Quantum state discrimination and estimation

This course is an introduction to quantum state estimation and discrimination, which are arguably the most basic quantum information tasks. A single measurement on a single system provides a very little amount of information about its state and, furthermore, it alters the system irreversibly. The only way to increase our knowledge about the state is by measuring on a large set of identically prepared systems. Quantum resources are costly, thus finding optimal discrimination and estimation protocols and quantifying their performance is a must.

The course is divided in three blocks. In the first one, we revisit quantum measurement from an information theory perspective, and introduce the so called generalized measurements and positive operator valued measures (POVMs). The second and third blocks address the issues of state discrimination and estimation respectively. In both cases we pay special attention to the asymptotic limit of many copies. We show show several useful techniques in this context which can be of wider application.

1. Quantum measurements
   - 1.1 The measurement postulate. Von Neumann and generalized measurements: POVMs
   - 1.2 Collective, separable, LOCC and separate measurements
2. Quantum state discrimination
   - 2.1 Introduction to classical and quantum discrimination
   - 2.2 Unambiguous vs minimum error discrimination
   - 2.3 Asymptotic rates: Chernoff bound; metrics on the space of quantum states
   - 2.4 Discrimination with LOCC measurements
   - 2.5 Programmable discrimination
3. Quantum state estimation
   - 3.1 Introduction. Pointwise vs Bayesian estimation; Fisher information
   - 3.2 Optimal estimation for pure states
   - 3.3 Mixed states (qubits)
   - 3.4 LOCC estimation
   - 3.5 Cramér-Rao and Holevo bounds
   - 3.6 Scavenging of information, finite mixtures, etc.