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EFFECT OF HIGH PRESSURE AND HIGH MAGNETIC FIELD ON MAGNETISM OF $\text{MnAs}_{1-x}\text{Sb}_x$ ($0 \leq x \leq 0.3$)

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Abstract. – Magnetic and crystallographic properties, pressure effect of the Curie temperature region are measured for $\text{MnAs}_{1-x}\text{Sb}_x$. Bean and Rodbell's theory with temperature dependent parameters can be applicable to the data. some change of the electronic state occurs at $x \approx 0.4$ in $\text{MnAs}_{1-x}\text{Sb}_x$.

The unusual magnetic properties of MnAs were studied by many authors [1-3]. On the other hand, Bärner observed the magnetic properties of $\text{MnAs}_{1-x}\text{Sb}_x$ and presented an idea to understand them [4]. Since the crystallographic transition in MnAs is removed by the Sb substitution for As of MnAs, to study $\text{MnAs}_{1-x}\text{Sb}_x$ is also helpful for understanding the magnetic properties of MnAs. In this work, effects of high pressure and high magnetic field on the magnetic properties are observed, together with the magnetic and crystallographic measurements.

The $\text{MnAs}_{1-x}\text{Sb}_x$ were prepared by sintering at 800 °C for two weeks. The compounds with $x \geq 0.1$ have the NiAs-type of structure, but a narrow temperature range of the MnP-type of structure was observed for $x < 0.1$, just above the Curie temperature. Curie temperature and lattice constants at R.T. are shown in figure 1. The Curie temperature shows a minimum at $x \approx 0.4$, where the *c*-axis shows a kink. Saturation magnetizations (σ_s) of $\text{MnAs}_{1-x}\text{Sb}_x$ have been measured and plotted against temperature in figure 2. The absence of temperature hysteresis at T_c was confirmed for the compounds with $x \geq 0.1$, therefore the relatively sharp decreases of magnetizations just below T_c in figure 2 are of second kind. The temperature dependence of lattice constants is shown in

figure 3. Large positive and negative exchange strictions are seen for *a*- and *c*-axes respectively, and from the data the volume strictions are positive. Pressure coefficients of T_c were determined under a high pressure of 3 kbar. The data are shown by the solid circles in figure 4. The $\partial T_c / \partial P$ starts to rise with decreasing x at around $x = 0.4$, which nicely corresponds to the composition at which the *c*-axis and the T_c in figure 1 show the kink and the minimum respectively. Magnetization curves of $\text{MnAs}_{0.9}\text{Sb}_{0.1}$ were measured

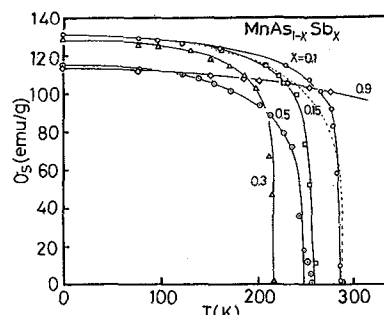


Fig. 2. – $\sigma_s - T$ curve for $\text{MnAs}_{1-x}\text{Sb}_x$. The dashed curve is drawn by Bean and Rodbell's theory (see text).

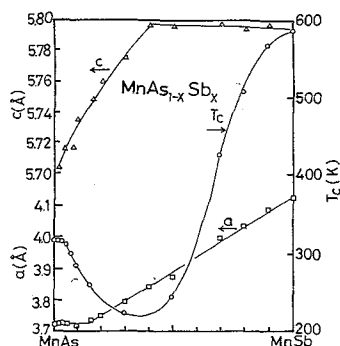


Fig. 1. – Lattice constants and Curie temperature vs. T .

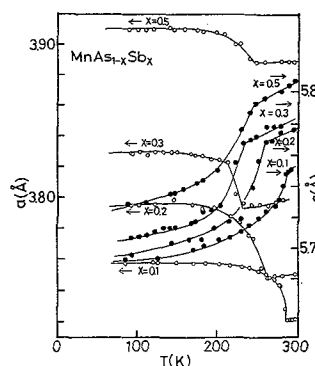


Fig. 3. – Temperature dependence of the lattice constants.

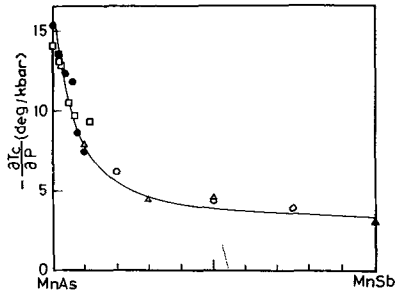


Fig. 4. - Pressure coefficients of T_C ; (●) present work; (○) ref. [2]; (○) ref. [5]; (□) ref. [6]; (△) the values deduced from the data in figure 3 (see text).

under a pulsed magnetic field at temperatures above T_C (Fig. 5). They have a metamagnetic nature, but the transitions are not of first kind, unlike MnAs.

All the data in figures 2-5 seem to be explained by the Bean and Rodbell theory [1], which is based on the equation, $T_C = T_0 (1 + \beta (v - v_0) / v_0)$, where v_0 means the crystal volume at $T = 0$ K in the absence of exchange striction. By extrapolating the data in figure 3 to $T = 0$ K, we can estimate the volume exchange strictions at $T = 0$ K, from which we can estimate the product of parameters, $KT_0\beta (= -\partial T_C / \partial P)$ defined in reference [1]. These values of $\partial T_C / \partial P$ are also shown by the open triangles in figure 4. They agree well with the directly measured values. For $\text{MnAs}_{0.9}\text{Sb}_{0.1}$, the value $KT_0\beta$ is 0.68×10^{-8} , on which we can calculate $\sigma_s - T$ curve for $\text{MnAs}_{0.9}\text{Sb}_{0.1}$ as shown by the dashed line in figure 2. The agreement is good. In the above calculation, we adopted 25 for β -value to get preferentially the best matching between the observed $\sigma_s - T$ and the calculated one in figure 2. On the other hand, the parameter values mentioned above can not reproduce the $\sigma - H$ curves in figure 5, but if we take the different values of parameters shown in figure 5, the agreement between the observed and calculated

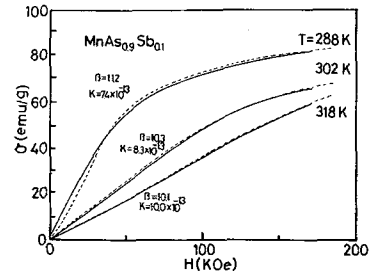


Fig. 5. - Magnetization curves. The dashed curves are calculated on the Bean and Rodbell theory with T -dependent parameters (see text).

$\sigma - H$ curves is excellent. Therefore we have to assume the parameter values to be temperature-dependent. In other words, a different meaning have to be given to the Bean and Rodbell parameters. This idea is also supported by the nonlinear relationship between T_C and the volume ($= \sqrt{3}/2a^2c$) in figure 1. The lattice constant c (Fig. 1), the pressure coefficient of T_C (Fig. 4) and the Curie temperature (Fig. 1) change their composition dependences at around $x = 0.4$. These results imply, as pointed out by Bärner [4], that some change of valence electron state in $\text{MnAs}_{1-x}\text{Sb}_x$ occurs at around $x = 0.4$.

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