Peter L Cook

Associate Professor of Physics
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Education

Ph. D. Experimental Condensed Matter Physics, University of Wisconsin – Madison
Madison, WI. May 2011.
Thesis: NEXAFS Spectroscopy of Biomimetic Dye Molecules for Solar Cells
Adviser: Franz J. Himpsel

M.A. Physics, University of Wisconsin - Madison, Madison, WI. December 2007.

B.S. Physics (with optics and math), Calvin College, Grand Rapids, MI. January 2006.

Interests and Skills

Synchrotron based spectroscopy, especially NEXAFS.
UHV chamber design and maintenance.
Physics pedagogy theory and practice, especially applied to demonstrations and assessment.

Activities

Professor of Physics at University of Wisconsin – Superior. Aug 2011 – Present. Promoted to Associate Professor June 2016. Tenured June 2017.

Science Fair Judge and judge coordinator. I judge a local middle or high school science fair typically once a year. For the last three years I coordinated approximately six UWS science majors to also judge a local middle school science fair – this is a short, quality academic service learning experience. 2012 – Present.

Science Night Physics Room. One night each year, UW Superior attracts members of the general public to teach them about science. I organize a themed set of interactive demonstrations staffed by approximately seven college students and staff to teach the 500-1000 people who come to our room some aspect of physics. Spring 2011 – Present.

Mobile E&M Experience – a 30-50 minute group of high interest demonstrations and interactive learning experiences focused on electricity and magnetism. It is designed to be taken into middle-school classrooms. I have started developing a similar set of experiences focused on Light and Color. Periodically by request Aug 2013 – Present.

Museum guide of physics demonstrations for preschool through college classes and the general public at the L.R. Ingersoll Museum of Physics in Madison Wisconsin. June 2010 – May 2011.

Delta Program – Two graduate courses, one seminar, and multiple workshops focused on the teaching and learning of science as applied to the college classroom, the general public, and mentoring relationships. September 2009 – May 2011.

Practicum with Mark Kern at Madison College. Semester long observation and reflection on teaching practice in a second semester physics course. Fall 2010.

Researched, designed and implemented a *Physics of Sound* booth for University of Wisconsin Science Expeditions event for the general public. Spring 2010.

Mentored an REU student doing research at the Synchrotron Radiation Center. Summer 2008.

Teaching Assistant at University of Wisconsin – Madison. August 2006 - Dec 2007.

Courses I have taught (as of Spring 2018)

- Algebra based Introductory Mechanics, five times.
- Calculus based Introductory Mechanics, seven times.
- Calculus based Introductory Electromagnetism with Optics, seven times. (My favorite.)
- Advanced Physics Laboratory (students choose 2 or 3 independent projects to complete during the semester, they submit a paper for each project and give an oral presentation), four times.
- Quantum Mechanics (first half of Griffiths), twice.
- Classical Mechanics (300 level, 4 credits), twice.
- Thermodynamics and Statistical Mechanics, once.
- Electronics, once as a pilot course done independent study with two students.
- As a graduate student I assisted for a course called “Physics in the Arts” which was a 100-level lab course on light and sound designed for non-science majors. I would love to recreate this course because light and sound is fascinating for me and many students.

Research Interests

NEXAFS Spectroscopy for Solar Cells

My primary research tool is synchrotron soft x-ray spectroscopy – mostly NEXAFS (near edge x-ray absorption fine structure) spectroscopy. By shining soft x-rays (100-1000 eV) at molecules, core level electrons are excited into the unoccupied states, which then decay by emitting electrons and photons. I typically measure the electron current. From this one can learn an incredible number of things about molecules including their energy structure, the presence or absence of particular molecular bonds, the oxidation state and spin states of metal atoms, the physical orientation of molecules on a substrate, and the crystal field parameters a metal atom.

My primary research goal is to systematically study organic dye molecules that are potentially useful in dye-sensitized solar cells (a.k.a. Gratzel cells). Conventional solar cells like any silicon-based semiconductors are very well understood. Unfortunately conventional solar cells are fundamentally too expensive to produce because it takes several years of continuous operation to recreate the energy used to make the silicon crystals in the solar cell. Organic dyes are potentially inexpensive alternatives to the silicon and are abundant in nature (e.g. chlorophyll, hemoglobin, and cytochrome). So far, theory is unable to accurately predict the energy levels of such organic semiconductors. By using x-ray spectroscopy, I study the effects of systematically changing these dye molecules and I hope to expand further to study the interaction of these dyes with potentially useful electron donor and acceptor materials.

Physics Demonstrations Education Research

A completely different area of research that I want to pursue centers on my love of a good physics demonstration. I believe physics demos *can* effectively build people's physical insight and excite them to learn about the physical world. When I was a guide at an interactive physics museum I observed that if unaided, many people cannot appropriately interact with or learn from a "perfectly good" demo. They come away thinking that the demos are boring, too hard, too abstract, or just broken. However, at other times the very same demo, often with a bit of help or explanation would open a new world of thought and understanding. A few of my questions are: 1) Are physics demos an effective way to teach physics concepts or are they just fun and exciting? 2) What makes a good physics demo? Which designs are effective? 3) What types of concepts are best taught with a demo? 4) Do people need someone to help explain and interpret what they are experiencing for them to learn?

