Experimental report

04/02/2017

Proposal: 4-02-450 **Council:** 4/2015

Title: Explore spin gaps by polarized neutron scattering on the heavily overdoped BaFe2-xNixAs2

Research area: Physics

This proposal is a continuation of 4-01-1372

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Samples: BaFe2-xNixAs2

Instrument	Requested days	Allocated days	From	To
IN20 CPA	9	7	19/09/2016	26/09/2016

Abstract:

Over the past 5 years,we have mapped out the spin spectrum of electron doped BaFe2-xNixAs2 throughout the phase diagram except the zone boundary of overdoped superconducting region. Whereas the high-energy spin excitations do not change with dopings, the low-energy spin excitations are quickly suppressed upon doping and finnally resulting in a large spin gap up to 50 meV in the heavily overdoped non-superconducting samples. It is still not clear whether the spin gap coincides with the disappearance of superconductivity in overdoped regime, where the Fermi surface nesting is invalid due to no hole pockets. We have tried to measure the spin gap for x=0.20, 0.22 and 0.27 in our last experiment at IN8, only weak magnetic signals with too many spurious from incoherent scattering and phonon excitations of sample and aluminum holder are obtained, which is hard to lead to any conclusions. Thus we propose to measure the magnetic excitations in these heavily overdoped BaFe2-xNixAs2 by using polarized neutron beam in spin-flip channel, which is a very efficient way to eliminate the mixed spurious signal from nuclear scattering and phonons

Explore spin gaps by polarized neutron scattering on the heavily overdoped $BaFe_{2-x}Ni_xAs_2$

It is argued that high-T_c superconductivity in iron pnictides is associated with both the presence of high-energy spin excitations and a coupling between low-energy spin excitations and itinerant electrons [1]. Specifically in the electron doped $BaFe_{2-x}Ni_xAs_2$ system, a large spin gap up to 50 meV is found beyond the superconducting dome [2][3]. Our recent time-of-flight neutron scattering experiments reveal that the spin gap actually only emerges after the vanishing of zero resistivity and directly responses to the disappearance of superconductivity (Fig. 1).

To finally determine whether this spin gap is related to the disappearance of hole pocket as well as the invalid of Fermi surface nesting in the overdoped side[4], we have perform this polarized neutron experiment at IN20 for the sample exactly located at the superconducting zone boundary with x=0.24.The mains results are shown in Fig.2. Here we set up the scattering plane as orthorhombic [H, 0, 0] X [0, 0, L] with x polarization along scattering vector Q, so both Q_1=(1, 0, 1) and Q_2=(1, 0, 3) can be reached by different scattering angles (Fig. 2a). By measuring all spin flipping channels (σ_x, σ_y, σ_z) at both Qs and solving the combined equations(Fig.2c,d), we then be able to obtain the components of fluctuating moments M_a, M_b and M_c[5]. Firstly, the sum of each channels, that is the total spin fluctuation, indeed shows a spin gap around 9 meV, consistent with our previous TOF results (Fig.2h). Secondly, the spin gap is anisotropic at both Q positions, e.g. for Q_1=(1, 0, 1), E_g (M_z)= 9 meV, E_g(M_z)=14 meV, which is further confirmed by the constant-energy scans (Fig.2b,e). Finally, the longitudinal component M_a is always zero in this compound, and there is a slightly anisotropy between the transverse mode M_b and M_c. Since the longitudinal mode is a sign for itinerant magnetism originated from Fermi surface nesting[6], these results suggest that the low energy spin excitations intimately related to Fermi topology are crucial to the superconductivity in iron pnictides.

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

[2] M. Wang *et al.*, Nature Commun. **4**, 2874(2013).

[3] H. Luo *et al.*, Phys. Rev. B **86**, 024508 (2012) and Phys. Rev. B **88**, 144516 (2013).

[4] C. Liu *et al.*, Phys. Rev. B 84, 020509(R) (2011); S. Ideta, *et al.*, Phys. Rev. Lett.,110, 107007 (2013);

[5] H. Luo *et al.*, Phys. Rev. Lett. 111, 107006 (2013).

