

Ph225ab "Advanced Quantum Mechanics", (September 2004 – February 2005)

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SCHEDULE: Monday & Wednesday, 10:30 AM -- 12:00 PM.

LOCATION: 107 Downs

INFORMATION: http://www.its.caltech.edu/~yehgroup/ph225_2004/

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Ph225a

- **Introduction**

-- Overview of modern topics in quantum physics:

- 1) Quantum field theory in modern physics;
- 2) "Quantum cooperation" – collective quantum coherent phenomena;
- 3) Quantum computation and information.

- **Basics notations of quantum field theory**

- The Path-integral formalism.
- Feynman diagrams.
- The canonical formalism.
- Spinors, Dirac spinor field, and quantization of the spinor field.
- Renormalization and gauge invariance.
- Symmetry and symmetry breaking.
- Relativistic vs. non-relativistic quantum field theory.

- **Symmetries and Group theory**

- Basic properties of groups.
- SO(N) and SU(N) groups.
- Point groups.
- Selection rules and their applications.
- Double groups.
- Translation groups and space groups.
- Lorentz group and the Poincaré group.
- Hierarchy of symmetry groups and unification.

- **Symmetry breaking and phase transitions**

- Spontaneous symmetry breaking and the Nambu-Goldstone bosons.
- Landau-Ginzburg theory of critical phenomena.
- Mean-field theory of phase transitions.

Ph223b (First half of the winter term, from January to mid-February of 2005)

- **Application of quantum field theory to collective phenomena**

- Superfluids.
- Superconductivity.
- Peierls instability.
- Solitons.
- Vortices, monopoles and instantons.

- **Application of quantum field theory to condensed matter physics**

- Fractional statistics, Chern-Simons term, and topological field theory.
- Integer and fractional quantum Hall effects; quantum Hall fluids.
- Duality.
- Ferromagnetism and antiferromagnetism.
- Renormalization group theory.

Text Book:

“Quantum Field Theory in a Nutshell”, A. Zee, Princeton University Press (2003).

Reference Books:

“Principles of Condensed Matter Physics”, P. M. Chaikin & T. C. Lubensky, Cambridge University Press (1995).

“Group Theory and Quantum Mechanics”, M. Tinkham, McGraw-Hill Inc. (1964).