NIU Course Syllabus for Physics 659

Special Problems in Physics

Spring Semester, 2015, Independent study (Daniel Boyden)

Special problems in physics under supervision of staff. Problems may be technical in nature or concerned with teaching procedure. May be repeated to a maximum of 15 semester hours, but no more than 10 semester hours may apply toward a master's degree.

Class room: FW101
Instructor: Yasuo Ito. La Tourette 218 and/or 101 (Electron Microscopy Lab)
Tel: 815-753-6477
e-mail: yito@niu.edu (preferred)
Office Hours: Tuesdays, Thursdays, and Fridays 2:00 pm – 3:00 pm; Other hours by an appointment.
Prerequisites : Consent of department
Credits: 2
Textbook/references:

- ✓ Transmission Electron Microscopy, 2nd ed., D.B. Williams and B. Carter, Springer (2009)
- ✓ Electron Energy-Loss Spectroscopy in the Electron Microscope, 3rd ed., R.F. Egerton, Springer (2011)
- ✓ Introduction to Conventional Transmission Electron Microscopy, M. de Graef, Cambridge press (2003).
- ✓ M. Nelhiebel, P.H. Louf, P. Schattschneider, P. Blaha, K. Schwarz, and B. Jouffrey, Theory of orientation-sensitive near edge-fine structure core-level spectroscopy, Phys.Rev.B.59,12806(1999).
- ✓ Jan Rusz, , Olle Eriksson, Pavel Novak, Peter M. Oppeneer, Sum rules for electron energy loss near edge spectra, Physical Review B. 76, 060408.(2007)
- ✓ Jan Rusz, Stefano Rubino, Peter M. Schattschneider , First-principles theory of chiral dichroism in electron microscopy applied to 3d ferro-magnets, Physical Review B.75, Pg.214425.(2007)

Overview: Over the course of the spring 2015 semester, the goal is to verify/test the applicability of electron energy-loss " Sum Rules" developed by Jan Rusz to the Electron chiral Magnetic Dichroism (EMCD) signal. A very preliminary work in spring 2014 was done and analyzed the test data by the student, Dan Boyden, and this work showed confidently that the measurements do work to within 30 percent of the accepted values. However, 30 percent is still a large error that was mostly introduced in the data analysis methods, such as integration and normalization.

This project require deeper knowledge of quantum mechanics, especially related to the theory of inelastic scattering, magnetism, crystallography, and transmission electron microscopy/diffraction and the electron energy-loss spectroscopy as well as x-ray absorption spectroscopy.

Goals:

A. Student will learn deeper knowledge of quantum mechanics and (electron) optics and spectroscopy, especially related to the theory of inelastic scattering, magnetism, crystallography, and transmission electron microscopy/diffraction and the electron energy-loss spectroscopy as well as x-ray absorption spectroscopy. Also the student will learn programing skills and the operation of the transmission electron microscoope

B. EMCD
   i. Optimization of the integration and normalization in the data analysis methods.
   ii. More precise calculations of parameter needed to evaluate the sum
   iii. By doing i and ii, increase the confidence up to 10% of the measured value comparable to the confidence level of the x-ray counterpart experiment (XMCD).

C. Building a basic condensed matter calculation libraries.
   i. Building a set of basic condensed matter calculation libraries that are necessary set of tools.
   ii. Apply this library to simulate basic electron energy-loss spectra for a more complete analysis of the data.

Grading (tentative)**:**

This is an independent study/research course. The evaluation will be done by one progress report and presentation, and the final report and presentation at the end of the semester. These reports and presentation will contain status and results of the above goals. Since this is on-going research, the absolute completion of the project is not required and should not be a component of the final grade.

Grading scale:

A ($90 \leq x$), A- ($85 \leq x < 90$), B+ ($80 \leq x < 85$), B ($75 \leq x < 80$), B- ($70 \leq x < 75$), C+ ($65 \leq x < 70$), C ($60 \leq x < 65$), C- ($55 \leq x < 60$), D ($50 \leq x < 55$), F ($x < 50$).

Grade points (assigned by University):

A (4.00), A- (3.67), B+ (3.33), B (3.00), B- (2.67), C+ (2.33), C (2.00), C- (1.67), D (1.00), F (0.00).

Accessibility Statement

Northern Illinois University is committed to providing an accessible educational environment in collaboration with the Disability Resource Center (DRC). Any student requiring an academic accommodation due to a disability should let his or her faculty member know as soon as possible. Students who need academic accommodations based on the impact of a disability will be encouraged to contact the DRC if they have not done so already. The DRC is located on the 4th floor of the Health Services Building, and can be reached at 815-753-1303 (V) or drc@niu.edu.

Time line:

Jan. 25. Work on Data analysis programming library (this makes for much faster data analysis).
Feb. 2. Have data analysis library completed.
Feb. 9. Data analysis.
Feb. 16. Have data analysis completed.
Feb. 23. Have bloch wave calculation programming under way. Have extinction distance calculations completed.
Mar. 7. Have programming finished to start simulations. Find out a way to figure out the sample orientation.
March. 14. Have theory/programming figured out for necessary crystal structure calculations.
March. 21. Programming for crystal structure calculations.
March. 28. Obtaining a basic simulated spectrum.