I wish to collaborate with one to three students and one or two faculty members with expertise in education or museum research. Students can contribute to every aspect of this project by designing, building, and testing a demo for their favorite physics concept, observing how people interact with the demo, measuring what and how well people learn about the physical world, and using that data to redesign and improve the demo. Ultimately I would like to build an *effective* physics demonstration museum.

Publications

My name bold, the names of my students underlined.

P L Cook, P S Johnson, J M Garcia-Lastra, C Kennedy, N Jersett, I Zegkinoglou, F J Himpsel
The 2p-to-3d Multiplet of Fe in 2D vs. 3D Organic Cages
In preparation *J. Chem. Phys.* (2017).

P L Cook
Binomial Approximation
https://en.wikipedia.org/wiki/Binomial_approximation (Feb 17, 2017).
Note: The article before my changes was a mere stub containing conceptual errors and a derivation that only reveals the linear correction. My edits fixed two significant conceptual errors in the introduction, rewrote half of the introduction, included a derivation of the Binomial Approximation using a Taylor Series expansion which explains how to get any higher order correction, and provided two example simplifications one which uses the quadratic term. Overall I quadrupled the length of the article.

F J Himpsel, **P L Cook**, I Zegkinoglou, I Boukahil, R Qiao, W Yang, S C Pemmaraju, D Prendergast, C X Kronawitter, M G Kibria, Z Mi, L Vayssieres.
Synchrotron-based spectroscopy for solar energy conversion.
Proc. SPIE 9560, Solar Hydrogen and Nanotechnology X, 95600G (2015).

P S Johnson, J M Garcia-Lastra, C Kennedy, N Jersett, I Boukahil, F J Himpsel, **P L Cook**
Crystal field of porphyrins and phthalocyanines from polarization-dependent 2p-to-3d multiplets
J. Chem. Phys. **140**, 114706 (2014).

F J Himpsel, **P L Cook**, G de la Torre; J M Garcia-Lastra, R Gonzalez-Moreno, J-H Guo, R J Hamers, C X Kronawitter, P S Johnson, J E Ortega, D Pickup, M-E Ragoussi, C Rogero, A Rubio, R E Ruther, L Vayssieres, W Yang, I Zegkinoglou
Design of Solar Cell Materials via Soft X-ray Spectroscopy
Review article at *J of Electron Spectroscopy and Related Phenomena **190**, 2 (2013).*

C J Thode, **P L Cook**, Y Jiang, M Serdar Onses, S Ji, F J Himpsel, P F Nealey
In situ Metallization of Patterned Polymer Brushes Created by Molecular Transfer Print and Fill
Nanotechnology **24**, 155602 (2013).

D F Pickup, I Zegkinoglou, B Ballesteros, C R Ganivet, J M García-Lastra, **P L Cook**, P S Johnson, C Rogero, F de Groot, A Rubio, G de la Torre, J E Ortega, F J Himpsel
Influence of Axial and Peripheral Ligands on the Electronic Structure of Titanium phthalocyanines
J. Phys. Chem. C **117**, 4410 (2013).

P S Johnson, **P L Cook**, I Zegkinoglou, J M García-Lastra, A Rubio, R E Ruther, R J Hamers, F J Himpsel
Electronic Structure of Fe- vs. Ru-Based Dye Molecules
J. Chem. Phys. **138**, 044709 (2013).

I Zegkinoglou, **P L Cook**, P S Johnson, W Yang, J Guo, D Pickup, R González-Moreno, C Rogero, R E Ruther, M L Rigsby, J E Ortega, R J Hamers, F J Himpsel
Electronic Structure of Diamond Surfaces Functionalized by Ru(tpy)2
J Phys. Chem. C **116**, 13877 (2012).

P S Johnson, **P L Cook**, X Liu, W Yang, Y Bai, N L Abbott, F J Himpsel
Imide Photodissociation Investigated by X-ray Absorption Spectroscopy
J Phys. Chem. B **116**, 7048 (2012).

P L Cook, J L Vanderhill, A E Cook, D Van Norstrand, M T Gordon, P E Harper
Light Scattering Measurement and Avrami Analysis of the Lamellar to Inverse Hexagonal Phase Transition Kinetics of the Lipid DEPE.
Chemistry and Physics of Lipids **165**, 270 (2012).

R Gonzalez-Moreno, **P L Cook**, I Zegkinoglou, X Liu, P S Johnson, W Yang, R Ruther, R Hamers, R Tena-Zaera, F J Himpsel, J E Ortega, C Rogero
Attachment of protoporphyrin dyes to nanostructured ZnO surfaces: characterization by Near Edge X-ray Absorption Fine Structure Spectroscopy.
J. Phys. Chem. C **115,** 18195 (2011).

P S Johnson, **P L Cook**, X Liu, W Yang, Y Bai, N L Abbott, F J Himpsel
Universal mechanism for breaking amide bonds by ionizing radiation.
J. Chem. Phys. **135**, 044702 (2011).

