Multiple pairing channels of superconductivity in YFe_2Ge_2

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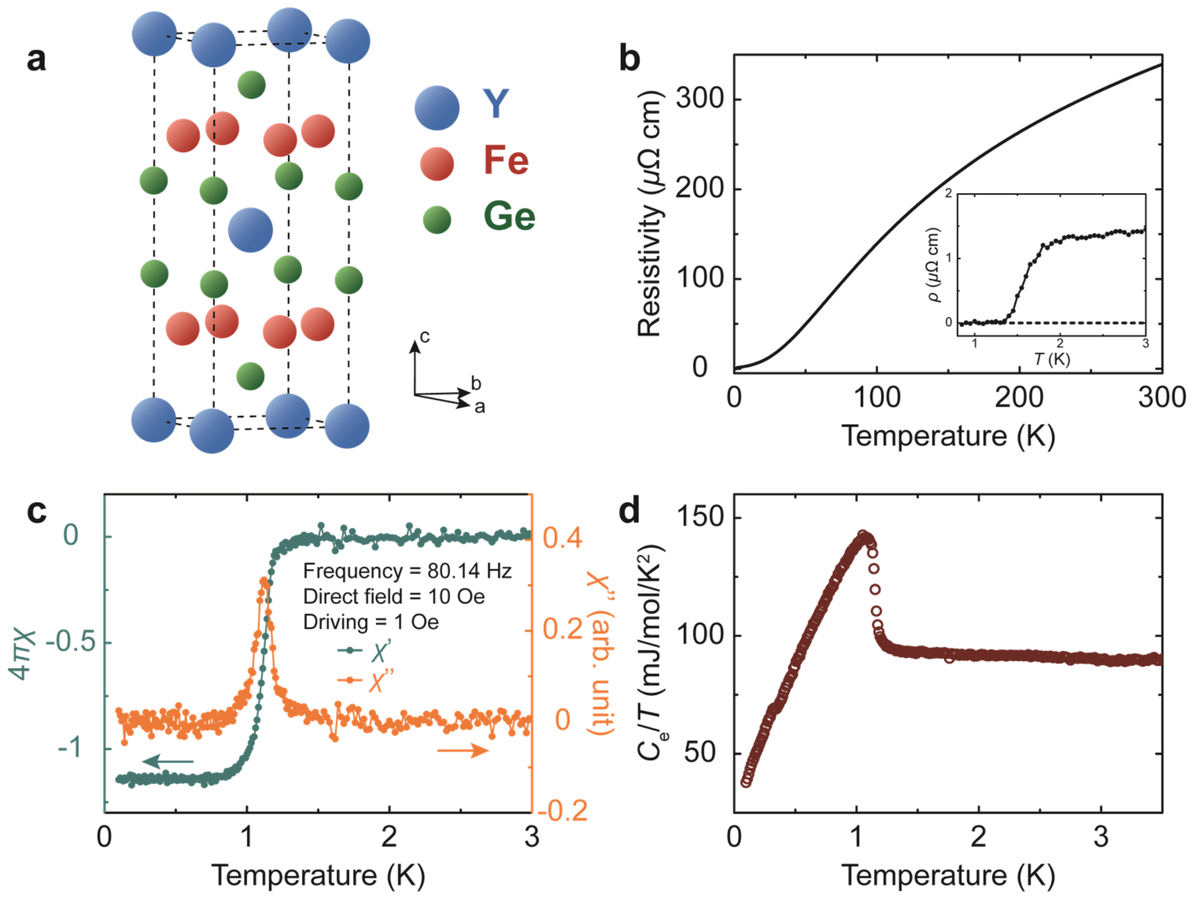
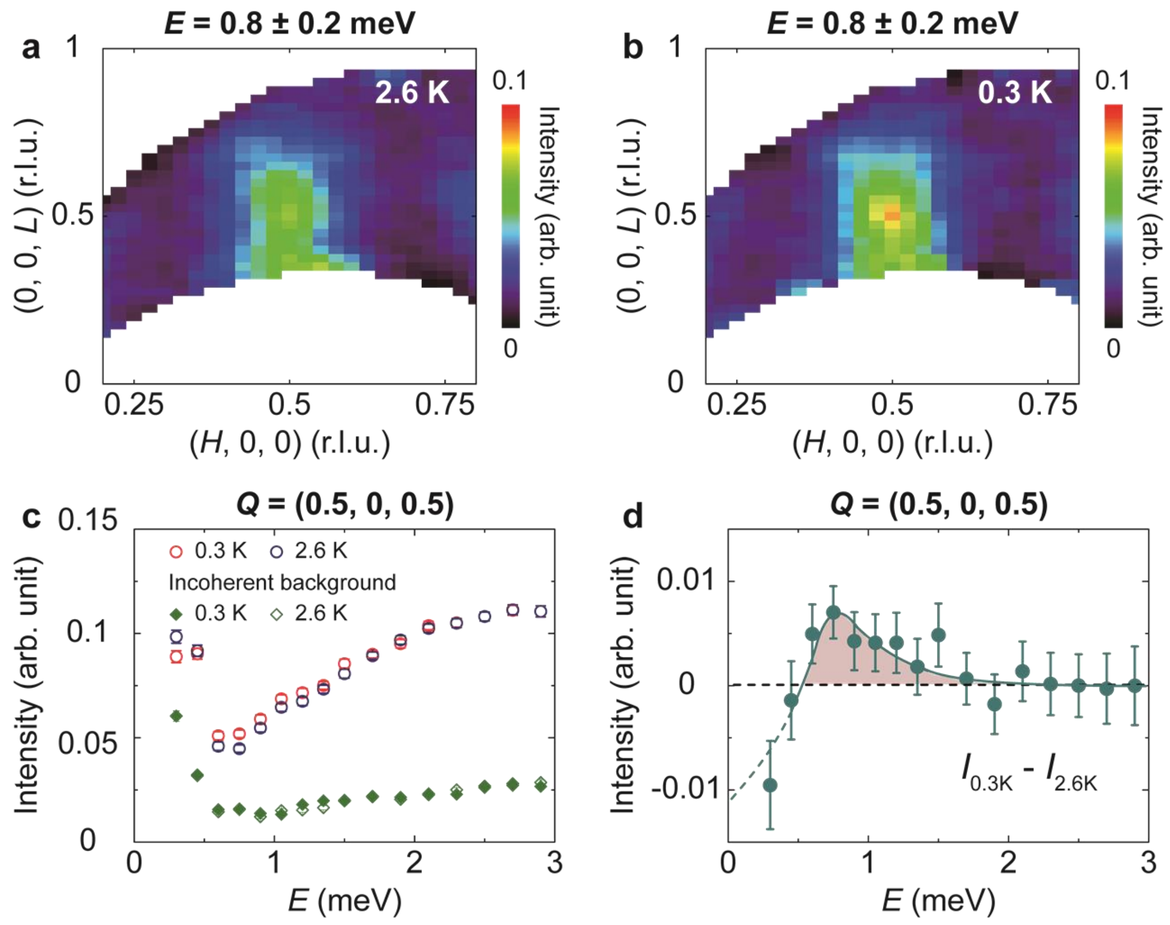
Abstract Spin fluctuations are widely believed to be the driving force for mediating Cooper pairs in unconventional superconductors. Enormous research interest has been devoted to the neutron spin resonance mode in anti-ferromagnetic spin excitation spectrum, which provides direct evidence for strong interplay between the corresponding spin pairing channel and superconductivity. By contrast, the coupling between ferromagnetic spin fluctuations and superconductivity remains elusive. Here, we unraveled the coexistence of spin resonance mode in both in-plane ferromagnetic and stripe-type anti-ferromagnetic spin fluctuations in iron-germanium superconductor YFe_2Ge_2. Below superconducting transition temperature, the ferromagnetic resonance mode emerged around 1.3 meV, together with the resonance mode in stripe spin channel peaked at 0.8 meV. The observation of spin resonance mode at two distinct wave vectors with different energy centers indicated the presence of multiple pairing channels in YFe_2Ge_2. Our results paved a new way to understand the joint contribution of diverse spin fluctuations to unconventional superconductivity.