[6] C. Wang *et al.*, Phys. Rev. X 3, 041036 (2013).

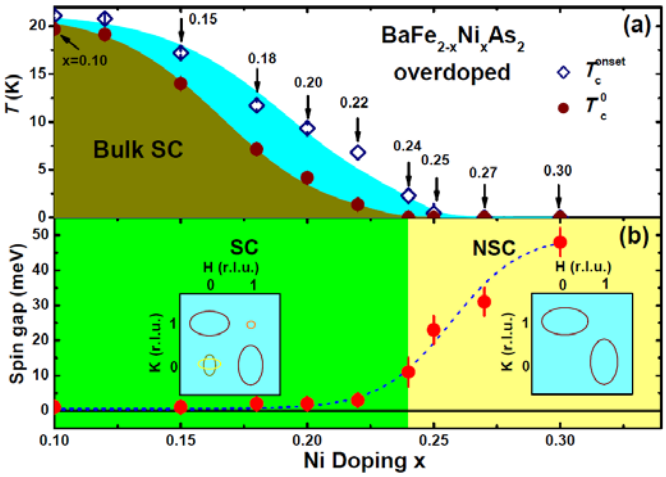

Fig. 1 Phase diagram and spin gaps in the electron overdoped $BaFe_{2-x}Ni_xAs_2$

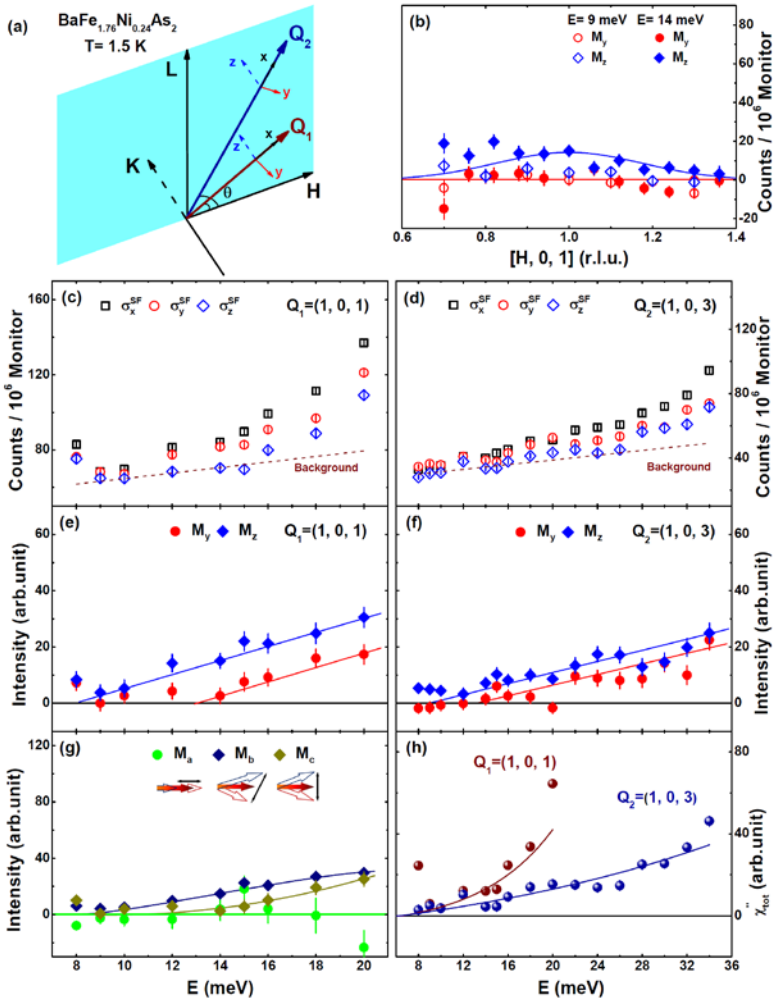

Fig. 2 Polarized neutron scattering results for $BaFe_{1.76}Ni_{0.24}As_2$