High pressure magnetic behaviour of amorphous YxNi1-x alloys

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Résumé. — Nous avons réalisé des mesures d'aimantation et de température de Curie sous haute pression sur plusieurs alliages amorphes Y_xNi_{1-x}. Les résultats obtenus semblent indiquer que le ferromagnétisme disparaît d'une manière plutôt inhomogène.

Abstract. — High pressure magnetization and Curie temperature measurements have been performed on several amorphous Y_xNi_{1-x} alloys. The results seem to indicate that ferromagnetism disappears in a rather inhomogeneous way.

1. **Introduction.** — Our previous results on Y_xNi_{1-x} amorphous alloys [1] showed that the magnetic moment and Curie temperature T_c decrease when Y is added and go to zero at $x = 20\,\%$. In the crystalline state [2] ferromagnetism disappears in YNi_5 ($x = 16.7\,\%$). In both crystalline and amorphous alloys a weak resurgence of magnetism is observed when Y concentration is increased to around 24 %. The amorphous alloys have been shown to exhibit several properties of weak itinerant ferromagnetism (W.I.F.), but not all of them [1]. This intriguing behaviour led us to undertake pressure experiments in order to test the validity of the itinerant and homogeneous picture. We note that so far there have been few high pressure magnetic measurements on amorphous rare earth transition metal alloys [3].

2. **Experimental.** — The Y_xNi_{1-x} thick films were prepared by means of D.C. triode sputtering with substrates cooled at liquid N_2 temperature [1]. The pressure experiments were performed at the S.N.C.I. (Grenoble) using a technical process already described [4].

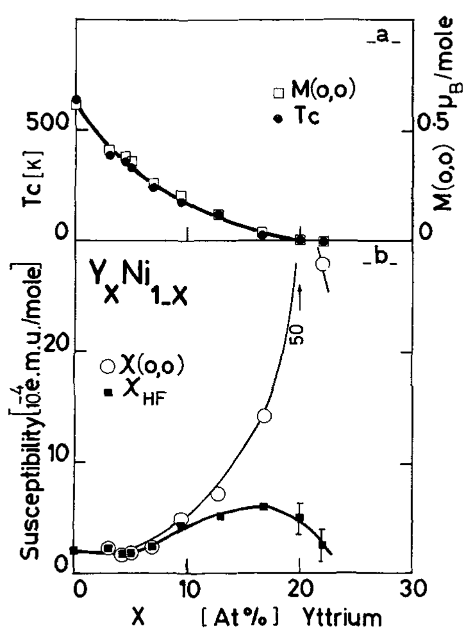

Fig. 1. — Y concentration dependence of T_c, $M(0, 0)$, $\chi(0, 0)$ and χ_{HF} for amorphous Y_xN_{1-x} alloys.

Figure 1 shows the concentration dependence of T_c, the spontaneous magnetization $M(0, 0)$, the initial ferromagnetic susceptibility $\chi(0, 0)$ and the high field susceptibility χ_{HF} measured at 150 kOe. As already observed [1], $M(0, 0)$ and T_c are not proportional to $\sqrt{x - x_F}$ as expected from the

Table I

x at % Y	0 (pure Ni)	3 %	9.5 %	12.8 %	16.7 %
$M(0, 0)$ [1] μ_B/mole	0.615	0.412	0.204	0.118	0.038
T_c (K) [1]	631	390	175	118	27
$10^3 \dfrac{d \log M(0, 0)}{dp}$ (kbar)$^{-1}$		0 ± 0.2	-1.4 ± 0.5	-9 ± 1	-4 ± 0.5
$10^3 \dfrac{d \log T_c}{dp}$ (kbar^{-1})			0 ± 0.5	-3 ± 0.5	-30 ± 3

W.I.F. model [5], where x_F is the critical concentration. $\chi(0, 0)$ diverges around $x = 20\,\%$, whereas χ_{HF} exhibits a maximum near $x = 17\,\%$. T_c at zero pressure and under pressure were deduced from the temperature dependence of the initial susceptibility. We found large differences between these values and those deduced from Arrott plots (as an example $T_c = 13$ and 27 K respectively for $x = 16.7\,\%$). These differences are characteristic of magnetic inhomogeneities. Nevertheless, the relative pressure effects determined in these two different ways are very close. The effects of pressure on T_c and $M(0, 0)$ are summarized in table I and plotted in figure 2 as a function of Y content.

