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by

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INTERNAL FIELDS AT IRON IN FePd ALLOYS *

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Considerable interest has been shown recently concerning the magnetic behaviour of FePd and CoPd alloys in light of the large magnetic moment per Fe(or Co) atom when in dilute solution in Pd.[1,4]. These large moments have been assigned to localized states of the 3d electrons of Fe (or Co) in the above alloys in conjunction with polarization of spin on those Pd atoms which are at the nearest neighbor sites with respect to the Fe impurity [3,4]. It was believed, therefore, that Mossbauer absorption experiments might yield additional information concerning this problem showing whether the internal magnetic field at Fe nucleus, H_i, varies, and whether the isomer shift shows changes in the density of s electrons at Fe nuclei with composition of the alloys.

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Previous investigation of H_i, at Fe impurity in CoPd has indicated that the internal field remained constant over the range of Co concentration between 3 at. % and 100 at. %.[5]. In the present experiments we have studied the Mossbauer absorption of gammas from a stainless steel source, Co^{57} diffused, by FePd alloys in the form of powder, of composition between 4 at % and 100 at % of Fe. FePd forms solid solutions at all compositions. The investigated range included a disordered region between 100 at % and 60 at % of Fe and two superlattices: a tetragonal form FePd and a cubic form $FePd_3$. The source was always held at 295° K. Temperature of the absorber was varied between 120° K and 350° K.

Our measurements indicate that:

1) H_i is approximately constant over the entire range of composition at $|333| \pm 9$ Koe, identical to the H_i of metallic iron. $FePd_3$ forms an exception with a field about 10% smaller.

2) The behavior of H_i as a function of temperature for FePd alloys is similar to the bahavior of magnetization in metallic iron as a function of T/T_c. (Fig. 1).

3) The shift of the center of gravity of the absorption spectra, , in ferromagnetic and paramagnetic states at 295° K is practically constant at 0.030 ± 0.003 cm/sec. for alloys of less than 70 at % Fe. For higher concentrations of Fe, δ approaches gradually the value of 0.015 cm/sec. characteristic of metallic iron. (Fig. 2).

4) The temperature variation of this shift is more pronounced than in metallic Fe. There exists an explicit temperature dependence of the isomer shift beyond the normally observed 2nd order Doppler shift. [6,7].

5) The alloys with 4 at.% and 8 at.% of Fe, paramagnetic at 295° K, show a shift identical to that observed for ferromagnetic alloys.

6) Broadening of lines occurs in disordered regions, indicating a possible influence of the number of rearest Fe neighbors on given Fe nucleus. This effect is, however, small and H_1 varies less than 10% for situations as different as those due to 12 and 2 nearest neighbors. This behaviour is substantially different than that for FeSi alloys.[8]

We can conclude that Fe in FePd finds itself in practically the same magnetic field as Fe in metallic form, regardless of changes in crystal structure, lattice spacing, and types of neigbors. The neutron diffraction measurements yield a value for the magnetic moment in FePd and $FePd_3$ about 30% larger than in the metallic Fe [9, 10]. The measured H_1 does not reflect this increase.

Clogston, et al.[4] have derived an expression for the total spin S_T associated with the localized spin S_o for the alloys which exhibit giant moments, of the form:

$$S_T = S_o + C_1 \tan^{-1} \left[C_2 \chi_M S_o J' \right]$$

where χ_M is the molar susceptibility of Pd (in our case), and J' is an exhange integral between the central Wannier function and the nearest neighbor Wannier functions. C_1 and C_2 are temperature independent quantities. The last part is a temperature dependent contribution due to magnetization of the Pd matrix. Our data indicate a lack of contribution from temperature dependent sources to H_i. We can identify therefore the observed effects as due to S_o only. [11] Clogston's estimate of S_o is of $2\mu_B$ while our data are in accord with $2.2\mu_B$ of metallic Fe. The temperature dependence of the isomer shift can, however, be related to the temperature dependent magnetic susceptibility of Pd along the lines indicated by Clogston.

