Quantum critical behavior and superconductivity in Zn-doped $CeCoIn_5$

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The heavy fermion superconductor $CeCoIn_5$ ($HoCoGa_5$-type tetragonal structure) has been intensively studied because of its unusual properties in the superconducting and normal state [1-4]. It shows clear signatures of quantum critical fluctuations near the superconducting upper critical field H_{c2}, but their origin is still unresolved because relevant magnetic order has not yet been identified in this compound.

Recently, we have revealed that in the mixed alloys $CeCo(In_{1-x}Zn_x)_5$, the doping of Zn into $CeCoIn_5$ suppresses the superconducting transition temperature T_c from 2.3 K (x = 0) to 1.3 K (x = 0.07), and then generates the antiferromagnetic order above x = 0.05 [5]. This experimental finding, along with the prior and progressive research for the Cd- and Hg-doped alloys [6], indicates the presence of the antiferromagnetic instability in $CeCoIn_5$.

In this project, we performed the elastic neutron scattering experiments for $CeCo(In_{1-x}Zn_x)_5$, and found that the antiferromagnetic order, possibly coupled with quantum critical fluctuations, emerges even for x less than 0.05, in which the antiferromagnetic ordering temperature is smaller than the superconducting critical temperature. The antiferromagnetic Bragg peaks are clearly observed at the wave vector of q = (1/2, 1/2, 1/2) and its equivalent positions in the reciprocal space (Fig.1). Assuming that the antiferromagnetic moment is polarized along the tetragonal c axis, magnetic scattering amplitude estimated from the antiferromagnetic Bragg-peak intensities is roughly in proportion to the magnetic form factor calculated for Ce^{3+}. A possible antiferromagnetic structure derived in the features above is depicted in the inset of Fig. 1, which is the same as that found in Cd and Hg-doped $CeCoIn_5$ [7,8]. We plan to further investigate the antiferromagnetic quantum critical behavior coupled with the superconductivity in Zn-doped $CeCoIn_5$ by using the neutron scattering and the other microscopic probes.

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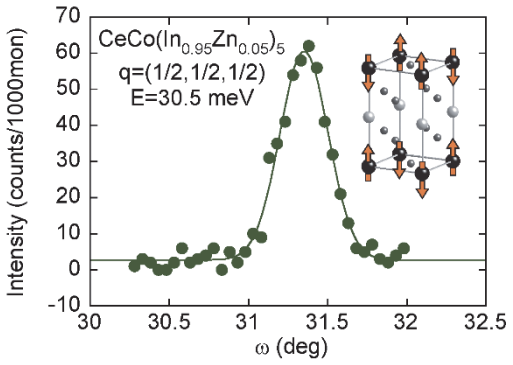

Fig. 1. The rocking curve around the momentum transfer of (1/2,1/2,1/2) at 0.7 K for $CeCo(In_{0.95}Zn_{0.05})_5$. The inset shows a possible antiferromagnetic structure of Zn-doped $CeCoIn_5$.