Experimental report

27/09/2022

Proposal: 4-02-544 **Council:** 10/2018

Title: Spin resonant mode in superconducting Ca(Fe1-xCox)AsF single crystals

Research area: Physics

This proposal is a new proposal

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Samples: Ca(Fe0.88Co0.12)AsF

Instrument	Requested days	Allocated days	From	To
IN8	7	5	08/06/2021	13/06/2021

Abstract:

Understanding the microscopic relationship among magnetism, nematic order and superconductivity is a pivotal issue in the research on iron-based superconductors. The presence of spin-orbit coupling and the interplay of various electronic degrees of freedom in these materials lead to complex ground- and excited-state properties. To understand the superconductivity, it is therefore important to focus on universal phenomena out of the material-specific details. To this end, the spin resonant mode probed by inelastic neutron scattering (INS) is widely regarded as an important handle. But due to the unavailability (until now) of sizable single crystals required by INS, the resonant mode has not been studied systematically in the 1111 single crystals, so the universality of such findings still awaits a thorough test. Here we propose to perform the first INS measurement of the spin resonant mode in single crystals of Ca(Fe1-xCox)AsF (x = 0.12, Tc = 20 K).This will enable further in-depth study of the Q-space structure, doping evolution, and relationship to spin-orbit coupling effects.

Experiment Report of spin resonant mode of CaFe0.88Co0.12AsF

Our neutron scattering experiment was carried out on IN8-Thermal neutron three-axis spectrometer at Institut Laue-Langevin, Grenoble, France. We used horizontally and vertically focused pyrolytic graphite [PG (002)] monochromator and analyzer with fixed scattered (final) energy E_f = 14.7 meV. The high order harmonics from the PG (002) monochromator are suppressed by an oriented PG-filter in the scattered beam. The sample consisted of over 300 pieces of $CaFe_{0.88}Co_{0.12}AsF$ single crystals with a total mass of about 1.0 g, which were coaligned within 6 ° mosaicity in the (*H*, *K*, 0) scattering plane on aluminum plates using a hydrogen-free adhesive.

We conduct Q scan at E = 5, 7.5, 10, 12, 14 meV below and above Tc as shown in Fig.1. The intensity difference below and above Tc demonstrates that the spin resonant mode is located at Q = (0.5, 0.5, 0) with resonant energy E = 12 meV.

