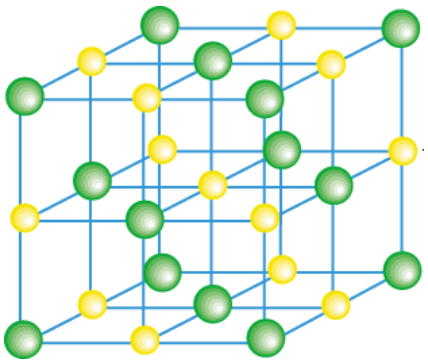
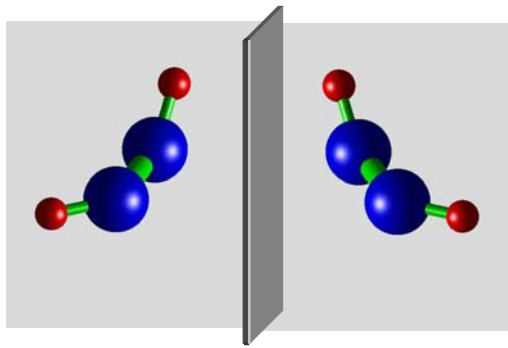
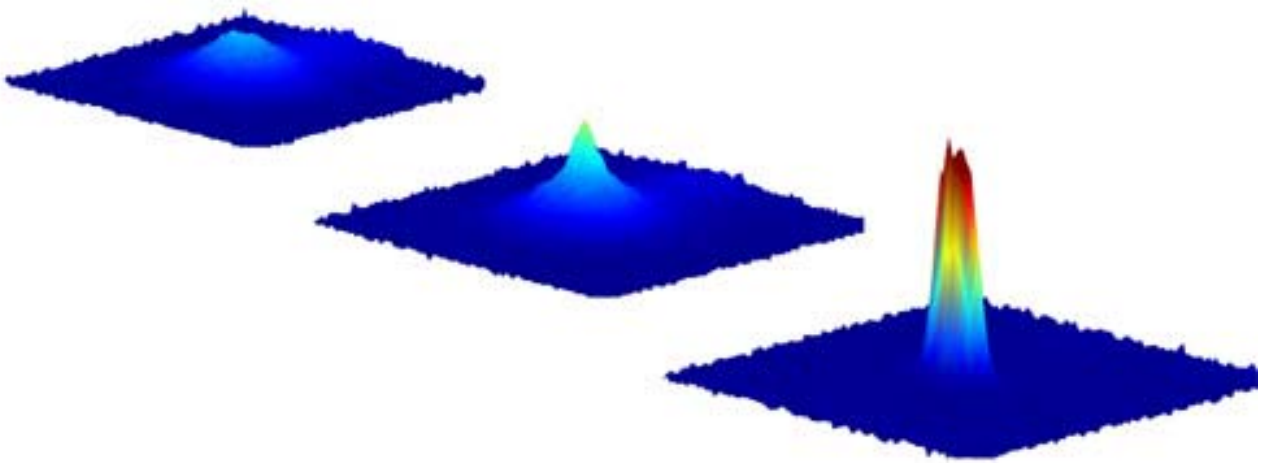
Physics 622:

Quantum Mechanics



-- *Part II* --





Instructors

Prof. Seth Aubin

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Lab: room 069, Small Hall (new wing), tel: 1-3532
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Satrio Gani

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e-mail: mgani@email.wm.edu

Martin Rodriguez-Vega

Office: room 135, Small Hall
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Office hours:

Aubin: Wednesday 3-4 pm
Gani: Tuesday 3-4pm
Rodriguez-Vega: Monday 11am-noon

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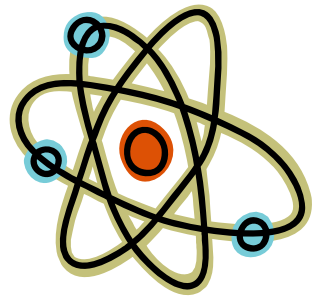
The course will cover in-depth **quantum mechanical** treatments and related **calculation methods** necessary for understanding **atomic, molecular, optical, solid state**, **particle**, and **many-body systems**.



