Week 1 (2/23)
1.5 hours on “Recent success in using quantum simulations to understand interesting physics and chemistry”
- Using quantum chemistry methods to predict metal surface reactions
- Ab initio molecular dynamics simulation on liquid/solid phase of water
- Quantum chemistry calculation of proteins
- Reaction dynamics using quantum chemistry based trajectories to understand curious reaction features for CD$_3$H+F

1.5 hour on “Born-Oppenheimer approximation and its failures (using equations)”

Week 2 (3/1)
2 hours of “Linear Combination of Atomic Orbitals (using equations and figures)”
- Diatomic molecules (H$_2^+$, H$_2$)
- Polyatomic molecules using LCAO

1 hours of “Vibration of diatomic molecules”
- Harmonic oscillator, morse oscillator
Week 3 (3/8)
1.5 hours on “Vibration in polyatomic molecules, normal modes”
1.5 hours on “Potential Energy Surface and reaction”

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Michitoshi Hayashi

Week 1 (3/15)
Wave-particle duality of large molecules
-- Review on the foundation and concept of quantum theory and its application to molecules

Week 2 (3/22)
Van der Waals force and weak interactions
-- Quantum fluctuation, Coulomb interaction, Exchange energy, etc.

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Jer-Lai Kuo

Week 1 (3/29)
Understanding structure of water via molecular spectroscopies (I)
-- This lecture will introduce different spectroscopic methods to probe different structures of water in gas, liquid to crystalline phases.

Week 2 (4/12)
Understanding structure of water via molecular spectroscopies (II)
-- We will introduce a few simple examples on how computational methods can be useful to understand experimental data to extract structural information.

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Ming-Shine Chang

3 weeks (4/19, 4/26, 5/3)
1. Introduction to atom-photon interaction
   - Two-level atom without spontaneous decay
   - Coherent control on a two-level atom: Rabi’s and Ramsey’s methods
   - Two-level atom with spontaneous decay
   - Optical Bloch equation

2. Atom trapping and cooling
Optical force on atoms
- Laser cooling
- Magneto-optical trap
- Magnetic trap
- Optical dipole trap
- Evaporative cooling

Ying-Cheng Chen

3 weeks (5/10, 5/17, 5/24)
1. Atom-photon interaction in a three-level system (4hrs)
   - Electromagnetically induced transparency (EIT)
   - Slow light, Storage of light and stationary light
   - Nonlinear optics based on the EIT
   - Single photon and bi-photon generation based on EIT

2. Coherent manipulation of atoms with lasers
   - Raman transition
   - Controlling the internal and external states
   - Application to quantum information sciences

Yu-Ju Lin

3 weeks (5/31, 6/7, 6/14)
- atoms dressed by photons
- Bose-Einstein condensates
- selected topics of cold atoms in optical lattices

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