Acknowledgements

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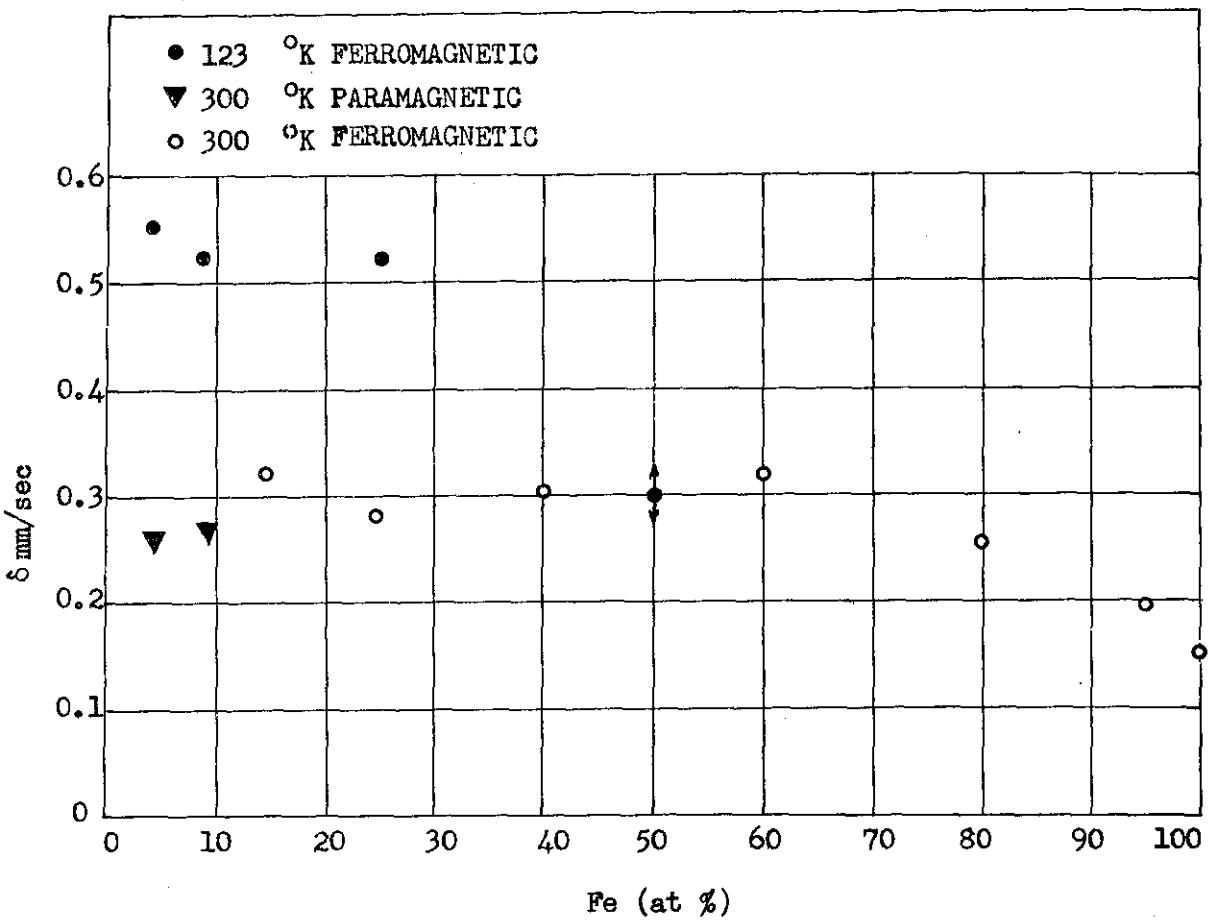

Fig. 1: The ratio of the observed $H_i(T)$ to $H_{Fe}(0)$ taken at 3.33×10^5 oe. as a function of T/T_c. The curve is the saturation magnetization of pure Fe. The magnitude of a typical error is indicated.

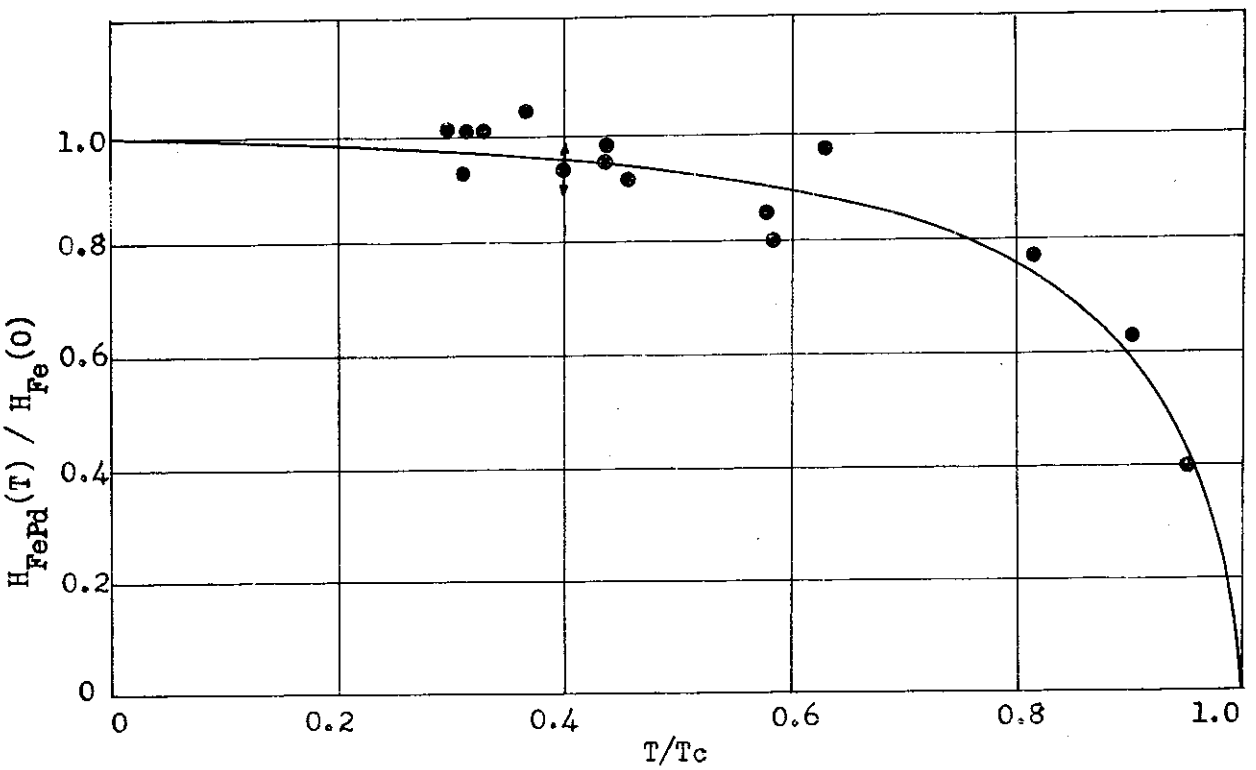

Fig. 2: The shift of the center of gravity of the ferromagnetic pattern, and of the single line of the paramagnetic line as a function of composition of the alloys. The arrow indicates the magnitude of typical error.

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