Quantum Information Theory, Fall 2010 at Institut Mittag-Leffler

Since Shor's discovery in 1994 of a polynomial time algorithm for factoring large numbers with a quantum computer, interest in using quantum systems for information processing increased dramatically. Although building a quantum computer remains a formidable technological challenge, other types of quantum information processing devices, particularly those for cryptographic purposes, have been demonstrated to be feasible. The theoretical side of quantum information processing is also developing rapidly, raising many interesting and difficult mathematical questions that go well beyond algorithm development and computational complexity. This semester at the Institut Mittag-Leffler will be devoted to mathematical questions in quantum information theory, with a particular emphasis on questions in operator theory, non-commutative analysis and convex geometry.

Quantum information theory today is a very multi-faceted field, with a multitude of mathematical connections: ranging from quantum error correcting codes (whose description and construction draws on classical coding theory as well as operator algebra theory), to quantum Shannon theory (linking with quantum versions of laws of large numbers, geometric measure concentration, and classical information theory), to quantum non-locality, i.e. "Bell inequalities" (convex geometry, and recently drawing on results on tensor norms), to quantum many-body physics (involving operator analysis, quantum laws of large numbers and, recently, increasing connections to theoretical computer science). Many of the interesting questions generated by quantum information theory appear as questions about "only" finite dimensional operators. Nevertheless, quantum information theory generates a wealth of highly nontrivial mathematical problems, due to several reasons: some questions involve asymptotic limits of the matrix size, others are concerned with nonlinear aspects of matrices such as functional calculus, the semidefinite partial order on matrices, or specific, well-motivated matrix norms.

The topics mentioned above, as well as related ones such as quantification and classification of entanglement, quantum complexity, quantum state estimation and hypothesis testing, have both its mathematical language and the physical intuition in common. Thus, the subject of quantum information theory is truly interdisciplinary, with collaborations often involving people in computer science and engineering as well as physics and mathematics. In addition to including most of the leading experts in quantum information theory among the participants, we plan to invite mathematicians working in related fields who have expressed an interest in interacting with quantum information theorists. We expect this cross-fertilization to be extremely productive and stimulating.

Program committee:
Alexander Holevo, Steklov Mathematical Institute, Moscow
Mary Beth Ruskai, Tufts University, MA
Erling Størmer, Oslo
Andreas Winter, Bristol, UK and National University of Singapore
Michael Wolf, Copenhagen