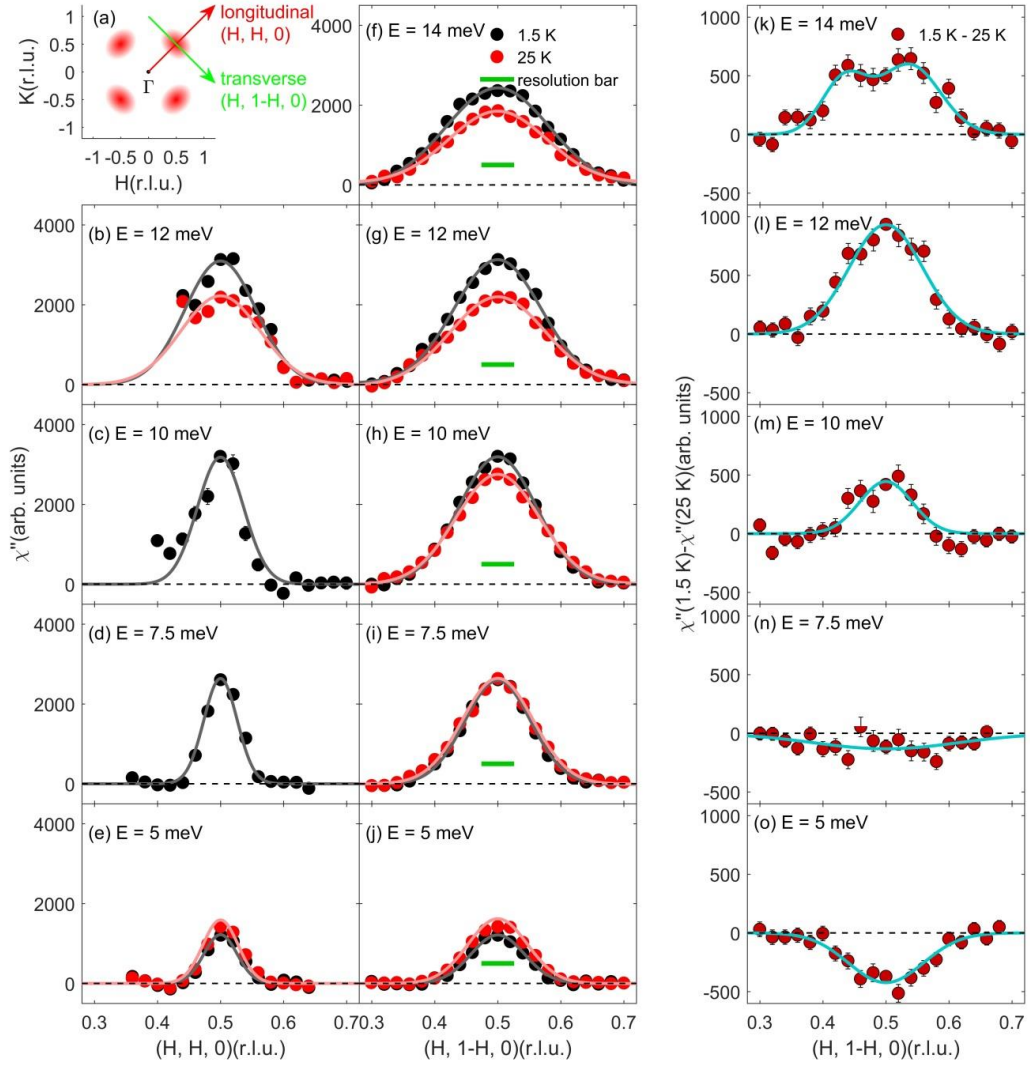

Fig. 1 The momentum dependence of spin excitations at 1.5 K and 25 K. (f-j) Transverse scan along (H, 1-H) direction with E from 5 meV to 14 meV. (b-e) Longitudinal scan along (H,H) direction. (k-o) Temperature difference between 1.5 K and 25 K.

Also, we conduct energy scan at Q = (0.5, 0.5, 0) and take the A3 off ±18 °scan as the background reference as shown in Fig.2. The resonant energy can be clearly seen at Er = 12 meV.

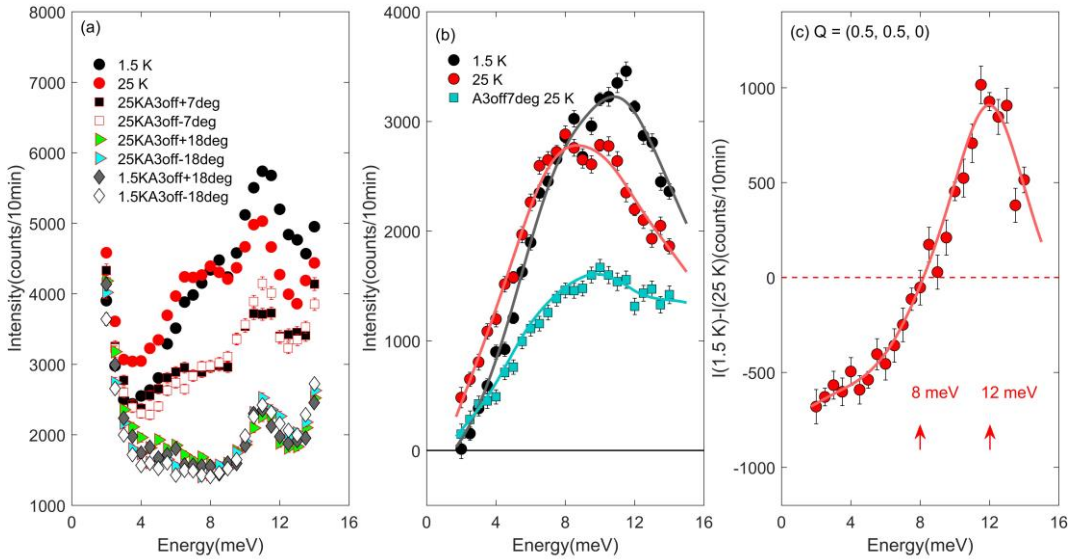

Fig. 2 The energy dependence of spin excitations. (a) raw data of energy scan for Q = (0.5, 0.5, 0), A3 off ±7 °and ±18 ° at 1.5 K and 25 K. (b) Spin excitations after substracting A3-off ±18 °as background at 1.5 K and 25 K respectively. (c) Spin resonant mode revealed by I(1.5 K)-I(25K) with Er = 12 meV and a superconducting gap below 8 meV .