Course Outlines

Instructors: C. Broholm, Johns Hopkins University (broholm@jhu.edu), T. Egami, University of Tennessee (egami@utk.edu). S.-H. Lee, University of Virginia, Y.-S. Lee, Massachusetts Institute of Technology, S. Nagler, Oak Ridge National Laboratory, R. Pynn, Indiana University, and S. K. Sinha, University of California, San Diego. The course coordinator is Meiyun Chang-Smith (changsmithm@ornl.gov).

Target Audience: Graduate Students and postdocs in the fields of Condensed Matter Physics and Materials Science. If you are interested in obtaining credits for this course and you are not at JHU, UTK, UVA, MIT, IU, or UCSD, have your professor contact Meiyun Chang-Smith.

Lectures: This course will be taught from the lecturers institutions and will be available on-line in real time and through web-casting. There will be two 75-minute lectures weekly from 4 to 5:15 pm (Eastern) for 13 weeks starting Tuesday 9/4/2012 and ending Thursday 12/7/2012.

Student Presentations: Each week a student at each participating institution will select a neutron scattering paper and present it to their class. These presentations will be recorded and made available to the full class via the class web site. All participants are encouraged to read the papers and watch the corresponding presentations.

Homework: Weekly assignments will be posted online and will be graded locally.

Technology: To participate in this course *minimally*, all you need is a web browser. For full two way communication and participation in real time with the lectures, please contact Meiyun Chang-Smith for further information.

Prerequisites: Quantum Mechanics, Statistical Physics, and Condensed Matter Physics at the graduate level.

Literature: Some Lecture notes will be provided. There will be reading assignments from the following books listed in order of importance for this course

[FMS] *Neutron Scattering in Condensed Matter Physics*, A. Furrer, J. Mesot, and T. Strässle, World Scientific (2009).

[GLS] *Introduction to the Theory of Thermal Neutron Scattering*, G. L. Squires, Cambridge University Press (1978).

[VFS] *Neutron Optics: an introduction to the theory of neutron optical phenomena and their applications*, Varley F. Sears, Oxford University Press (1989).

[SWL] *Theory of Thermal Neutron Scattering*, S. W. Lovesey, Clarendon Press (1984).

Syllabus

Week	Subject	Lecturer
Lecture 1 (Tue 9/4) Lecture 2 (Thu 9/6)	Preliminaries • Periodic solids • Neutron properties • The scattering cross section • Fermi pseudo-potential • Partial wave scattering theory	C Broholm
Lecture 3 (Tue 9/11) Lecture 4 (Thu 9/13)	Theory of elastic neutron scattering • Born approximation • Debye-Waller factor • From cross section to structure factor • Small Angle Neutron Scattering • Reflectometry	T Egami
Lecture 5 (Tue 9/18) Lecture 6 (Thu 9/20)	Theory of inelastic neutron scattering • Fermi's golden rule • Heisenberg picture • Phonon expansion	C Broholm
Lecture 7 (Tue 9/25) (Lecture 8 (Thu 9/27)	Magnetic neutrons scattering • Dipole interactions • Elastic & inelastic magnetic scattering • Spin-wave excitations	C Broholm
Lecture 9 (Tue 10/2) Lecture 10 (Thu 10/4)	Neutron sources and instrumentation • Spallation and fission sources • Guides & Shielding • TOF and crystal monochromation • Neutron detection • Archetypical instruments	S Nagler
Lecture 11 (Tue 10/9) Lecture 12 (Thu 10/11)	Polarized Neutrons • Theory of polarized scattering • Polarized beam techniques • Polarized diffraction • Polarized SANS • Polarized reflectometry	R Pynn
Lecture 13 (Tue 10/16) Lecture 14 (Thu 10/18)	Larmor labeling techniques • Spin echo theory • Zero field spin echo • Spin-echo angular resolution	R Pynn

Lecture 15 (Tue 10/23) Lecture 16 (Thu 10/25)	Structure Determination • Powder diffraction (Rietveld method) • Single crystal analysis • Local structure from PDF analysis	T Egami
Lecture 17 (Tue 10/30) Lecture 18 (Thu 11/1)	Surfaces and interfaces • Specular reflection • Off-specular reflection • Grazing incidence scattering	S Sinha
Lecture 19 (Tue 11/6) Lecture 20 (Thu 11/8)	Magnetic Structure Determination • Group theory survival manual • Magnetic space groups • Relevant software • Examples	S.-H. Lee
Lecture 21 (Tue 11/13) Lecture 22 (Thu 11/15)	Phonons • Phonons multi-atom basis • Incoherent approximation • Electron phonon interactions • Soft modes • Relaxor ferro-electrics	T Egami
11/19	**Thanksgiving Break**	
Lecture 23 (Tue 11/27) Lecture 24 (Thu 11/29)	Magnetic Excitations • Correlation functions • Crystal field excitations • Magnons and spinons • Spinons • Spin fluctuations in metals	Y.-S. Lee
Lecture 25 (Tue 12/4) Lecture 26 (Thu 12/6)	Critical Phenomena • Synopsis of critical phenomena • Experimental challenges • Probing thermal criticality • Probing quantum criticality	Y.-S. Lee