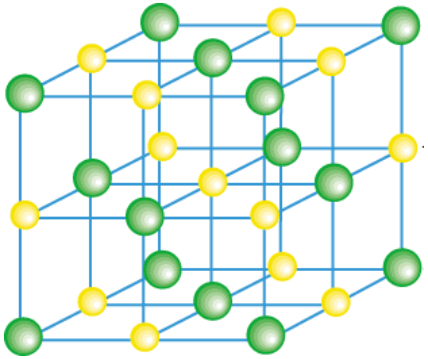
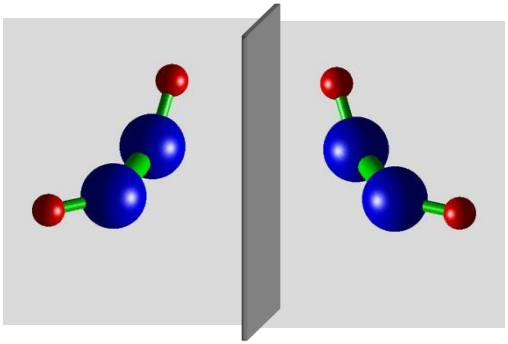
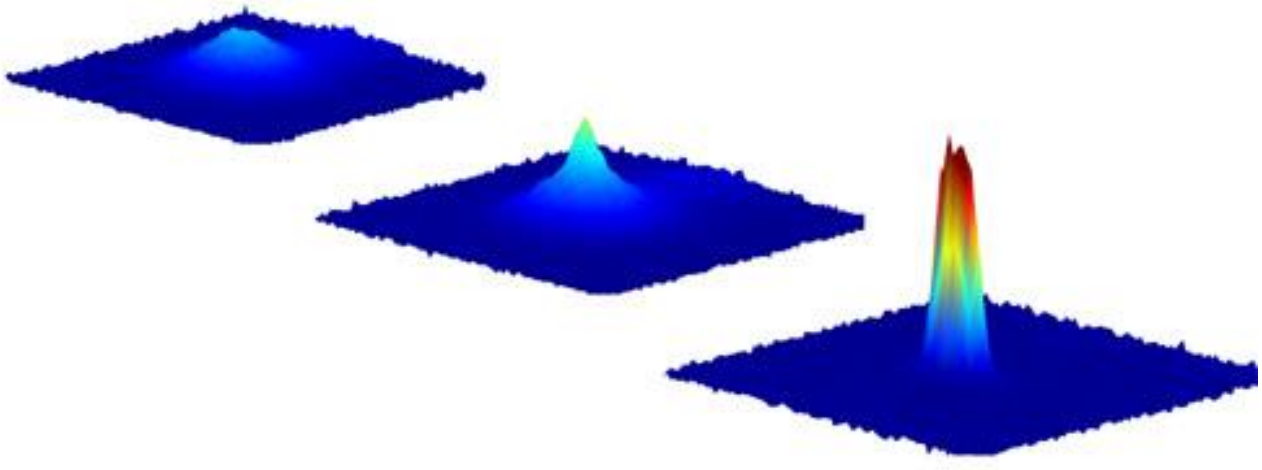
Physics 622:

Quantum Mechanics



-- *Part II* --





Instructors

Prof. Seth Aubin

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Charles Fancher

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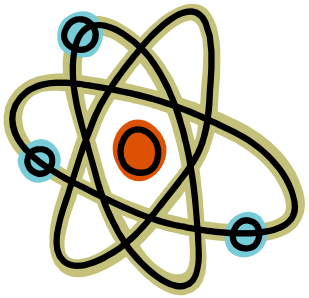
Office hours:

Aubin: Wednesday 3-4 pm
Fancher: Monday 2-3 pm

Course Objectives

The course will cover in-depth **quantum mechanical** treatments and related **calculation methods** necessary for understanding **atomic, molecular, optical, solid state**, **particle**, and **many-body systems**.



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- **Hydrogen**-like atoms, **fine** and **hyperfine structure**.
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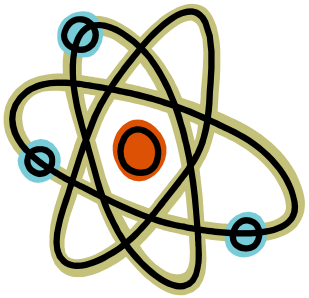

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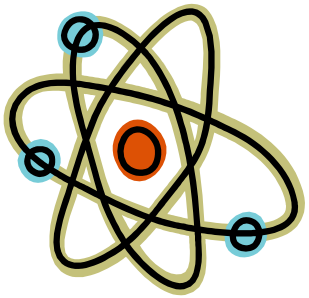

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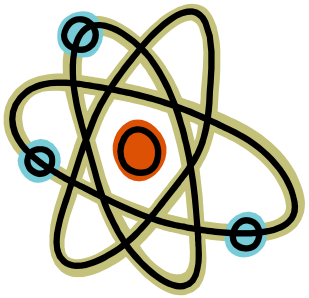

