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TITLE: GIANT MOMENTS IN Pd(Mn,Co) ALLOYS

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1. Introduction.— The Mossbauer Effect (ME) has been used to determine magnetic field profiles of Type-II superconducting tapes carrying a current /1/. From the field profiles, the current distribution in the tape can be implied and used as a test of various critical state models. Fine, thin probes of ^{57}Co in Pd located at or near the surface of the superconducting tape are used to measure the fields. As the fields are typically less than 0.2 T, the sensitivity of this method is marginal despite the large effective moment μ of Fe in Pd.

In an effort to improve the sensitivity of the method, we have sought other host materials for ^{57}Co in which the effective magnetic moment of the ^{57}Fe is significantly larger than $10\text{--}12 \mu_B$; resolved ME spectra are desirable in order to determine both the magnitude and the direction of the applied field. Iron in Ni_3Ga has a giant moment of about $60 \mu_B$ /4/, but it is difficult to dope and to fabricate in the small sizes needed for a ME magnetic probe. Iron in various ductile Pd-X alloys (X = Mn, Co) offers the possibility of high saturation fields ($\sim 30\text{ T}$) and large effective moments near the magnetic ordering temperature, T_M . The functional behavior of the hyperfine field of paramagnetic Fe in metals typically follows a (slightly modified) Brillouin function at low temperatures /2,3/.

2. Results and discussion.— ME spectra were obtained as a function of temperature of the

source from 1.1 to 30 K and applied field from 0 to 6 T. In a solenoidal field most spectra were easily described by a polarized four-line fit constrained to a 3:1 ratio of the areas of the outer-to-inner peaks. A sample ME spectra is shown in Fig. 1. At low fields the outer lines were always wider than the inner lines; at high fields this difference disappeared. We ascribe this behavior primarily to nonequivalence of the ^{57}Co sites associated with the random distribution of the constituents of the alloy. At high fields the Fe moments saturate, and all sites become equivalent. From the ME spectra we obtained H_{eff} , the average field at the ^{57}Fe impurity. This field is comprised of the applied field H and the internal field H_i arising from polarization of the Fe moments. H_i opposes H , but at low temperatures H_i dominates. At very large values of H/T , H_i tends to a saturation value, H_{sat} .

Fig. 1: Mossbauer spectrum of ^{57}Fe in $\text{Pd}_{0.99}\text{Mn}_{0.01}$ at 10. K and 2.0 T.

For each alloy H_1/H_{sat} as a function of H/T was fitted to a Brillouin function for a particular temperature above T_M , with the assumption that $g = 2$. A typical result is shown in Fig. 2. The moments derived for temperatures well above T_M are reasonably constant. The effective moment μ increased dramatically as the temperature approached T_M . All data for a given source fit a universal Brillouin curve if we used the argument $H/(T-\theta)$, where θ is an adjustable parameter closely related to T_M . Although some systematic deviations were found, the analytical fits provide a good interpolation scheme for deducing the field at a ME probe.

The Curie-Weiss parameter θ_X was determined for each alloy from ac susceptibility measurements; a summary of the experimental results is in Table I.

3. Conclusions.— Near T_M , the large effective moment on Fe in the Pd(Co,Mn) alloys provides a high sensitivity ME magnetic field probe. For the

Fig. 2: ME hyperfine field data of ^{57}Fe in $\text{Pd}_{0.99}\text{Mn}_{0.01}$ fitted to a Brillouin function for three temperatures.

Table I:
Magnetic Parameters of Pd(Co,Mn) Alloys

Host	T(K)	$\mu(\mu_B)$	$-H_{\text{sat}}(\text{T})$
$\text{Pd}_{0.99}\text{Mn}_{0.01}$	6.5	228.(20)	27.8(6)
	10.	61.(5)	29.3(7)
	20.	28.(4)	29.0(14)
	All ^a	24.(2)	28.C(4)
$\text{Pd}_{0.999}\text{Co}_{0.001}$	1.5	76.(7)	29.1(6)
	2.1	50.(5)	29.1(7)
	4.0	29.(2)	29.9(6)
	8.0	29.(3)	29.9(10)
	All ^b	23.(1)	29.2(3)

^a θ , T_M , and θ_X are 5.72(7), 5.2(3), and 5.5 K.

^b θ , T_M , and θ_X are 1.03(5), 1.2(2), and 0.8(2) K.

$\text{Pd}_{0.99}\text{Mn}_{0.01}$ alloy, peak sensitivity occurs in the 6.5 to 10 K range, but T_M , and therefore the region of high field sensitivity, can easily be shifted by changing the Co or Mn concentration. These probes represent an order of magnitude improvement in sensitivity over the Pd ME probes previously used, and they should be quite useful in magnetic field profiling at cryogenic temperatures.

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