OAK RIDGE NATIONAL LABORATORY
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SNS shows novel spin waves in iron chalcogenide $Fe_{1.05}Te$

Measurements conducted at the Spallation Neutron Source at ORNL have determined exchange couplings in the magnetically ordered chalcogenide Fe1.05Te, a nonsuperconducting member of the iron-based family of superconductors. The results show the exchange pairings thought to be related to superconductivity occur in a next-nearest-neighbor ordering of atoms, rather than in nearest-neighbor order as in a previously studied iron arsenide.

Researchers from the University of Tennessee, ORNL, and other institutions collaborated to study the spin waves in $Fe_{1.05}Te$. Superconductivity in iron-based superconductors emerges in proximity to magnetic order; similarly, many researchers think superconductivity in the copper oxides is driven by magnetic fluctuations. The magnetic order in $Fe_{1.05}Te$ is considerably different from the related iron pnictide superconducting system (see Fig. 1), raising the question of whether magnetism can in both cases still drive the superconductivity in iron-based superconductors.

To answer that question, the exchange coupling energies in the $Fe_{1.05}Te$ system were characterized using the ARCS instrument at SNS and other instruments to measure the spin waves (Fig. 2) and fitting the waves to a Heisenburg Hamiltonian. The dispersion of the spin waves in this system is novel and very different from that in the previously measured iron pnictide $CaFe_2As_2$. Fitted exchange couplings of J_{1a} =-17.5 ± 5.7, J_{1b} = -51.0 ± 3.4, $J_2 = J_{2a} \approx J_{2b}$ = 21.7 ± 3.5, J_3 = 6.8 ± 2.8 meV were found (Fig. 1).

Although the nearest-neighbor couplings are very different (opposite in sign) from those in the pnictides, the next-nearest-neighbor couplings are isotropic and very similar. It has been shown theoretically that such an antiferromagnetic next-nearest-neighbor interaction can lead to the superconducting pairing symmetry observed in these systems. Therefore, the discovery of a universal next-nearest-neighbor coupling in these systems suggests superconductivity in both these classes of iron-based superconductors has a common magnetic origin that is intimately associated with the antiferromagnetic next-nearest-neighbor exchange couplings.

The paper was recently accepted for publication in *Physical Review Letters.*

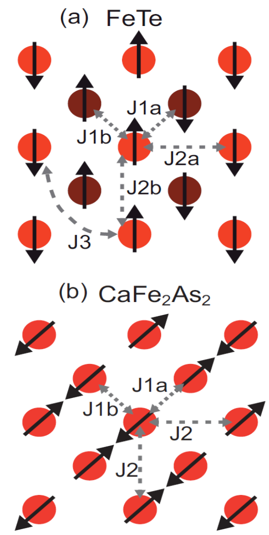

Fig. 1. Magnetic structure of the (a) iron chalcogenide, and (b) iron pnictide systems, showing exchange couplings of the Heisenberg Hamiltonian.

"Spin waves in the (π, 0) magnetically ordered iron chalcogenide $Fe_{1.05}Te$" by O. J. Lipscombe, G. F. Chen, C. Fang, T. G. Perring, D. L. Abernathy, A. D. Christianson, T. Egami, N. Wang, J. P. Hu, and P. Dai, *Phys. Rev. Lett.* (2011, in press)

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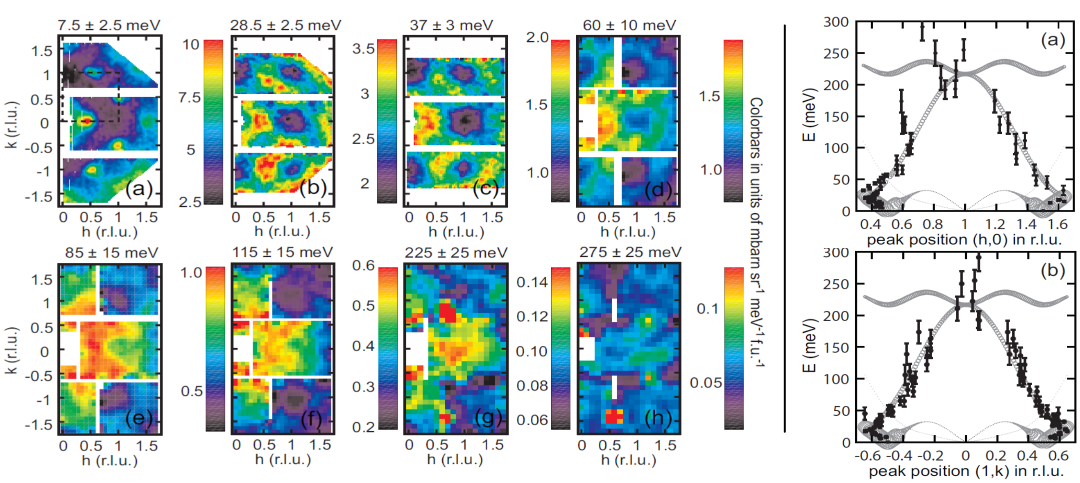

Fig. 2. (a)–(h): Constant energy slices of the data collected at various representative energies. (a)-(c) collected on ARCS and (d)-(h) on MAPS.

(i)-(j): Dispersion and fit along the (h,0) and (1,k) directions. Solid black points show dispersion of data, open grey circles show fit, with radius proportional to intensity.

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