Physics 8.322 Quantum Theory II

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∅. Course Logistics

Lectures	M & W (& some F)	9:30-11:00	4-153	(WT)
Recitation	F	11:00 - 12:00	~~5-233~~ 8-302	~~(Y. He)~~ (N. Moeller) (moeller@mit.edu)

Homework: Assigned Mondays
Due following Monday by 4PM (4-339 B)
Graders: ~~Y. He~~ N. Moeller, J. Partsmath (jamiep@mit.edu)
HW 1: On web by next Mon. due Tues Feb 18

No exams - grade based on HW

Text: Sakurai: "Modern Quantum Mechanics" (revised edition [Red cover])

OH:

WT	M	11 AM	(6-308)
NM	F	3-4	(6-110)
JP	F	2-3	4-338 (Phys. tutorial room)

First Friday class: Fri. Feb ~~14~~ 14

Review/overview of last semester (8.321)

1. Fundamental concepts

- classical vs. quantum physics
- Hilbert spaces & operators
- Rules of QM
  - i) state = ray in $\mathcal{H}$
  - ii) Observable = Hermitian operator with complete set of eigenvectors
  - iii) $i\hbar \frac{d}{dt}|\psi(t)\rangle = H|\psi(t)\rangle$ (Schrödinger)
  - iv) Measurement & collapse

    Probability $A = a$: $\langle\psi|P_a|\psi\rangle$,

    $P_a = \sum_{j:a_j=a} |a_j\rangle\langle a_j|$

    After measurement, system $\longrightarrow |\tilde{\psi}_a\rangle = P_a|\psi\rangle / \sqrt{\langle\psi|P_a|\psi\rangle}$
- spin 1/2 systems
- tensor product spaces (e.g. multiple spin 1/2 particles)
- Position & momentum ops, translation
- Uncertainty relations
- Eigenvalue problems & methods for solving (op. methods, num. methods, variational method)

2. Time evolution

- Schrödinger, Heisenberg, & Interaction pictures
- time evolution operator $U(t, t_0)$
- connections between classical & quantum pictures
- Interpretation of wavefunction "probability fluid"
- path integrals
- QM in potential, EM fields

3. Angular momentum
   - $SO(3)$ & $SU(2)$
   - representation theory of $SU(2)$; $|j,m\rangle$, spherical harmonics
   - addition of A.M., Clebsch-Gordan coefficients
   - Wigner-Eckart theorem

4. Perturbation theory (time independent)
   - perturbative formalism for states & energies (degen. & nondegen.)
   - Examples in Hydrogen atom
     (Stark (E), Zeeman (B), Fine & hyperfine structure)
   - Nonconvergence of perturbation series - asymptotic expansions

5. Quantum statistics & measurement
   - Density matrices
   - Quantum stat. mech.
   - Measurement problem: Bell, GHZ

This semester

6. Time-dependent perturbation theory & radiation

7. Discrete symmetries, identical particles, & many-body systems

8. Scattering theory

9. Relativistic theory of electrons (Dirac eqn.)

10. Applications