

Course title: An introduction to Quantum Statistics

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Abstract: The recent advances in Quantum Information and Quantum Computation have brought a paradigm shift in the way we think about encoding and manipulating information. Atoms and photons are carriers of a new type of information and thanks to the modern technology we have reached the point where we can manipulate and measure individual quantum systems. A fundamental implication of these developments is that statistical inference based on data obtained by measuring a limited number of individual systems, will play a much greater role in quantum theory.

These lectures give a short overview of the current status in quantum statistics starting from the first methods developed in the 70's, and up to the latest theoretical and experimental results. The guiding principle is to adapt and extend well established 'classical' statistical inference techniques to the quantum set-up, and to identify the 'purely quantum' features that need to be explored. In parallel, some recent practical applications will be discussed.

First Lecture: Quantum mechanics as a probabilistic theory.

I will introduce some of the basic notion of quantum mechanics with an emphasis on the parallels and differences with probability theory.

Second lecture: Quantum Statistics: basic examples

I will define the set-up of quantum statistical problems and discuss a few basic examples such as the estimation of a qubit, Gaussian state, discrimination between two states. Then I will formulate the quantum Cramer-Rao bound and discuss its implications.

Third lecture: Asymptotics in Quantum Statistics

In this lecture I will give an introduction to a new technique in quantum state estimation, called 'local asymptotic normality'. This tool is an extension of the classical notion of asymptotic normality introduced in Mathematical Statistics by Lucien Le Cam. In the quantum setting, this shows that a large sample of independent, identically prepared quantum systems can be approximated by a quantum Gaussian state uniformly over a range of (unknown) parameters. This reduces the problem of optimal state estimation to that of estimating the mean of a Gaussian state.

Other applications of this technique will be mentioned.

Literature:

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