Comments and Addenda

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Easy direction of magnetization in $HoCo_2$ at 4.2 K

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Reexamination of the Mössbauer spectrum of ^{57}Fe in $HoCo_2$ at 4.2 K indicated the presence of a small angle ($\sim$12–30°) between the easy direction of magnetization and the [110] crystal axis. This conclusion reconciles previous Mössbauer results of ^{57}Fe-doped $HoCo_2$ with the magnetization data of single-crystal $HoCo_2$ and yields crystal-field parameters consistent with those of other RCo_2 and RFe_2 Laves phases.

The Mössbauer effect of ^{57}Fe was recently[1] used to study the magnetocrystalline anisotropy in the cubic Laves phase $NdCo_2$ and $HoCo_2$ compounds doped with ^{57}Fe. Spin rotations were observed[1,2] to occur in both compounds and the temperature dependence of the easy direction of magnetization was determined.[1] In $HoCo_2$, the spin rotation takes place at 16 K,[1,3] above that temperature the easy direction of magnetization $\vec{n}$ is parallel to the [100] cubic axis. Mössbauer spectra of ^{57}Fe-doped $HoCo_2$, taken immediately below 16 K were interpreted[1] in terms of a nonmajor [*uuw*]-type axis $\vec{n}$. At 4.2 K we reported that an adequate least-squares computer fit to the experimental spectrum could be obtained by assuming[1] $\vec{n} \parallel [111]$. This result is apparently in contradiction with the high-field magnetization data of Gignoux *et al.*,[4] which indicate that $\vec{n} \parallel [110]$ in $HoCo_2$ at 4.2 K.

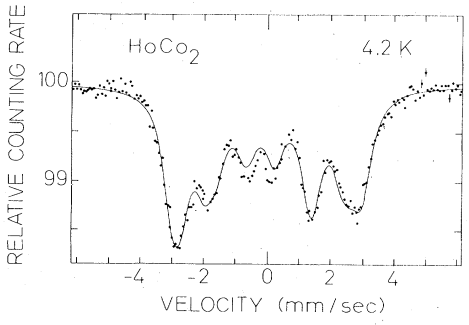

FIG. 1. Mössbauer spectrum of ^{57}Fe-doped $HoCo_2$ at 4.2 K. The solid line is a least-squares computer fit assuming an easy direction of magnetization within the $(1\bar{1}0)$ plane, 12° away from the [110] crystal axis.

We have reexamined the 4.2-K Mössbauer spectrum[1] of ^{57}Fe in $HoCo_2$ (Fig. 1), carrying out several trial computer fits[1] for various easy directions of magnetization. Although adequate [110]-type fits could be obtained, [*uuw*]-type simulations, which assume an angle between $\vec{n}$ and the [110] axis, were successful. In Fig. 1, such a [*uuw*]-type fit (solid line) is shown. It implies $\vec{n}$ to lie within the $(1\bar{1}0)$ plane, 12° away from the [110] axis. Similarly adequate [*uuw*] fits could be obtained for larger angles between $\vec{n}$ and [110], up to ~30°. Even though excluding the possibility that $\vec{n} \parallel [110]$ in $HoCo_2$ at 4.2 K, the present conclusion reconciles the ^{57}Fe Mössbauer data[1] with the magnetization study of single-crystal[4] $HoCo_2$. Magnetization measurements are not always sensitive enough to permit detection of slight deviations of $\vec{n}$ from a major axis of cubic symmetry. The close resemblance between the [*uuw*]-type fit of Fig. 1 and the [111] fit previously reported [1] indicates, for ^{57}Fe in $HoCo_2$, a particularly weak angular dependence of the spectrum with $\vec{n}$ between [111] and close to [110].

It should be recalled that the single-ion crystal-field calculations that were made[1] to reproduce a [111]-to-[100] spin rotation in $HoCo_2$, required a very large positive sixth-order crystalline-electric-field (CEF) parameter. This result stood out conspicuously at least as compared to the results

for the heavy rare-earth[5] $R\mathrm{Fe}_2$ and[1,6] $R\mathrm{Co}_2$ Laves phases for which a single pair of CEF parameters, $A_4 = 36Ka_0^{-4}$ and $A_6/A_4 = -0.043a_0^{-2}$ was sufficient[5,6] to reproduce the experimental spin-orientation data. It is reassuring to note that for both $HoCo_2$ and[7] $HoFe_2$, the CEF parameters as above[5] yield *nonmajor* axes of $\vec{n}$ below 16 K and a [100] direction above ~16 K.

Apart from the presence of three inequivalent ^{57}Fe (i.e., Co) sites with relative intensity 2 : 1 : 1, the hyperfine parameters of ^{57}Fe in $HoCo_2$ at 4.2 K, as obtained by the [*uuw*] fit of Fig. 1, are very similar to those obtained previously[1] using the [111]-type fit with two inequivalent (3 : 1) iron sites. The intensity weighted average of the three hyperfine effective fields (2 : 1 : 1) of Fig. 1, coincides with that of the two [111] fields[1] (3 : 1). The magnetic hyperfine fields at each site are 186 ± 2, 166 ± 2, and 154 ± 2 kG, with relative intensity of sites 2 : 1 : 1, respectively. The lattice and induced quadrupole constant obtained for ^{57}Fe in $HoCo_2$ at 4.2 K (Fig. 1) are 1.38 ± 0.02 and 0.77 MHz, respectively.

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