OBSERVATION OF THE EXCHANGE NARROWING IN THE $\pi$-$d$ CORRELATED ORGANIC CONDUCTORS

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Introduction

Novel magnetic organic conductors of the $\pi$-$d$ interaction type have commanded attention since the discovery of the field induced superconductivity here at the NHMFL. One of these, $\beta$-(BDA-TTP)$_2$FeCl$_4$, is based on non tetrachalcogenafulvalene (TCF), where BDA-TTP is 2,5-bis(1,3-dithian-2-ylidene)-1,3,4,6-tetrahiapentalene. The crystal structure is monoclinic with unit cell dimensions $a=12.469\text{Å}$, $b=38.768\text{Å}$, and $c=7.735\text{Å}$. The conducting plane is the $a$-$c$ plane and the least conducting direction is along the $b$ axis due to the insulating layers of the anions sitting between the conducting layers. Previous studies of the pressure- and magnetic-field-dependent electrical transport properties show a M-I transition around 120K and an AF transition at $T_N=8.5\text{K}$, suggesting that the exchange interaction between the conduction electrons and the $d$-electrons from Fe (III) is finite. Meanwhile the electrical properties of $\beta$-(BDA-TTP)$_2$GaCl$_4$ are very similar with exception of the absence of the antiferromagnetic transition. The difference between these two analogues is the localized $d$ electrons i.e. very small $\pi$-$d$ interaction. Hence the electron magnetic resonance measurements are desirable to probe the local magnetic field.

Experimental, Results and Discussion

Angle dependent X band (9.4 GHz) EMR measurements on single crystals were carried out on a Bruker ELEXSYS E680X with a continuous He-flow system (from 4K to room temp.) at the EMR facility. The angle dependence of the linewidth and lineshape analysis at room temperature are shown in Fig.1 and 2, respectively. Data (closed circle) show a $(3\cos^2\theta-1)$ dependence with minima at 55 degrees from the $b$ axis toward the $c$ axis. The lineshape at the $b$ axis is a mixture of Gaussian and Lorentzian while in the minima it is Lorentzian. This is the typical behavior of exchange narrowing of low dimensional magnets. The Red line is for a 1D magnet fit $(3\cos^2\theta-1)^{1/2}$: $\theta$= angle between spin chains (the $b$ axis) and the applied magnetic field $B$ and blue line is for a 2D system $(3\cos^2\theta-1)^{1/2}$: $\theta$= angle between normal to the spin sheets (the $b$ axis) and $B$). The significantly broadened linewidth shows no low dimensionality at 6K (below $T_N$) in Fig.3. The Green line is the fit for $A+B\cos^2(\theta-\theta_0)$. The Lorentzian lineshape is absent in Fig.4, which indicates the disappearance of the low dimensional magnetism and the possibility of 3D long-range ordering. The formation of low dimensional magnetism is interesting especially for the 1D case because the interaction between Fe$^{3+}$ spins are least expected in the direction along the $b$ axis. Therefore this indicates that the significant $\pi$-$d$ interaction plays an important role in the formation of the magnetic chains as well as the development of the 3D ordering at low temperature. This work is supported by NHMFL/IHRP 5042 and NSF-DMR-0203532. The NHMFL is supported by a contractual agreement between NSF and the state of Florida. This research was partially supported by the Grant-in-Aid for Young Scientists (B) (no. 17740207) from MEXT of Japan.

References