

QUANTUM MATERIALS

Neutrons can quicken the pace of your quantum research

Oak Ridge National Laboratory (ORNL) is the US epicenter of neutron scattering, a powerful technique for studying the nature of quantum materials in helping develop quantum computing, secure communications and much more.

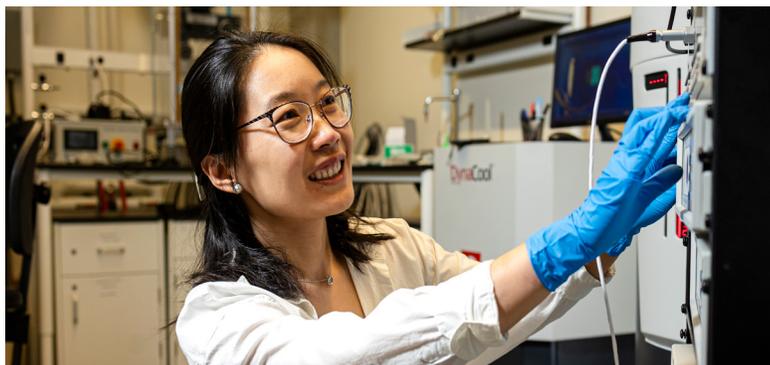
Both scientists and non-scientists can access ORNL's research facilities via the U.S. Dept. of Energy's **User Program**. ORNL's two world-leading, complementary neutron research user facilities — the **High Flux Isotope Reactor (HFIR)** and the **Spallation Neutron Source (SNS)** — are open to researchers to facilitate their studies in science and technology. Together, HFIR and SNS offer users 30 advanced instruments and their supporting laboratories to use for a wide range of materials research experiments.

"ORNL's sample mail-in program for neutron scattering experiments enabled us to determine crystal field levels in hexagonal metallic magnetic Ce₂Zn₁ in a timely manner without having to leave our own laboratory."

Yishu Wang, Ph.D.

University of Tennessee

Photo credit: Shawn Poynter



No neutron science experience is necessary

Oak Ridge National Laboratory's neutron science User Program invites you to collaborate with us, onsite or remotely, to achieve greater success. No neutron science experience is necessary, as our experts work closely with users to ensure the success and safety of their experiments. We can help you find the neutron techniques, instruments and sample environments best suited for your research.

Neutron users can access neutron facilities – at little or no cost

Beam time is granted through a proposal system managed by the User Program and is free of charge (with the exception of travel costs, if necessary) as long as researchers intend to publish their results to the scientific community. A fee is charged only for proprietary research that will not be made public.



Contact the Neutron Users Office

Web: neutrons.ornl.gov/users

Email: NeutronUsers@ornl.gov

Phone: 865-574-4600 or 865-341-4451

QUANTUM MATERIALS

Neutrons are ideal for studying quantum materials

Each year, ORNL neutrons help scientists gain a better understanding of the processes and properties of quantum materials. From penetrating dense materials and probing light elements, to their neutral charge and magnetic moment, neutrons facilitate studies that are difficult or impossible for other research techniques. Neutron scattering is also often used as a key characterization technique along with x-ray scattering, magnetometry measurements, and Mössbauer spectroscopy, for example, to better understand structure-property relationships in quantum materials.

Neutron scattering on quantum materials includes a variety of materials and techniques as seen below. There are many sample environments that support quantum experiments, including ultra-low temperature cryostats, closed cycle refrigerators, high temperature furnaces, sample changers, high field magnets up to 14T, and much more.

Superconductivity

- Single crystal diffuse scattering was performed on a material to understand the role of homogeneity in the fundamental physics.
- Advances enabled improved location of hydrogen atoms at high pressures to aid the search for room temperature superconductivity.
- Inelastic scattering showed that superconductivity in a unique material is coupled to a sharp magnetic excitation at a boundary near antiferromagnetic order.

Chiral magnetism

- Magnetic excitation spectrum of a chiral ferromagnet was determined using inelastic scattering.
- Complex magnetic structure of corundum-type material was uncovered using polarized neutron scattering.
- Inelastic scattering identified crystal electric field excitation in chalcogenide.

Ferromagnets

- Ruthenium contribution to magnetism was better understood through use of polarized reflectometry on thin film.
- High temperature ferromagnetic phase was discovered in transition metal pnictide using single crystal diffraction.

Quantum disordered states

- Grazing incidence polarized reflectometry was described ground state structure.
- Mott state transition to quantum disordered ground state upon cooling was discovered with diffraction and inelastic scattering.
- Crystal field excitations were measured in a Shastry-Sutherland lattice using inelastic scattering.

Quantum entanglement

- Proof of principle studies showed that neutron scattering can be used for observing entanglement.
- Methodologies were developed to use neutron spin echo to probe entanglement in direct and accessible way.

Frustrated magnetism

- Powder diffraction revealed temperature and field dependent magnetic phase diagram.
- Pair distribution function analysis revealed local atomic and magnetic structures to identify distortions that lift degeneracy.

Topological magnons

- Spectroscopy provided evidence for the size of topological magnon gap.
- Dispersion and orbital motion of magnons were studied using polarized inelastic scattering.

Molecular magnets

- Effect of NH_4^+ motion in molecular multiferroic was studied using vibrational spectroscopy.
- Unique spin dynamics were discovered in reduced molybdenum oxide using low temp inelastic scattering.
- Magnetic structure and magnetic ground states of Ru dimers were revealed using diffraction and inelastic scattering.

Hybrid magnets

- The 3D structure of hybrid skyrmions was determined through polarized reflectometry and small angle neutron scattering.
- Fe-based compound was measured under high magnetic field to determine switching mechanism.
- Defect structure of iron-based superconductors was studied via pair distribution function analysis.

Altermagnetism

- Diffraction and polarized reflectometry revealed antiferromagnetic structure with a weak ferromagnetic moment.
- Spectroscopy was used to measure how the electronic band structure influences magnetic excitations.