P L Cook, W Yang, X Liu, J M García-Lastra, A Rubio, F J Himpsel
Unoccupied states in Cu and Zn octaethyl porphyrin and phthalocyanine.
J. Chem. Phys. **134,** 204707 (2011).

M S Onses, C J Thode, C Chun Liu, S Ji, **P L Cook**, F J Himpsel, P F Nealey
Site-Specific Placement of Au Nanoparticles on Chemical Nano-Patterns Prepared by Molecular Transfer Printing Using Block-Copolymer Films.
Advanced Functional Materials **21**, 3074 (2011).

J M García-Lastra, **P L Cook**, F J Himpsel, A Rubio
Systematic shifts of the lowest unoccupied molecular orbital peak in x-ray absorption for a series of 3d metal porphyrins.
J. Chem. Phys. **133**, 151103 (2010).

Y Bai, X Liu, **P Cook**, N L Abbott, F J Himpsel
Characterization of Surfaces Presenting Covalently Immobilized Oligopeptides Using Near-Edge X-ray Absorption Fine Structure Spectroscopy.
Langmuir **26**, 6464 (2010).

D G de Oteyza, Y Wakayama, X Liu, W Yang, **P Cook**, F Himpsel, E Ortega
Effect of fluorination on the molecule-substrate interactions of pentacene/Cu(100) interfaces.

Chem. Phys. Lett. **490**, 54 (2010).

P L Cook, P S Johnson, X Liu, A L Chin, F J Himpsel
Radiation damage in biomimetic dye molecules for solar cells.
J. Chem. Phys. **131**, 214702 (2009).

P L Cook, X Liu, W Yang, F J Himpsel
X-ray absorption spectroscopy of biomimetic dye molecules for solar cells.
J. Chem. Phys. **131**, 194701 (2009).

L A Molnar, M J Haegert, C N Beaumont, M J Block, T H Brom, A R Butler, **P L Cook**, A G Green, J P Holtrop, K M Hoogeboom, J J Kulisek, J S Lovelace, J S Olivero, A Shrestha, J F Taylor, K D Todd, J D Vander Heide, S O Van Scoter.
Lightcurve Analysis of a Magnitude Limited Asteroid Sample.
The Minor Planet Bulletin **35** 9-12 (2008).

Presentations and Posters

Sylvester Coker-Gibbs, **P L Cook**
Making Electricity with an Exercise Bike
UW–Superior Department of Natural Science Undergraduate Research Symposium (2017).

Jonathan K Patras, **P L Cook**
Color Prediction of an Optically Active Material
UW–Superior Department of Natural Science Undergraduate Research Symposium (2017).

Samantha R McClung, **P L Cook**
How does the Location of a Hole in a Pipe Instrument Change its Natural Resonance?
UW–Superior Department of Natural Science Undergraduate Research Symposium (2017).

P L Cook
Estimation – how to generate quality numbers based on limited information.
UW–Superior Teach-in on the situation at UWS (2017).

P L Cook
The Monkey Zone: Understanding random guessing in assessment of introductory physics students.
Kicking Ass-essment Workshop. University of Wisconsin – Superior (2016).

C Kennedy, **P L Cook**
Revealing Unoccupied Energy Levels in Organic Molecules for Solar Cells.
UW–Superior Department of Natural Science Undergraduate Research Symposium (2014).

N Jersett, **P L Cook**
Inverted (Kapitza's) Pendulum.

UW–Superior Mathematics and Computer Science Department Colloquium (2014).

C Kennedy, P Johnson, I Boukahil, F J Himpsel, **P L Cook**
Revealing Unoccupied Energy Levels in Organic Molecules for Solar Cells.
WiSYS Science and Technology Foundation Symposium (2013).
Poster also presented at the Annual URSCA Celebration (2014).

P L Cook, N Jersett, C Kennedy, P S Johnson, F J Himpsel
Shining light on solar power with x-rays and blue jeans
UW–Superior Thursday Noon Seminar (2013).

P L Cook, X Liu, F J Himpsel
NEXAFS Spectroscopy of Biomimetic Dye Molecules for Solar Cells.
Physical Electronics Conference (2010).

P L Cook, X Liu, W Yang, F J Himpsel
NEXAFS Spectroscopy of Biomimetic Dyes for Solar Cells.
American Physics Society March Meeting D20.00008 (2009).

M T Gordon, M J Machiela, **P L Cook**, P E Harper
2-D Cellular Automata Simulation of the L_{α}–H_{II} phase transition.
Biophysical Journal Meeting **86** 368A (2004).

Grants Received

Innovation Project to create an Associate's of Science Degree in Pre-Engineering at UWS. January 2016. $6k.

SURF (Summer Undergraduate Research Fellowship) to fund an undergraduate student to accompany me to the Synchrotron Radiation Center to collect NEXAFS data during summer 2013. $3k.

Wisconsin System Applied Research Grant for *Donor dye pairs for dye-sensitized solar cells.* June 2012. $22k.