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Observation of electron structure of chiral magnet $Yb(Ni_{1-x}Cu_x)_3Al_9$ by ARPES

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Trigonal $YbNi_3Al_9$ has a chiral crystal structure belonging to space group of *R*32 (No. 155) and is of interest as the first chiral magnetic alloy discovered in 4*f* electron compounds [1]. The localized Yb 4*f* spins are magnetically ordered below T=3.4 K, ferromagnetic in the *ab*-plane, and exhibit left-handed or right-handed helical magnetism with period q_z=0.8 in the *c*-axis direction [2]. Substitution of Ni with Cu significantly alters the magnetic interaction and shortens the helical period to q_z=0.4 for $Yb(Ni_{0.94}Cu_{0.06})_3Al_9$. Spin-polarized conduction electrons are thought to be responsible for this phenomenon. In this study, angle-resolved photoemission spectroscopy (ARPES) was performed on $YbNi_3Al_9$ and $Yb(Ni_{0.94}Cu_{0.06})_3Al_9$ to investigate the band structure of conduction electron bands near the Fermi level (E_F). Single crystals used for the ARPES measurements were synthesized by the flux-method [3]. The experiments were performed at BL-1 and BL-9A of Hiroshima Synchrotron Radiation Center (HSRC), Hiroshima University.

Figures 1(a) and (b) show the ARPES intensity plots of $YbNi_3Al_9$ measured at $h\nu$=24 eV with *p*-polarized geometry along the $\bar{\Gamma}$-$\bar{M}$ and $\bar{\Gamma}$-$\bar{K}$ directions of the surface Brillouin zone, respectively. Some hole-like bands around the $\bar{\Gamma}$ point and an electron-like band around the $\bar{M}$ point cross E_F. The bands located at around E_B=2.0~3.0 eV are due to the Ni 3*d* states. A parabolic band with a top of E_B~3.0 eV centered at the $\bar{\Gamma}$ point is also observed.

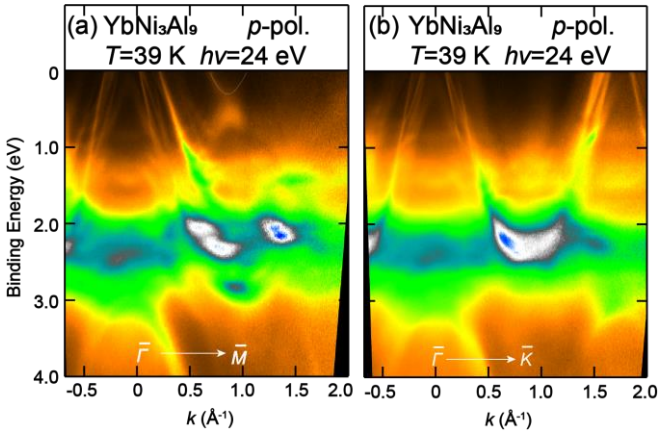

Fig. 1. ARPES intensity plots of $YbNi_3Al_9$ measured along (a) $\bar{\Gamma}$-$\bar{M}$ and (b) $\bar{\Gamma}$-$\bar{K}$ directions measured at $h\nu$=24 eV with *p*-polarized geometry.

Figures 2(a) and (b) represent the Fermi surfaces of $YbNi_3Al_9$ measured at $h\nu$=24 eV with *p*- and *s*-polarized geometries. The horizontal and vertical axes are the wavenumbers (k_x, k_y) along $\bar{\Gamma}$-$\bar{K}$ and $\bar{\Gamma}$-$\bar{M}$ directions, respectively. In Fig. 2(a), five hole-like Fermi surfaces, (a)~(e), were observed around the $\bar{\Gamma}$

point. The bands (b)~(e) in Fig. 2(a) correspond to the bands (b')~(e') in Fig. 2(b). The band (b) appears three-fold symmetric, reflecting the trigonal crystal structure with the three-fold symmetry. On the other hand, the (f) band at k_x=0.6~0.9 Å^{-1} and k_y=0.3~0.6 Å^{-1} in Fig. 2(a), which is not detected in Fig. 2(b), is an electronic-like Fermi surface. The (f) band has six-fold symmetry.

The Fermi surfaces of $Yb(Ni_{0.94}Cu_{0.06})_3Al_9$ becomes smaller in comparison with that of $YbNi_3Al_9$, although the feature is almost unchanged. This observation indicates the electron doping due to the substitution of Ni ion with Cu. The spin-resolved ARPES measurements for $YbNi_3Al_9$ are in progress.

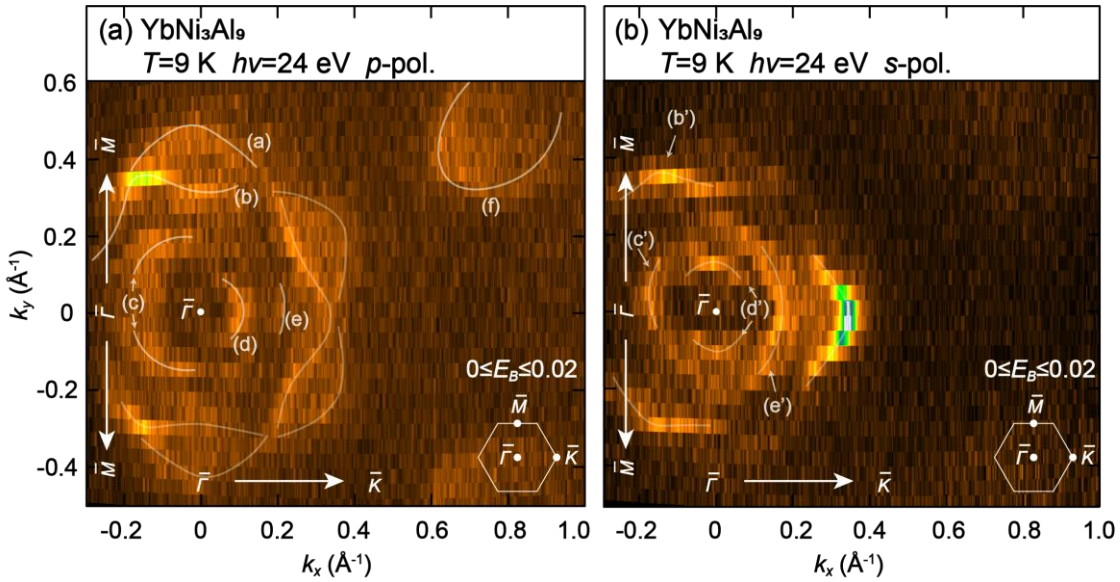

Fig. 2. Fermi surfaces of $YbNi_3Al_9$ measured at $h\nu$=24 eV with (a) *p*- and (b) *s*-polarized geometries.

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