Magnetic excitations in metallic antiferromagnet (Mn,Fe)$_3$Si

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Heusler-type intermetallic compound Mn_3Si is an antiferromagnetic metal with $T_N = 21$ K, and it has two types of Mn moments: $m_I \sim 2\mu_B$ and $m_{II} \sim 0.2\mu_B$. [1] Although the static susceptibility χ appears to show a Curie-Weiss-type thermal evolution, its Weiss temperature extrapolated from the raw data reaches $\Theta_p \sim -650$ K, associated with an effective Bohr magneton of $\mu_{\text{eff}} \sim 2\mu_B/\text{Mn}$ (average). Therefore, a quite large magnetic-energy scale than $\sim k_B T_N$ is inferred in Mn_3Si, judging from the ratio of $|\Theta_p|/T_N \sim 30$. Indeed, there is little change in susceptibility, specific heat, and resistivity under strong magnetic fields of 12 T ($m_I H \sim k_B T_N$). [2] Also, paramagnetic scattering persists even at 200 K ($\sim 10T_N$), [3] and magnetic excitations emerging at around the antiferromagnetic Bragg point extend with a steep slope at least up to $\sim$15 meV ($\sim 7k_B T_N$). [4]

Recently, we measured inelastic neutron spectra of $Mn_{2.8}Fe_{0.2}Si$ ($T_N = 23$ K) on a modern time-of-flight chopper-spectrometer at the high-flux neutron source SNS, Oak Ridge, U.S.A. In this sample, the Weiss temperature decreases to $\Theta_p \sim -400$ K by Fe doping, but it is still much larger in magnitude than T_N. As a result, the steep magnetic dispersion is found to extend up to $\sim$30 meV. Besides, beyond our expectation, the magnetic symmetry in $\mathbf{Q}$ space substantially changes at further high energies. Hence, the magnetic energy scale of $Mn_{3-x}Fe_xSi$ is no longer small.

A possible scenario for the suppression of T_N is due to magnetic frustration in metals. At present, however, we do not know whether it is correct or not. Rather, we are interested in the similarity with antiferromagnetic metal of α-Mn with respect to the temperature dependence of susceptibility and resistivity. [5] In the presentation, we will show the newly found magnetic excitations in detail and discuss what the Weiss temperature means in itinerant-electron systems.

References

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