

Phys. 720: Selected Topics in Theoretical Physics

Quantum Information Science and Many-Body Physics

(Fall 2009, WPH204, M-W, 2-3,50 PM)

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Fifteen years have passed since the discovery of the fast factoring quantum algorithm by Peter Shor triggered the spectacular explosion of the Quantum Information Science (QIS) field. The momentum of that explosion is far from fading away and the field is still quite rapidly evolving and it by now it comprises somewhat specialized sub-areas.

This Course will focus on the the most active of those subareas: *the intersection between QIS and many-body physics*. QIS taught us that information is physical e.g., processing information quantumly might be better than doing that classically. Similarly physics is informational i.e., physical states always encode for some sort of information and their dynamics can be regarded as naturally enacted algorithm. In particular this implies that several of the conceptual as well as technical tools developed by the QIS community could be of big value in addressing important questions concerning complex, interacting many body systems.

The goal of this advanced Course is to bring you right at the frontier of this exciting research field.

Course contents: The (Very) Rough RoadMap

- 1) Equilibrium stat-mech: the quantum information foundation
- 2) Non equilibrium stat-mech: thermalization
- 3) Quantum entanglement in many-body systems
- 4) Quantum Phase transitions and entanglement
- 5) Area laws, variational quantum states and simulatability

6) Quantum fidelity and critical phenomena

Textbook

There won't be any. The Course will entirely be based on research papers published in the last few years. Relevant journal references will be provided time by time and/or posted on the BB. I may also in some (special) case provide handwritten notes.

Grading

Your grade will be determined by a

- A) Class participation. In principle I don't plan to give regular HWs but we'll have in-class problem solving sessions (one of you at the board the others helping...)
- B) *Final Exam* consisting of *two* parts: **a)** a chalkboard/slide presentation (30') about a class-related subject you pick. **b)** Oral exam: I ask, you answer (30')