Quantum Statistical Dynamics and Control

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Timetable: 16 hrs. Class meets every Monday and Wednesday from 10:30 to 12:30. First lecture on Wednesday, June 1st, 2016. Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements: Linear algebra and probability theory.

Examination and grading: Homeworks.

Aim: The course starts by providing an introduction to (elementary) quantum mechanics from the viewpoint of probability theory, accessible without any quantum mechanics background. The second part of the course is devoted to the definition and the study of quantum dynamical semigroups. This class of dynamics is widely used to model physical systems of interest in quantum information and control. In the last part of the course, some applications, illustrating the use of the mathematical tools developed, will be presented, including problems of information encoding and state preparation for finite-dimensional systems.

Topics:

- **Quantum Theory as a Probability Theory:** Densities, observable quantities, measurements in a non-commutative setting. Composite systems and entanglement. Partial trace and marginal densities. (4h)
- **Quantum Dynamical Systems:** Unitary dynamics, open quantum systems and quantum operations. Kraus representation theorem. Examples for two-level systems. Quantum dynamical semigroup and completely positive generators, and their representations. (4h)
- **Stability Analysis:** Basic stability properties, existence and structure of the invariant sets. Elements of Lyapunov-type analysis and natural Lyapunov functions. (4h)
- **Applications:** Noiseless encodings of quantum information; Preparation of states, subspaces and subsystems; Feedback master equations and their control. (4h)

References:

- Lecture notes and supplementary material provided by the instructor;
- A good introductory reference to modern quantum mechanics for finite dimensional systems is contained in the first chapters of: M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum information (Cambridge, 2000).
- A "classic" reference for continuous-time dynamical semigroups is: R. Alicki and K. Lendi, Quantum Dynamical Semigroups and Applications. Springer-Verlag, Berlin, 1987.