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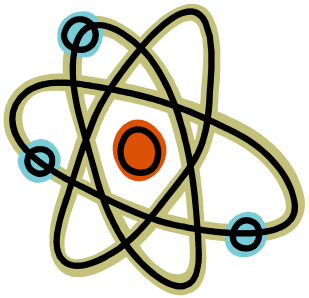

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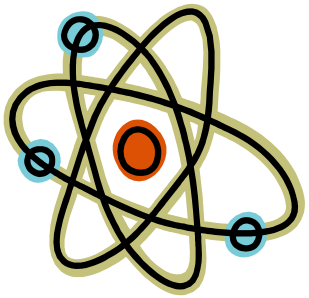

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- **Scattering theory:** from particle physics to cold atoms.
- Relativistic quantum mechanics, **Dirac equation**.

Course Work

- **Problem sets:** weekly.
- **Participation:** class attendance, classroom discussion, occasional quiz.
- **Midterm** (after spring break).
- **Final** covers all course material with emphasis on 2nd half of course.

Weighting:

Problem sets:	45%
Participation:	10%
Midterm:	15%
Final Exam:	30%
Total =	100%

References

Text: The majority of the course materials and problem sets will be taken from the following required text for the course:

Modern Quantum Mechanics, by J. J. Sakurai and J. Napolitano. (2nd ed., 2011)

Some course materials will also be taken from the following texts:

Quantum Mechanics, by C. Cohen-Tannoudji, B. Diu, and F. Laloë (1st ed., 1992).

Quantum Mechanics, by L. I. Schiff (3rd ed, 1968).

Quantum Mechanics, by L. D. Landau and E. M. Lifshitz (3rd ed., 2003).

Schedule (I)

Week 0: 1/16 **Hydrogen atom review**
Hamiltonian, energy levels, electronic states, additional corrections.

Week 1: 1/21-23 **Perturbation theory (time-independent)**
Basic theory, 2-level systems, Van der Waals interactions.

Week 2: 1/28-30 **Degenerate perturbation theory**
Basic theory, no-crossing theorem, spin-orbit coupling

Week 3: 2/4-6 **Fine, hyperfine, and nuclear structure**
Spin-orbit coupling, nuclear spin, and nuclear structure.

Week 4: 2/11-13 **Zeeman and Stark effects**
Atoms in electric and magnetic fields, Wigner-Eckart theorem

Week 5: 2/18-20 **Variational method**
Ground state approximations, Ritz th., mini-max th., oscillation th.

Week 6: 2/25-27 **Time-dependent quantum systems**
2-level systems, Landau-Zener transitions, Rabi flopping.

---------- Spring Break ----------

Schedule (II)

Week 7: 3/11-13 **Midterm, time-dependent perturbation theory**
Fermi golden rule, Wigner-Weisskopf theory of excited state decay.

Week 8: 3/18-20 **Discrete symmetries**
Parity symmetry (and parity violation), time-reversal symmetry.

Week 9: 3/25-27 **Identical particles and multi-particle systems**
Bosons, Fermions, 2nd quantization, quantization of EM field.

Week 10: 4/1-3 **Lattice translation symmetry**
Tight binding model, Bloch theorem, basic band theory, Bloch oscillations.

Week 11: 4/8-10 **Scattering theory I**
Partial wave expansion, scattering length, quantum statistics.

Week 12: 4/15-17 **Scattering theory II … Dirac Equation I**
Born approximation, Lippman-Schwinger, Klein-Gordon equation, Dirac equation

Week 13: 4/22-24 **Dirac Equation II**
Symmetries, Dirac equation for a central potential

May 1, 2014, 14:00-17:00 **Final Exam**

Quantum Accuracy

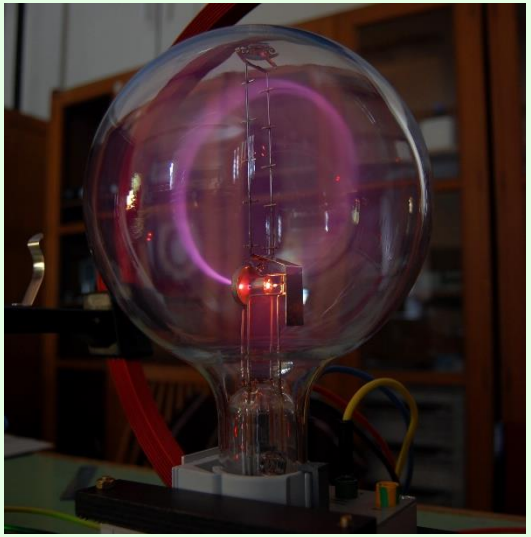
Electron's g-factor

Schrodinger: $g_e = 1.0$

Dirac: $g_e = 2.0$

QED: $g_e = 2.002\ 319\ 304\ 362$

12-digits



[Wikipedia, 2009]

Theory and experiment agree to 9 digits.