

List of topics for the Quantum Exam

1. The general probabilistic framework of a physical system; state space and measurements, the “no restriction” principle. Joint measurements. The classical and the quantum case; states as density operators, measurements as “partitions of unities” (or “positive operator valued measures”).
2. Perfect distinguishability of states, the concept of n -level quantum systems and their classical informational capacity; game 1.
3. State discrimination, binary hypothesis testing; type I and II errors, the maximum chance of guessing the state correctly (the homework problem). Game 2 and its comparison with game 1; “the moral of the story”.
4. Bipartite systems: general description using tensorial products, partial states, marginals and partial traces, independence and product states, measurements on parts, entanglement.
5. Classical vs. quantum pre-arrangement; pseudo telepathy (game 3). Quantum coloring of graphs.
6. Non-signalling oracles, classical and quantum realisations, Bell and Tsirelson inequalities, Gisin’s theorem, Werner states.
7. Physical operations as convex combination preserving maps from $S_1^+(\mathcal{H})$ to $S_1^+(\mathcal{H})$, the no-cloning theorem and its consequences, complete positivity, reversible physical operations as unitaries.
8. Dense-coding: the discussed protocol, why is it strange, its relation to entanglement, quantum-teleportation and to secret sharing.