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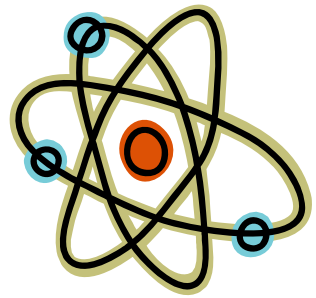

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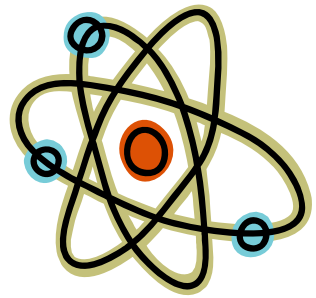

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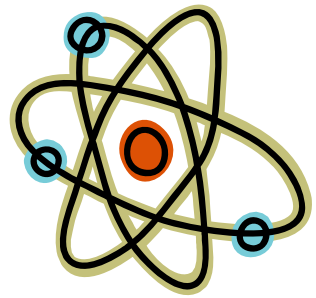

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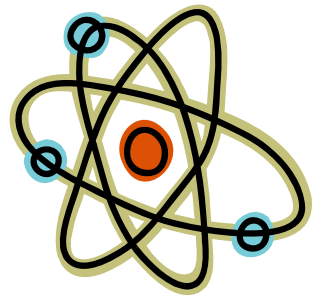

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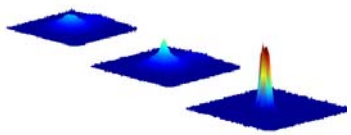

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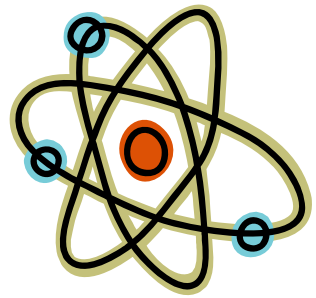

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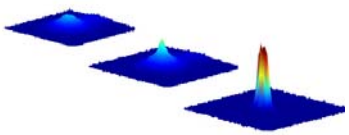
- ***Quantization of the electromagnetic field.***
- Relativistic quantum mechanics, **Dirac equation**.



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

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

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

Schedule (I)

Week 0: 1/17 **Hydrogen Atom Review**
Hamiltonian, energy levels, electronic states.

Week 1: 1/22-24 **Perturbation Theory (time-independent)**
Basic theory, degenerate theory, nuclear radius, Van der Waals force.

Week 2: 1/29-31 **Variational Method**
Ground state energy perturbations, no-level-crossing theorem.

Week 3: 2/5-7 **Stark and Zeeman Effects**
Interaction of an atom with electric and magnetic fields.

Week 4: 2/12-14 **Fine and Hyperfine Structure**
Spin-orbit coupling, nuclear spin

Week 5: 2/19-21 **2-Level Systems**
Rabi oscillations, rapid adiabatic passage, Landau-Zener transitions.

Week 6: 2/26-28 **Perturbation Theory (time-dependent)**
Fermi's golden rule, sinusoidal perturbations, transition amplitudes.

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

Schedule (II)

Week 7: 3/12-14 **Midterm**

Week 8: 3/19-21 **Fundamental Symmeries**
Parity (and parity violation), time-reversal, lattice translation.

Week 9: 3/26-28 **Identical Particles**
Bosons, Fermions, Pauli exclusion principle, helium, multi-electron atoms.

Week 10: 4/2-4 **Scattering Theory**
T matrix, Lippman-Schwinger equation, Born approx., partial wave expansion.

Week 11: 4/9-11 **Scattering … Second Quantization**
Scattering length, many-body physics, Gross-Pitaevskii equation.

Week 12: 4/16-18 **Quantization of the Electromagnetic Field**
Hamiltonian approach, photons, Casimir force.

Week 13: 4/23-25 **Dirac Equation**
Klein-Gordon equation, gamma matrices, anti-particles, hydrogen revisited

May 6, 14:00-17:00 **Final Exam**

Quantum Accuracy

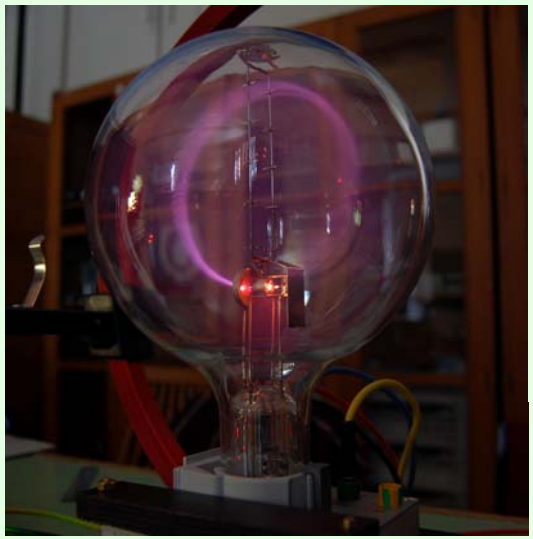
Electron's g-factor

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.