Experimental report

04/02/2017

Proposal: 4-02-501 **Council:** 10/2016

Title: Search for spin resonance in the first nitrogen-containing iron pnictide superconductor ThFeAsN

Research area: Physics

This proposal is a new proposal

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Samples: ThFeAsN

Instrument	Requested days	Allocated days	From	To
IN8	3	0		
IN4	0	3	20/01/2017	23/01/2017

Abstract:

Antiferromagnetic fluctuation is one of the most possible candidates driven the electron pairing and superconductivity in unconventional superconductors. The most promnent features in these materials is the neutron spin resonance, which is an enhancement of spin excitations at a particular energy on cooling below the superconducting transition temperature. So far as we known, the resonance energy discovered in all copper-oxide and iron-pnictide superconductors is linearly scaling with Tc. Recently, Wang et al. has discovered the first nitrogen-containing iron pnictide superconductors ThFeAsN.Unlike other 1111 families such as oxides, fluorides and hydrides with same structure, this new material show bulk superconductivity below 30 K without any obvious anomaly but metallic behavior of resistivity. It is still not clear that whether this system shares similar origin of such high superconductivity with other iron-based families or not. Thus we propose to search the magnetic excitations as well as spin resonance in this unique nitride iron-based superconductors.

Search for spin resonance in ThFeAsN

The most prominent features for the spin fluctuations in the unconventional superconductors is the neutron spin resonance, which is an enhancement of spin excitations at a particular energy on cooling below the superconducting transition temperature[1]. So far as we known, the resonance energy discovered in all copper-oxide and iron-pnictide superconductors is linearly scaling with T_c[2]. Recently, the first nitrogen-containing iron pnictide superconductors ThFeAsN, is found to be have bulk T_c = 30 K without any doping[3], unlike other 1111 families such as oxides, fluorides and hydrides with same structure and anomaly in resistivity[4,5].

To indentify whether there is a spin resonance in this new material, we have performed inelastic neutron scattering at IN4 and IN8 on powder sample with T_c = 24 K. Due to limited detector banks at the low angle for IN4, it is very hard to focus the data collection centering at the supposed antiferromagnetic vector in 1111 system, Q=1.1 A^{-1}. With most data ranged from Q=1 A^{-1} to 8 A^{-1}, we only detect the phonon signal as show by Fig.1a. The difference between 2 K and 30 K data set show NO trace of any spin resonance for the explored Q range (Fig.1b). To further search the spin resonance signal, we have carried out experiment at IN8 with much high flux and flexibility. Again, there is NO clear difference between 2 K and 30 K at Q=1.1 A^{-1}, but a tiny higher counts for 2 K between 10 and 13 meV. Such weak difference also may be caused by the sample phonon population effects. Therefore, the spin resonance, even if it exists in this compound, must be very weak comparing to other iron pnictide superconductors[6]. Further experiments are needed to clarify this issue.

[1] P. D. Johnson *et al.*, Iron-based Superconductivity, Springer (2015).

[2] P. Dai, Rev. Mod. Phys. **87**, 855 (2015).

[3] C. Wang *et al.*, J. Am. Chem. Soc. 138, 2170 (2016).

[4] M. Hiraishi *et al.*, Nat. Phys. 10, 300 (2014).

[5] J. Yang *et al.*, Chin. Phys. Lett. 32, 107401 (2015).

[6] H. Mukuda *et al.*, J. Phys. Soc. Jpn. 83, 083702 (2014).

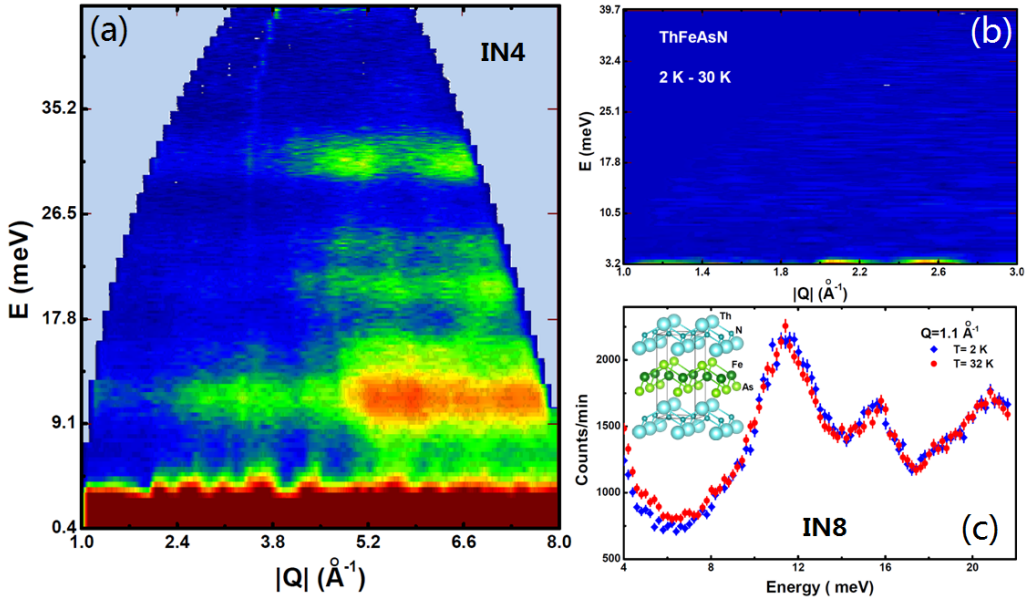

Fig. 1 Inelastic neutron scattering results in ThFeAsN