MAGNETIC HYPERFINE STRUCTURE OF ^{125}Te IN FERROMAGNETIC Pd_2MnSb

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A large internal magnetic field of +857 ± 9 kOe has been observed at ^{125}Te in ferromagnetic Pd_2MnSb (4.2 K). This gives a precise measure of the nuclear g factor ratio $g_e/g_0 = -0.2270 \pm 0.0015$.

A clear magnetic hyperfine structure (fig. 1) for ^{125}Te has been observed in the cubic ferromagnetic Heusler alloy Pd_2MnSb in a Mossbauer experiment. Such a structure has been observed previously in other hosts [1,2], but the internal field in the present experiment $H_{int} = +857 \pm 9$ kOe at 4.2 K is to our knowledge the largest yet seen at the Te nucleus. The observation of a large H_{int} has resulted in a precise measurement of the nuclear g-factor ratio $g_e/g_0 = -0.2270 \pm 0.0015$. Combining this result with the known [3] ground state g factor, $g_0 = -1.77666 \pm 0.00006$, one obtains the excited state g factor $g_e = +0.403 \pm 0.003$. Also, the internal fields at non-magnetic sites (X and Y) in ferromagnetic Heusler alloys (X_2MnY) are of current interest. Combining results for Sn [4], Sb [5] and Cd [6] at Y sites with the present measurement on Te, one observes a systematic increase (fig. 2) in the magnitude of the fields with the number of outer electrons Z_I of the "5sp" impurity.

Samples of Pd_2MnSb were prepared from 99.9% pure Pd and Mn and 99.999% pure Sb by induction melting in an argon atmosphere. X-ray examination showed a cubic phase with a lattice constant $a_0 = 6.432 \pm 0.005$ Å [7]. Radioactive ^{125}Sb was electroplated onto a Pd_2MnSb platelet (ca. 1 mm thick) and diffused into the sample by heating to 1000°C in vacuum for approximately 2 days. Fig. 1 reproduces Mossbauer spectra of the 35.5 keV γ-ray from ^{125}Te in Pd_2MnSb

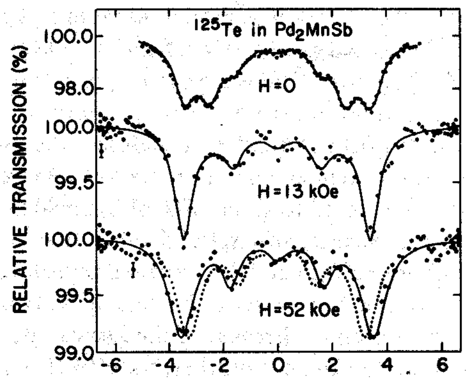

Fig. 1. Mossbauer spectra of a $Pd_2Mn^{125}Sb$ source ($E_\gamma = 35.5$ keV) taken with a ZnTe absorber (8 mg/cm^2 of ^{125}Te) at 4.2 K for three values of a longitudinal magnetic field applied to the source. The absorber was exposed to a field 48% as large as that applied to the source. The spectrum for 52 kOe is shown with the fit for a positive hyperfine field (solid line) along with the spectrum (dotted line) calculated for a negative field. The weak line at zero velocity is due to undiffused ^{125}Sb.

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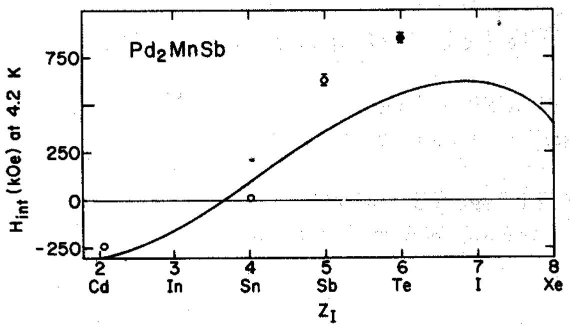

Fig. 2. Internal field systematics for "5sp" impurities in Pd_2MnSb. The Sn, Sb and Cd values were taken from refs. [4], [5] and [6], respectively. The signs of the Cd and Sb fields have not yet been measured, but are assigned on the basis of the systematics presented here.

taken at 4.2 K with a ZnTe absorber. The zero field spectrum was fitted to a six line magnetic spectrum to yield H_{int} and g_e/g_0. At 78 K the internal field value was 819 ± 12 kOe, which is 4.4% less than at 4.2 K, and thus it appears to scale with the host magnetization.

The positive sign of the Te field in Pd_2MnSb was established from measurements on the ^{125}Sb source placed in a magnetic field [8] produced by a superconducting solenoid. Since the γ rays were detected parallel to the applied field, the linearly polarized $\Delta m = 0$ lines of the spectrum were suppressed in an applied field of 52 kOe and nearly so in a field of 13 kOe. The sign of the hyperfine field is seen to be positive in fig. 1 since the line positions are observed to shift to larger velocity in the field of 52 kOe. In addition, the ZnTe absorber was located at a point on the solenoid axis where it was exposed to about 50% of the field applied to the source. Such a "split-split" combination of source and absorber results in an 8 line magnetic spectrum which appears as 4 unresolved doublets in the two lower spectra in fig. 1. Because of the Zeeman polarizations in the source and absorber, the effective shifts of these doublets are non-linear, so that the weak inner lines show a relatively larger shift with applied field than the outer lines, as can be seen by comparing the solid and dotted curves in the 52 kOe spectrum. Since this effect involves the non-magnetic absorber the excellent fit to the solid curve (positive sign) removes any doubt that the observed shifts might be due to a magnetic solid-state effect.

We have also calculated the hyperfine fields H_{int} at Cd, In, Sn, Sb, Te, I and Xe nuclei substituted in the Sb site, using the theory of Jena and Geldart [9], based on a modified Daniel-Friedel model [10]. The hyperfine field is due primarily to the direct contact interaction of the spin polarized medium at the impurity site. The systematics of H_{int} follows from the screening of the impurity charge. The results contain a parameter Δ/E_f which was fixed by normalizing to the Sn hyperfine field in Cu_2MnSn and then scaled for other Heusler alloys according to the magnetic moment per molecule of the alloy in question. Results of this calculation for Pd_2MnSb are compared with the available experimental data in fig. 2. In view of the simplicity of the model, the agreement between theory and experiment can be considered satisfactory. The sign of the internal field is available only from the present measurement on Te, where it agrees with the prediction of the model, and for Sn where the field is very small.

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