
products of certain maps. There was a lot of discussion about this problem, as well as how to formulate the class of maps known as “local operations and classical communication” (LOCC) used for distillation in operator theoretic language. However, we are still far from a resolution of this problem and a satisfactory translation of LOCC and distillation.

M. Junge has been particularly active in applying operator space methods to problems in quantum information theory. The seminars included talks by his collaborators on previous work on Tsirelson's problem and Bell inequalities. During the program, he and C. Palazuelos had extensive discussions with other participants about quantum capacity; they obtained a new bound in terms of CB norms, which they are continuing to study for particular channels.

The full list of talks and preprints posted to date are given separately. A few of these results and description of ongoing work are mentioned briefly below.

B. Nachtergaele and R. Werner obtained a complete classification of nearest neighbor interactions for translation invariant quantum spin chains that allow for frustration-free (i.e., zero-energy) ground states in a number of cases of interest. These ground states can be completely described in terms of an irreducible representation of a Clifford algebra. They are extending this work to other models with quantum group symmetry.

E. Störmer, E. Paulsen, L. Skowronek and others discussed mapping cones and operator systems, clarifying the connections between them and leading to improvements in ongoing work with others in Canada. Farenick and Paulsen studied operator system quotients of matrix algebras, obtaining a new proof of Kirchberg's theorem and a new relationship to Connes' embedding problem.

M.B. Ruskai asked when certain maps associated with “monotone metrics” are completely positive (CP); D. Petz found several new examples and a connection to “operator means”. F. Hiai then showed that his work with H. Kosaki could completely resolve this issue for all of the well-known families. They are continuing this work in the hope of finding a complete characterization of the convex subset of operator means associated with CP maps.

Stimulated by discussions with D. Leung and T. Cubitt, Bjelaković and Nötzel extended their work on of capacity of varying channels from the arbitrarily small to the zero capacity situation.

M. Shirokov finished his paper “Entropy reduction of quantum measurements” after discussions with Effros and others helped him overcome a key stumbling block.
M.B. Ruskai and A. Winter collaborated on entropy inequalities, continuing an ongoing project with F. Matus (Prague) on the entropies of stabiliser states.

An unusual aspect of this program was formal, as well as informal, interactions with other groups in Stockholm. Early in the program, R. Werner introduced a Stockholm math colloquium audience to quantum information with a beautiful explanation of Bell inequalities. The first week of October, an International Conference on Quantum Information and Computation, October 4-8, 2010, was held in Stockholm in conjunction with both a Nordita Program on Quantum Information, and the Institut Mittag-Leffler program on Quantum Information Theory. Participants of the IML program, namely, C. Bennett, A. Holevo, R. Werner were plenary speakers invited by the Nordita organizers. In addition, P. Hayden, F. Verstraete, and M. Wolf gave invited talks in the Thursday program which the IML organizers were asked to plan as a showcase for the mathematical side of quantum information theory. There were many interactions between various groups during the rest of the conference, including contributed talks by IML participants E. Andersson, T. Heinosaari, and D. Leung. The highlight of joint activity during the other five weeks of the Nordita program was a visit to Institut Mittag-Leffler by A. Klyachko. In Nov.-Dec., Nordita held a program on random geometry with additional overlap of interests, particularly with those working on random matrices.

Organizing committee:

Alexander Holevo, Steklov Mathematical Institute, Moscow
Mary Beth Ruskai, Tufts University, USA
Erling Størmer, University of Oslo
Andreas Winter, University of Bristol, UK and National University of Singapore
Michael Wolf, University of Copenhagen
## Quantum Information Theory

### Participants 2010 fall

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<th><strong>City</strong></th>
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<td>Andersson, Erika</td>
<td>Heriot Watt University</td>
<td>Edinburgh</td>
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<td>Aubrun, Guillaume</td>
<td>Université Claude Bernard, Lyon 1</td>
<td>Villeurbanne</td>
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<td>Audenaert, Koenraad</td>
<td>University of London</td>
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<td>Bae, Joonwoo</td>
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<td>Bennett, Charles</td>
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<td>Yorktown Heights</td>
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<td>Berta, Mario</td>
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<td>Bjelakovic, Igor</td>
<td>Technische Universität München</td>
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<td>Brandão, Fernando</td>
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<td>Duan, Runyao</td>
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<td>Effros, Edward</td>
<td>UCLA</td>
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<td>Eisert, Jens</td>
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<td>Ericsson, Åsa</td>
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<td>Hiai, Fumio</td>
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<td>Horodecki, Karol</td>
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<td>Musat, Magdalena</td>
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<td>Oppenheim, Jonathan</td>
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<td>Palazuelos, Carlos</td>
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<td>Petz, Dénes</td>
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</table>
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Some of the participants on their way in the rain for lunch at Djurholms Värdshus.
Quantum Information Theory
Preprints 2010 fall

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**Douglas Farenick, University of Regina**
Non-commutative convexity

**Stanislaw Szarek, Case Western Reserve University**
Generic quantum states

**Kari Ylinen, University of Turku**
Quantum instruments and harmonic analysis

**Erling Størmer, University of Oslo**
An informal talk on positive maps

**Benoit Collins, University of Ottawa**
Random matrix theory and quantum information theory

**Ion Nechita, University of Ottawa**
Graphical calculus for random quantum channels

**David Perez-Garcia, Universidad Complutense de Madrid**
Tensor network states

**Vern Paulsen, University of Houston**
Applications of abstract operator systems to entanglement theory

**Marius Junge, University of Illinois at Urbana-Champaign**
Superdense coding and teleportation from an operator algebra and operator space perspective

**Andreas Winter, University of Bristol**
1001 quantum channel capacities

**Ed Effros, UCLA**
When QFA met QIT

**Magdalena Musat, University of Copenhagen**
Factorizable maps and the asymptotic quantum Birkhoff property

**Runyao Duan, University of Technology Sydney**
On the perfect distinguishability of quantum operations

**Koenraad Audenaert, University of London**
On telescopes and cuckoo clocks

**Runyao Duan, University of Technology Sydney**
On the perfect distinguishability of quantum operations

**Koenraad Audenaert, University of London**
On telescopes and cuckoo clocks

**Patrick Hayden, McGill University, Montreal**
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Fumio Hiai, Tohoku University, Aoba-ku, Sendai
Operator log-convexity and its applications

Alexander Holevo, Steklov Mathematical Institute
Entanglement-breaking channels in infinite dimensions.

