Advanced Quantum Information Theory (WS 09/10)

Initial meeting: Monday, 12.10.2009 at 9.15 in room 25.31 HS 5J
(The lecture time and day can be discussed/shifted if necessary)

Summary:
This lecture is a continuation of the quantum information part of “Theoretical Quantum Optics and Quantum Information”. Attendance of this lecture is helpful but not mandatory. Here, we will focus on recent achievements and ongoing topics in quantum information theory. After a short repetition of the concepts of Quantum Mechanics we will discuss the notion of “non-locality” (why is quantum mechanics as it is) and how this can in principle be confirmed in experiments. It follows an outline of multi-partite entangled states and how entanglement can be detected or proven. The One-Way Quantum Computer approach, where specific entangled states, so-called Cluster States, are used, will be discussed. The next part will focus on the general problem of obtaining information about quantum states or sets of quantum states via measurements (state identification, characterization and discrimination). At the end we will discuss different types of operations and measurements (local, separable, general) and generalized superdense coding protocols with noisy channels.
Advanced Quantum Information Theory
Lecture Plan (WS 09/10)

- Fundamental Quantum Mechanics
  - basic principles of quantum mechanics
  - Bell inequalities
  - loopholes in Bell inequality tests
  - non-local boxes [arXiv:0808.0651]
  - information causality [arXiv:0905.2292]

- Multipartite Entanglement
  - distillability, separability
  - entanglement classes
  - entanglement criteria (Entanglement witnesses, covariance criterion, OMEC)

- Projected Entangled-Pair States (PEPS): A new approach in many body quantum simulations

- One-way Quantum Computation
  - cluster states, graph states
  - quantum gates by measurements
  - universality of measurement based quantum computation

- State Identification and Characterization
  - parameter estimation
  - state tomography (standard, maximum likelihood and bayesian mean estimation)
    - example: multipartite entanglement detection

- State Discrimination
  - minimum error discrimination (MED)
  - unambiguous state discrimination (USD)
  - other approaches

- Local Operations and Classical Communication (LOCC), Separable and General maps

- Superdense coding with many parties and noisy channels