Bulk superconductivity of YFe_2Ge_2 singe crystals



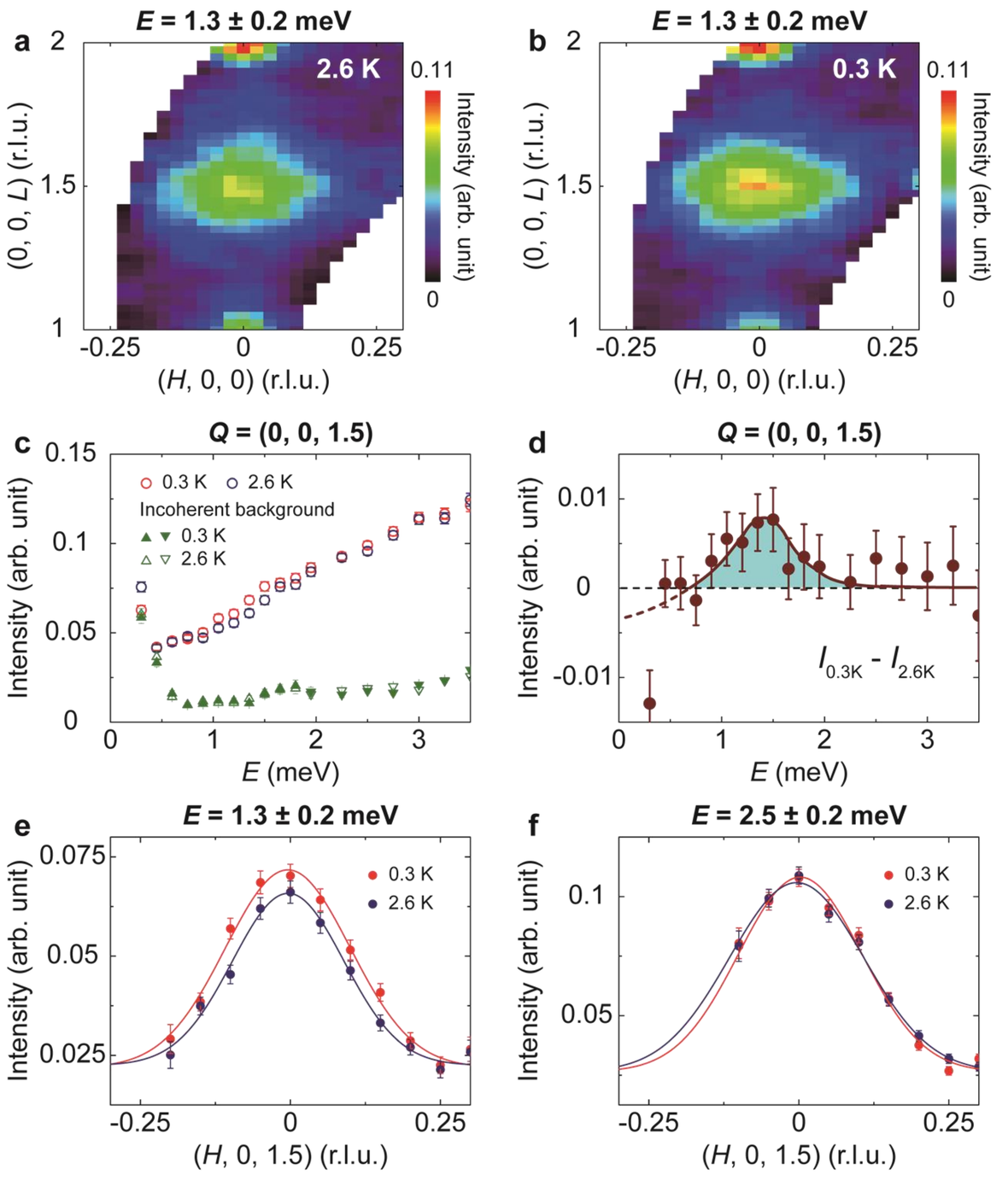
a, Schematic diagram of YFe_2Ge_2 crystal structure. (**b**-**d**), Resistivity, ac susceptibility and heat capacity measurements on as-grown YFe_2Ge_2 singe crystals, showing the bulk superconductivity at T_c ~ 1.15 K.

