Neutron Scattering

Description: The principal objective of this program is the study of fundamental interactions in solids by elastic and inelastic neutron scattering. The phenomena studied include structural and magnetic phase transformations, magnetic structure, and elementary excitations such as spin-waves and phonons. Neutron scattering provides a unique tool for the study of these phenomena. While the ultimate motivation is the broad understanding of underlying physical principles, the materials studied are often chosen to represent topics of high current topical interest, and the mode of operation involves strong elements of cooperation with the broader condensed-matter physics community. In particular, we depend upon these interactions for sample preparation and characterization, as well as for theoretical guidance in the interpretation of results. Because of the current shutdown of the High Flux Beam Reactor, experiments are being performed at a number of other facilities around the world.

Program Highlights:

- Spin *and charge order in cuprate superconductors.* Our neutron diffraction studies have demonstrated the coexistence of charge and spin order with superconductivity in several cuprate systems. The charges form stripes that act as antiphase domain walls between antiferromagnetic domains.
- *Charge-stripe order in nickelates.* 3-dimensional charge-stripe-order, and the corresponding magnetic order and excitations, have been discovered and characterized in La2NiO4'8
- *Interstitial order in oxygen-doped* La2CU0418 *and* La2Ni04'.8- We have shown that the interstitial oxygens are
- ordered in a staged fashion, much like alkali ions in graphite.
- *Coexistence of a quantum spin gap with long-range magnetic order in an S=I chain system.* In the system R2BaNiO5 (R=Y, Pr, Nd), we have shown that the gap for spin excitations in Ni-O chains (Haldane gap) survives, surprisingly, in the presence of long-range antiferromagnetic order induced by rare-earth moments.
- *Phonon mode coupling in superconducting* RNi2B2C- Our studies show that the strong, phonon softening above T. is caused by mode coupling, and the dramatic phonon profile changes below T., are consistent with the response expected in a BCS superconductor.
- *Magnetic order and excitations in the S=112 chain and ladder system,* (LaSr,Ca)14CU24041- We have found charge and magnetic order in La-doped crystals, and have made the first measurements of spin excitations in the Cu-0 chains.
- *Spin-Peierls compound* CuGe03- We have characterized the cross-over from dimerized to antiferromagnetic order on substitution of small amounts of Zn for Cu or Si for Ge.

Impact:
Our research results have motivated a wide range of complementary experimental and theoretical investigations throughout the world. The impact is reflected in the number of invited talks and literature citations.

Interactions:

- U.S. Universities: MIT, Univ. of Delaware, Univ. of Pennsylvania, Univ. of Connecticut, Univ. of Houston, Princeton Univ., SUNY Stony Brook, Johns-Hopkins Univ., Univ. of Missouri
- Non-U.S. Universities: Univ. of Tokyo, Tohoku Univ., Kyoto Univ., Univ. of Electro-Communications;
- U.S. National Laboratories: Ames Lab., NIST, ORNL
- Non-U.S. Laboratories: Hasylab, ILL, JAERI, PSI
- Industrial: Lucent Technologies, NEC

Personnel:
J. M. Tranquada (group leader), S. M. Shapiro, G. Shirane, A. Zheludev, B. 0. Wells (U. Conn.) Recent departures:
J. D. Axe, W. Bao (Res. Assoc.), S. Raymond (student), B. J. Stemlieb, P. Wochner

Recognition:
* I member of the NAS, 3 Fellows of the APS
* 15 invited talks at national and international conferences in last 2 years
* 2 invited review articles in last 2 years

Budget: S2158K