Title: Probing Quantum Materials with Light

Outline for 6 online sessions for the CIQM Online Community.

Max enrollment: 30

This course will help give students a foundational knowledge of quantum materials and how they can be probed with light from an experimentalist’s viewpoint. No background knowledge is assumed.

Goals of course – be able to understand what a quantum material is and the optical spectroscopy techniques that are commonly used to probe quantum materials.

Time commitment of students: 12 hours of live online participation, plus time reading, plus time problem solving. (no formal exams or grading)

Online session dates:

2 hour ‘lecture and discussion’ each Wednesday from 1-3 pm,

Duration: June 24th – July 29th

Lecture Session Topics: (tentative)

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| Wednesday 2 hour sessions |
| June 24th - Introduction to materials science and solid-state physics concepts that are essential for understanding quantum materials |
|  What is a crystal? What is a band gap? How do band structures arise in a material? How band  structures can be engineered? What are bosons, fermions, photons, phonons? |
| July 1st - What experimental observations lead to the formulation of quantum mechanics? |
|  Wave particle duality. The photoelectric effect. How do we know about spin? Atomic emission spectra. |
| July 8th - A crash course in linear algebra |
|  What is an eigenvector or an eigenvalue? Why are they useful concepts? |
| July 15th - Different types of optical spectroscopy in context |
|  UV-VIS, FTIR, Raman, PL, SHG. What information can be extracted about a material from each technique?  |
| July 22nd - Introduction to group theory for spectroscopists |
|  The mathematical formalism behind selection rules for the different types of optical spectroscopy |
| July 29th - Applications of optical spectroscopy for probing quantum materials |
|  Single layer determination of TMDs, PL of NV Centers in diamonds, polarized Raman and polarized SHG for determination of crystal orientation in TMDS, circular polarized PL for valleytronics, optical bandgap determination with UV-VIS,  |