Search for neutron resonance in $Rb_{0.8}Fe_{1.6+x}Se_2$

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The neutron magnetic resonance is arguably the most important neutron scattering feature of novel superconducting materials such as cuprates that exhibit strong spin fluctuations. Experimentally, the neutron resonance can be broadly defined as a prominent peak in the energy dependence of the imaginary part of the dynamical susceptibility, $\chi''(\omega)$, whose intensity increases significantly below T_c. In the newly discovered Fe-based superconductors, the resonance has been found in the “122” (AFe_2As_2, where A = Ca, Sr, Ba …), “1111” (RFeAsO, where R = La, Pr, Nd …) and “111” (LiFeAs) systems [1].

The discovery of $A_yFe_{2-x}Se_2$ (A = K, Rb) provides another opportunity to further gain insight to the origin of resonance and its relationship with superconductivity, especially when it is realized that the Fermi surfaces in this system are significantly different from those of others [2]. Very recent experiments have found that the resonance in $Rb_yFe_{2-x}Se_2$ is roughly located at (0.5, 0.25, 0.5) [3], which is consistent with the prediction of RPA theory [4] but is different from the antiferromagnetic wave vector (0.5, 0.5, 0.5) in the non-superconducting sample [5]. In order to further investigate the presence of resonance in this newly discovered family of iron superconductors, we studied the magnetic spin excitation spectrum of the single-crystalline $Rb_{0.82}Fe_{1.68}Se_2$ superconductor with a T_c = 32 K.

Several single crystals of $Rb_{0.82}Fe_{1.68}Se_2$ were co-aligned with a total mass of about 4 grams. We used C5 triple axis spectrometer to measure magnetic excitation response of the system with a final energy E_f = 14.7 meV and a PG filter on the k_f side to eliminate higher order contamination from the neutron beam. We define the wave vector Q at (q_x, q_y, q_z) as $(H_o, K_o, L_o) = (q_x a_o/2\pi, q_y a_o/2\pi, q_z c_o/2\pi)$ r.l.u., where $a_o \approx b_o$ =5.48 Å and c_o = 14.69 Å are the orthorhombic cell lattice parameters similar to iron pnictides. In this notation, the magnetic resonance reported in Ref. [3] will occur at Q = ($\pm$1, $\pm$0.5, L) with L = odd, while the antiferromagnetic Bragg peaks are located at ($\pm$0.6, $\pm$0.2, L) or ($\pm$0.2, $\pm$0.6, L) with L = odd. We thus set the scattering plane with one axis along c and another axis to be in the middle of the wave vectors of the resonance and antiferromagnetic order so that we can reach either of the wave vectors simply by rotating the arc on the sample table.

We first measured spin waves in this system. We confirmed that strong antiferromagnetic peaks exist in the superconducting sample. The observed spin waves associated with the long range antiferromagnetic order are consistent with the previous results [6]. Below 8 meV, a spin gap exists as shown in Fig. 2(a). The magnetic excitations at 14 meV show little temperature dependence between 3 and 130 K (Fig. 2(b)). This is not surprising since T_N is higher than 500 K.

At the magnetic resonance wave vector (1, 0.5, 1), the energy scans at 3 K (below T_c) and 40 K (above T_c) show a clear difference around 13 meV as shown in Fig. 2(c). The direct subtraction of the data at these two temperatures is shown in Fig. 2d. As seen there is a clear indication that scattering at ~13 meV is increased below T_c. We attribute this scattering to magnetic resonance. However, we were unable to further pursue its full properties such as wave vector dependence due to the weak signal. It should be noted that the ratio of the intensities between the AF excitations and the resonance is about the same as that reported in Ref. [3].

References

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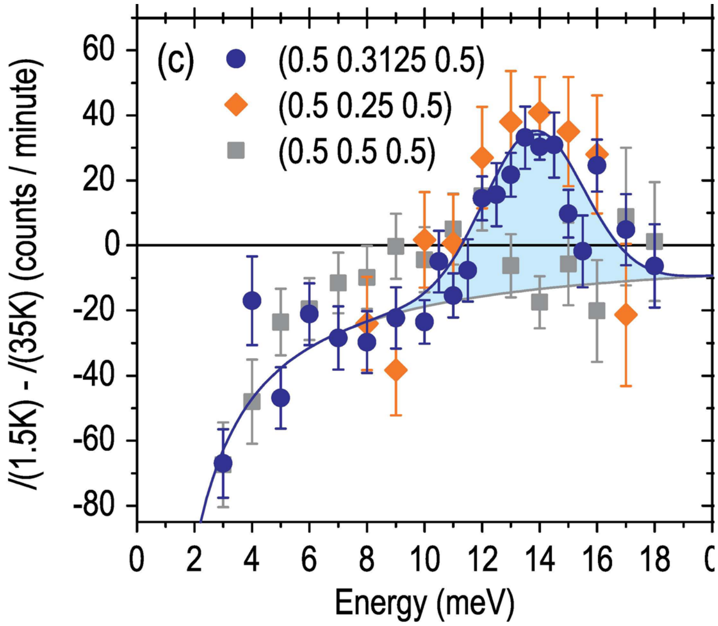