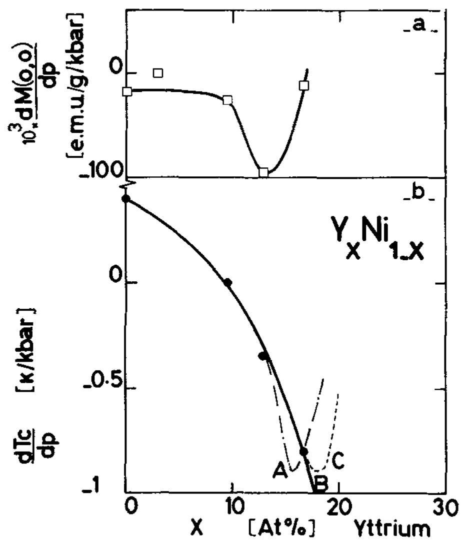

Fig. 2. — Pressure effects on $M(0, 0)$ (a) and T_c (b) for amorphous Y_xNi_{1-x} alloys.

3. **Discussion.** — Relative pressure effects on $M(0, 0)$ are rather small $\left|\frac{d \log M(0, 0)}{dp}\right| \leqslant 4 \times 10^{-3}\ \text{kbar}^{-1}$, except at $x = 12.8\,\%$ where there is the most effect $(-9 \times 10^{-3}\ \text{kbar}^{-1})$. Relative pressure effects on T_c are low for

$$x \leqslant 12.8\,\% \left(\left|\frac{d \log T_c}{dp}\right| \leqslant 3 \times 10^{-3}\ \text{kbar}^{-1}\right),$$

but for $x = 16.7\,\%$ we found a large effect

$$(-30 \times 10^{-3}\ \text{kbar}^{-1}).$$

Due to a lack of samples with Y concentration on both sides of $x = 16.7\,\%$, we have to imagine two types of behaviour for dT_c/dp below the critical concentration ($x_F \simeq 20\,\%$), as indicated in figure 2 : i) a maximum of the pressure effect below x_F (curves A and C), ii) a divergence of the pressure effect around x_F (curve B). In the W.I.F. model, dT_c/dp and $dM(0, 0)/dp$ are expected to be proportional to $1/T_c$ and $1/M(0, 0)$ respectively. This could be true with curve B for dT_c/dp but is not observed on the $dM(0, 0)/dp$ curve which exhibits a maximum effect of pressure before reaching x_F. On the other hand the W.I.F. model predicts $\frac{d \log T_c}{dp}$ and $\frac{d \log M(0, 0)}{dp}$ to have the same order of magnitude, which is not verified (table I). The experimental results presented here may be seen as characteristic of a disappearance of magnetism in a rather inhomogeneous way. A model by neighbourhood effects would lead to maxima in the effects of high fields and high pressure [7]. These maxima would correspond to the concentration range where the polarization of nearly magnetic atoms by the magnetic ones is maximum. Such effects have been already observed in PdNi alloys below the critical concentration [7]. In such a model, T_c and $M(0, 0)$ are expected to be proportional to the concentration of magnetic atoms and thus dT_c/dp and $dM(0, 0)/dp$ also. Curves A and C (figure 2), with decreasing values when approaching x_F, and the shape of the curve of $M(0, 0)$ *vs.* x (figure 1) would favour this model. Weak ferromagnetic atoms coupled through a quasi-magnetic matrix with a high density of states at the Fermi level may exhibit some macroscopic properties predicted for strictly itinerant weak ferromagnets. In particular, a linear relationship between M^2 and H/M, as observed in these alloys [1], may be expected.

4. **Conclusion.** — The magnetization measurements under high pressure seem to favour a localised inhomogeneous picture of the magnetic moments in Y_xNi_{1-x} amorphous alloys. On the contrary, our previous results were discussed on the basis of several theories of itinerant ferromagnetism [1]. None of these results allows to decide conclusively between these two pictures. A definite answer could be given by a microscopic measurement, such as the magnetic hyperfine field distribution at the Ni sites.

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