

Phys 645:
Advanced Topics in Interdisciplinary Physics:
Neutron Scattering
Spring 2024:



Course Description & Syllabus

Faculty Contact Information

Prof. Alan Tennant
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Office: 306 South College Hall

Instructor Availability: Please don't hesitate to email me with updates, questions, or concerns. I will typically respond within 24 hours during the week and 48 hours on the weekend. I will notify you if I will be out of town and if connection issues may delay a response.

Meeting Time

The course is held in Nielsen Room 608 on Tuesdays & Thursdays 9:45 – 11:00 AM with supporting material posted on the course canvas site.

Office Hours

Thursday 1:30 - 3:00 PM

1-on-1 meetings to discuss any course related item can also be made by scheduling via email.

Course Description

Neutron scattering is one of the most powerful techniques being applied in contemporary science. The course gives a comprehensive grounding in the techniques and application of neutron scattering and imaging. It covers the theory of scattering as well as the instrumentation used to reveal the behavior of matter from the atomic to real world scales. Special topics include latest research in condensed matter physics, disordered and glassy materials, biophysics of membranes and proteins, engineering materials, chemistry and catalysis, and quantum science. The fundamental role of computation and simulations will also be addressed with latest advances in machine learning and data science.

An outline of the topics discussed include:

1. Theory of scattering from non-magnetic and magnetic materials
2. Fundamentals of sources and instruments
3. Neutron imaging and optics
4. Neutron crystallography to determine magnetic and crystal structures
5. Neutron spectroscopy to probe excitations
6. Reflectometry and small angle scattering from large scale structures
7. Review of applications in condensed matter, materials science, biophysics, chemistry, engineering, and quantum science.
8. Tour of neutron facilities at Oak Ridge National Laboratory

Science applications will be stressed throughout

Prerequisites

To be successful in this course you will need an understanding of the atomic structure of materials and basic physics for undertaking scattering calculations. An understanding of Fourier transforms is helpful. Students require a background in any of condensed matter, materials science, biophysics, chemistry, or engineering materials to have the subject matter background to relate neutron scattering to scientific applications in their topic area.

Student Learning Outcomes

This course aims to provide students with the skills needed to understand the applications of neutron scattering and how it can be used in research. This includes (1) understanding neutron data; (2) knowing how the principal measurement techniques work; (3) how the neutron techniques can be used to solve scientific problems; (4) the basics of designing experiments; and (5) understand how to apply for beamtime. Due to the many similarities with X-ray synchrotron and electron scattering techniques students will also be able to transfer much of their understanding to these techniques too.

Value Proposition

Experimental science using large scale facilities is an essential part of modern research. This course provides the grounding necessary to both understand papers as well as conduct research using these facilities and techniques.

Learning Environment

The class will be delivered in person with lecture notes and worked examples provided online. Weekly exercises to explore the material in the lectures will be assigned to strengthen student's understanding and time will be available in class as well as during office hours for the students wishing to interact with the instructor. We are fortunate to have world leading experts in neutron science both at UT and Oak Ridge National Laboratory where the most advanced neutron facilities worldwide are located. Guest lecturers will be invited to present several of the lectures to give students an up-to-date perspective on the latest developments in key scientific fields. Tours of the neutron facilities at Oak Ridge National Laboratory will be arranged.

Canvas

All course details, assignments, lecture notes and announcements will be available on Canvas. You are required to be aware of anything posted to the course website. Please update your canvas notification settings.

Reference Materials

I will provide copies of my lecture notes and videos on Canvas. There is no specific textbook for the course and it is designed to be self-contained. I will take material from a variety of sources including:

- Introduction to the theory of thermal neutron scattering, G. L. Squires, Dover Publications Inc. (1996).
- Theory of neutron scattering from condensed matter, Stephen W. Lovesey vols. I & II, Oxford Science Publications (2004).

Grading & Policies

Exercises and short quizzes on Canvas 20%
Assignments 40%
Final Project & Presentation 40%

Participation

I would like everyone to participate in the classes, canvas pages, email, office hours etc. Canvas can be used for course discussions out-with the classroom.