Fig. 1 Magnetic resonance found in $Rb_yFe_{2-x}Se_2$ [3].

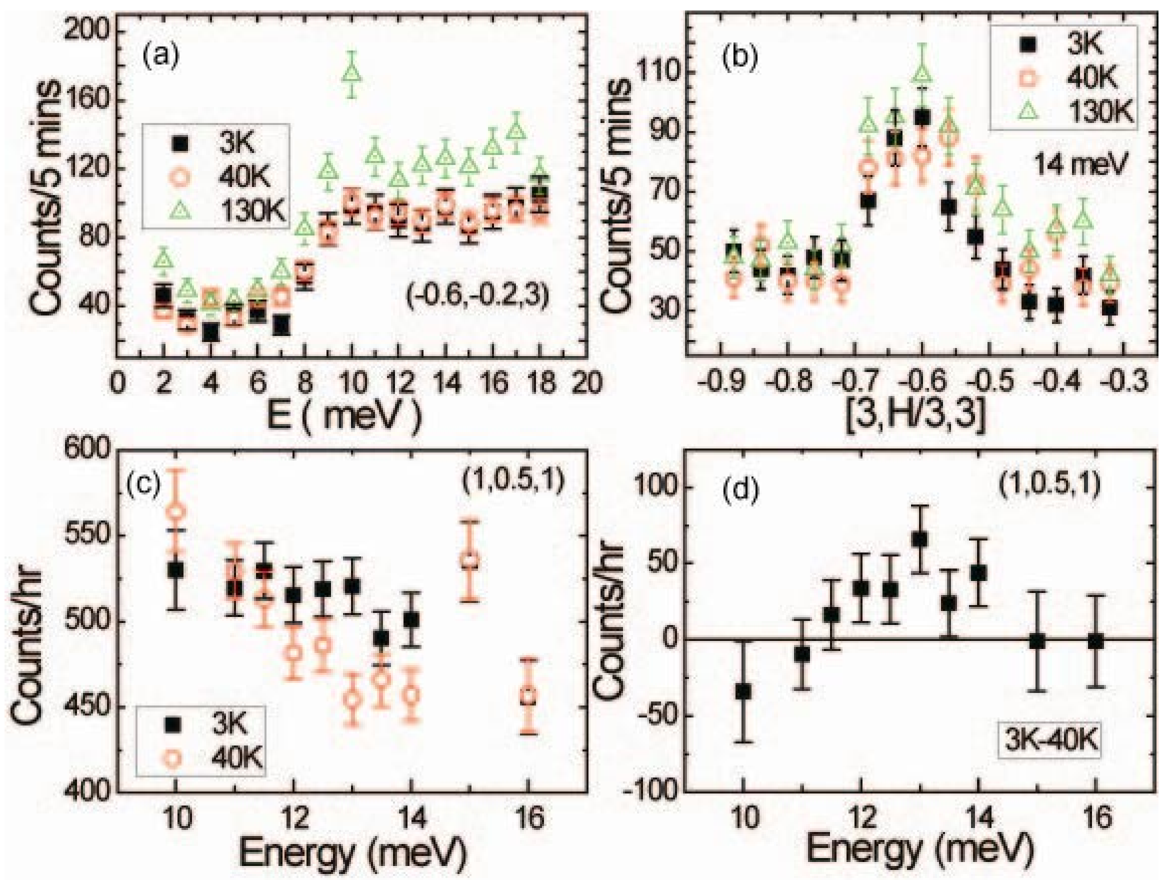

Fig. 2 (a) Constant Q-scans at (-0.6,-0.2,3) at 3 K, 40 K, and 130 K. (b) Constant E-scans at 14 meV at 3 K, 40 K, and 130 K. (c) Constant Q-scans at (1,0.5,1) at 3K and 40 K. (d) difference between 3 K and 40 K in c.