Spin resonance mode in stripe-type AFM spin channel



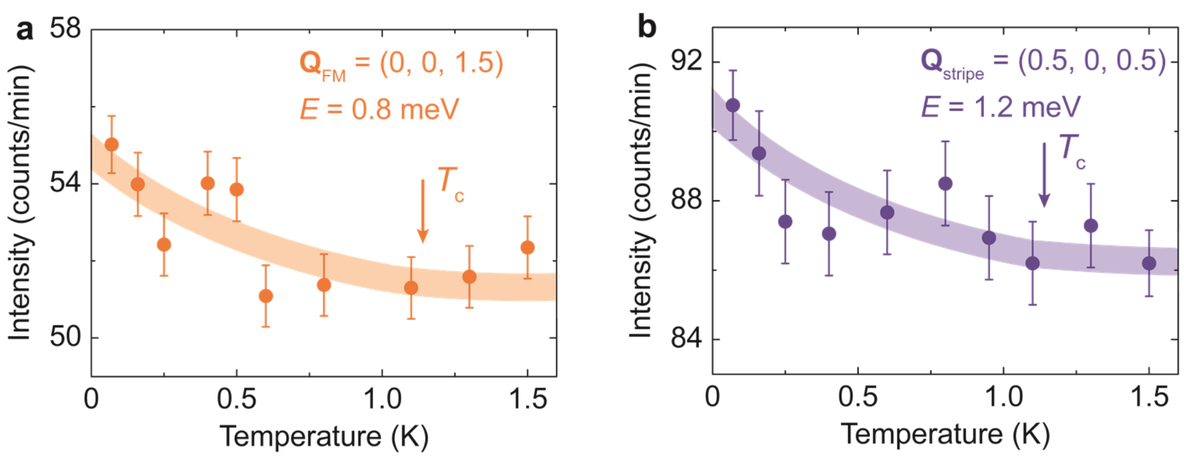
(**a**-**b**), Constant energy contour plots around stripe wave vector above and below T_c. **c**, Energy cuts of the stripe-type AFM signals. **d**, The subtraction of energy cuts at 0.3 K and 2.6 K illustrated in (**c**), showing the spin resonance mode in stripe spin channel. (**e**-**f**), Constant energy cuts along *H* direction across T_c, with energy at and above the resonance peak.

Spin resonance mode in FM spin channel



(**a**-**b**), Constant energy contour plots around FM wave vector above and below T_c. **c**, Energy cuts of the FM signals. **d**, The subtraction of energy cuts at 0.3 K and 2.6 K illustrated in (**c**), showing the spin resonance mode in FM spin channel. (**e**-**f**), Constant energy cuts along *H* direction across T_c, with energy at and above the resonance peak.

Temperature evolution of two spin resonance modes



Temperature dependence of the peak intensities of (**a**) FM and (**b**) stripe spin resonance mode in YFe_2Ge_2. The intensities of both spin excitation show an upturn coincident with T_c. The shadow line represents for a guide to the eye. The data was collected on a cold neutron tripe-axis spectrometer.

Summary

- Bulk superconductivity was achieved in as-grown YFe_2Ge_2 single crystals.
- FM spin resonance mode indicates strong coupling between FM spin fluctuations and superconductivity.
- Spin resonance mode was also revealed at stripe wave vector, as in many other iron-based superconductors.