Assignments

Late assignments will be accepted with a penalty of 15% per day.

Important Dates

The final project will be due on our scheduled final exam date: Thursday May 9, 2023.

Religious Holidays

Students have the right to practice the religion of their choice. If you need to miss class to observe a religious holiday, please submit the dates of your absence to me in writing via email by the end of the second full week of classes. You will be permitted to make up work within a mutually agreed-upon time.

Statement on Civility & Community

The Department of Physics & Astronomy at the University of Tennessee is committed to creating an environment that welcomes all people, regardless of their identities. We value the diversity that enriches our department. We understand the importance of free and open dialogue that includes the free exchange of ideas. We do not tolerate uncivil speech or any form of discourse that infringes on others' rights to express themselves, or has a negative impact on their education, or work environment. We actively promote an environment of collegiality and an atmosphere of mutual respect and civility. We understand that respect includes being considerate of others' feelings, circumstances, and their individuality. We recognize the necessity of a civil community in realizing the potential of individuals in teaching, learning, research, and service. We believe these values extend beyond the department into our work within physics regionally, nationally, and internationally, as well as work and studies in the university, and the broader community. We encourage all members of the department to intervene and report any incidents involving bigotry, or that violate the university code of conduct.

<http://www.phys.utk.edu/about/civility-community.html>

COVID-19

The best source of information for information related to the University of Tennessee's response to the COVID-19 pandemic can be found online at: <https://www.utk.edu/coronavirus/>.

1 Campus Syllabus

1.1 University Civility Statement

“Civility is genuine respect and regard for others: politeness, consideration, tact, good manners, graciousness, cordiality, affability, amiability and courteous-ness. Civility enhances academic freedom and integrity and is a prerequisite to the free exchange of ideas and knowledge in the learning community. Our community consists of students, faculty, staff, alumni, and campus visitors. Community members affect each other’s well-being and have a shared interest in creating and sustaining an environment where all community members and their points of view are valued and respected. Affirming the value of each member of the university community, the campus asks that all its members adhere to the principles of civility and community adopted by the campus.”

<https://civility.utk.edu/>

1.2 Emergency Alert System

The University of Tennessee is committed to providing a safe environment to learn and work. When you are alerted to an emergency, please take appropriate action. Learn more about what to do in an emergency and sign up for UT Alerts. Check the emergency posters near exits and elevators for building specific information. In the event of an emergency, the course schedule and assignments may be subject to change. If changes to graded activities are required, reasonable adjustments will be made, and you will be responsible for meeting revised deadlines.

<https://safety.utk.edu/>

1.3 Academic Integrity

Each student is responsible for his/her personal integrity in academic life and for adhering to UT’s Honor Statement. The Honor Statement reads: “An essential feature of the University of Tennessee, Knoxville is a commitment to maintaining an atmosphere of intellectual integrity and academic honesty. As a student of the university, I pledge that I will neither knowingly give nor receive any inappropriate assistance in academic work, thus affirming my own personal commitment to honor and integrity.”

1.4 Your Role in Improving This Course Through Assessment

At UT, it is our collective responsibility to improve the state of teaching and learning. During the semester you may be requested to assess aspects of this course either during class or at the completion of the class. You are encouraged to respond to these various forms of assessment as a means of continuing to improve the quality of the UT learning experience.

1.5 Students with Disabilities

Any student who feels they may need an accommodation based on the impact of a disability should contact Student Disabilities Services in Dunford Hall, at 865-974-6087, or by video relay at, 865-622-6566, to coordinate reasonable academic accommodations.

<https://sds.utk.edu>

1.6 Accessibility Policy & Training

<https://accessibility.utk.edu>

1.7 Wellness

The Student Counseling Center is the university's primary facility for personal counseling, psychotherapy, and psychological outreach and consultation services. The Center for Health Education and Wellness manages 974-HELP, the distressed student protocol, case management, the Sexual Assault Response Team, and the Threat Assessment Task Force.

<https://counselingcenter.utk.edu/> and <https://wellness.utk.edu/>