Debbie Leung, University of Waterloo
Entanglement can increase rates of zero-error classical communication over classical channels

Toby Cubitt, University of Bristol
Laying the quantum and classical embedding problems to rest

Igor Bjelakovic, Technische Universität Berlin
Communication under adversarial quantum noise

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Faithful Squashed Entanglement

Milan Mosonyi, National University of Singapore
Operator distinguishability measures for information theory

Aram Harrow, University of Bristol
Schur-Weyl duality for fun and profit

Reinhard Werner, Leibniz Universität, Hannover
Quantum correlations - how to prove a negative from finitely many observations

Alexander Klyachko, Bilkent University, Ankara
Geometry and physics of invariant theory

Graeme Smith, IBM TJ Watson Research Center, Yorktown Heights
Superactivation of quantum channel capacities

Bruno Nachtergaele, University of California, Davis
Local perturbations perturb locally

Magdalena Musat, University of Copenhagen
On the asymptotic quantum Birkhoff conjecture

Volkher Scholz, Leibniz Universität
Tsirelson’s problem and the QWEP conjecture

Denes Petz, Alfred Renyi Institute of Mathematics, Budapest
An introduction to free probability

Guillaume Aubrun, Université Claude Bernard, Lyon I
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Participants from the Nordic Countries

Denmark
Kristensen, Simon, Aarhus
Heinosaari, Teiko, Copenhagen
Lunemann, Carolin, Aarhus
Musat, Magdalena, Copenhagen
Shulman, Tatiana, Copenhagen
Wolf, Michael, Copenhagen

Finland
Brännström, Niklas, Helsinki
Lahti, Pekka, Turku
Nordström, Kenneth, Oulu
Ylinen, Kari, Turku

Norway
Kruglikov, Boris, Tromsö
Stoermer, Erling, Oslo

Sweden
Andersson Forsman, Oscar, Stockholm
Aspenberg, Magnus, Gothenburg
Benedicks, Michael, Stockholm
Bjerklöv, Kristian, Stockholm
Gaidashev, Denis, Uppsala
Johnson, Tomas, Uppsala
Nilsson, Lisa, Stockholm
Saprykina, Maria, Stockholm
Schmeling, Jörg, Lund
Schnellmann, Daniel, Stockholm
Steif, Jeff, Gothenburg
Wiegman, Igor, Stockholm
Winckler, Björn, Stockholm
Markström, Klas, Umeå
Silvestrov, Sergei, Lund
Turowska, Lyudmila, Gothenburg
Öberg, Anders, Uppsala

Research in Peace (RIP)
Bölling, Reinhard, Potsdam, Germany
Holmbom, Anders, Mid Sweden University, Östersund
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Institut Mittag-Leffler publishes two research journals. *Acta Mathematica* was founded by Gösta Mittag-Leffler in 1882, while *Arkiv för matematik* traces its roots back to a journal founded in 1903 by the Royal Swedish Academy of Sciences.

Since January 1, 2006, Springer is handling printing, subscriptions and distribution of both journals. Naturally, the Institute retains full ownership and full editorial control of the journals. All back volumes of both journals have been digitized by Springer and are available on the web for subscribers.

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The influx of manuscripts has been very good.

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from 2010-12-01
Technical editor of Acta Mathematica, 50% from
October 2010 75%
Computer administrator, 80%
Administrator of the scientific program
Caretaker
Deputy Director, 40%, from 2010-09-01
Librarian
Head of administration and economy

Marie-Louise Koskull retired 31 December 2010 after 22 years at
Institut Mittag-Leffler. Here together with Kjell-Ove Widman, Dan
Laksov and Anders Björner, directors with whom she has been
working.

After 25 years at Institut Mittag-Leffler Mikael Rågstedt
receives a gold watch and is celebrated with a specially
made cake.
Library and historical archive

The library subscribes to several electronic journals and to around 110 print journals. In addition, we receive some 70 journals in exchange for *Acta Mathematica* and *Arkiv för matematik*.

Information and copies from the historical archive are frequently requested, including visits by mathematical historians.
## Financial statement (kSEK)

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<td>Contributions from Nordic countries</td>
<td>1 362</td>
<td>1 067</td>
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<td>Contribution from the Swedish Research Council (VR)</td>
<td>2 500</td>
<td>1 100</td>
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<td>Grant Income</td>
<td>1 424</td>
<td>1 260</td>
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<tr>
<td>Other Income</td>
<td>913</td>
<td>592</td>
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<td><strong>Total External Income</strong></td>
<td><strong>6 198</strong></td>
<td><strong>4 019</strong></td>
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<td>Journals net</td>
<td>672</td>
<td>495</td>
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<td>918</td>
<td>2 974</td>
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<td>1360</td>
<td>1 069</td>
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<td><strong>9 148</strong></td>
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