TABLE II. Data for the magnetic $B8_1$ to $B31$ transition in MnAs.

Pressure (kbar):	0.001	1.22	2.33	3.73	4.23	4.5	4.5
$B8_1 \rightarrow B31\, T_c$ (°K):	317	298	278	243	223	201	77
Temperature (°K):	307	298	283	245	240	201	138
$B31 \rightarrow B8_1\, P_c$ (kbar):	0.001	0.7	0.9	2.0	1.7	1.4	0.001

Kelvin. Differentiation gives $dT_c/dP = -13.8$°C/kbar at 1 atm. This is in moderate agreement with the results of Rodbell and Wilson[8] and of Samara and Giardini,[6] who report -12 and -12.3°C/kbar. (DeBlois and Rodbell[3] give -24.1°C/kbar for the $B31 \rightarrow B8_1$ transition, which is also in reasonable agreement with Table II and Fig. 3.) However, these authors imply that the slope is constant. Our experiments were done on polycrystalline samples, whereas they used single crystals and were confined to $P<2.5$ kbar. (Also see note added in proof at end of paper.)

The pressure dependence of T_c is displayed in Fig. 3, where the smooth curve for increasing pressure in the interval $190 \leq T \leq 317$°K is Eq. (2). The data clearly demonstrate a critical pressure $P_c \approx 4.6$ kbar above which the $B31$ phase is indeed stable down to lowest temperatures. In addition, the pressure hysteresis increases with decreasing temperature, so that pressures $P>2$ kbar applied at room temperature are sufficient to stabilize the $B31$ phase to lowest temperatures. In fact, it is possible to obtain the $B31$ phase at atmospheric pressure below 138°K if the pressure is reduced from $P>4.6$ kbar at a $T<138$°K.

The transition at $T=138$°K was obtained as follows: A specimen of MnAs was placed under 5-kbar pressure in the high-pressure gas apparatus, and the apparatus was cooled to 77°K. Pressure was then released and the specimen transferred to the cold stage (4.2°K) of a vibrating-coil magnetometer. At no time was the specimen allowed to warm up more than a few degrees above 77°K. The magnetic properties were measured from 4.2°K to room temperature. Below 138°K there was a small susceptibility that decreased with increasing temperature. An abrupt transition occurred at 138°K, the magnetization increasing by over a factor of 50 to the magnetization value of the $B8_1$ phase.

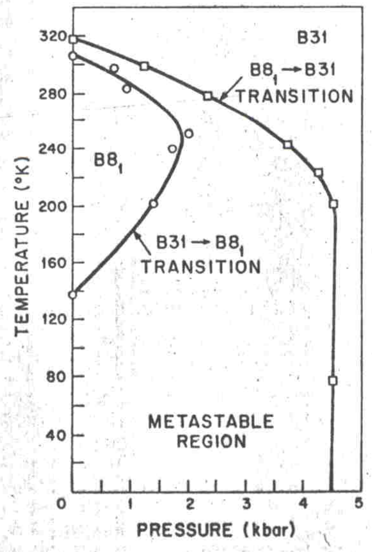

FIG. 3. Temperature-pressure diagram for first-order $B8_1 \rightarrow B31$ and $B31 \rightarrow B8_1$ transitions in MnAs below 320°K.

Although the low-temperature $B31$ phase appeared to resemble the metamagnetic phase of low-temperature MnP and $MnAs_{0.9}P_{0.1}$, our preliminary measurements on a polycrystalline sample do not allow characterization of the magnetism of this phase. This point is significant because Rodbell and Bean[9] have anticipated a ferromagnetic⇄antiferromagnetic phase change with increasing pressure at low temperatures. A pressure bomb for further magnetic studies is under construction. Meanwhile, monitoring of the resistance at room temperature up to 12 kbar has shown only one first-order phase change. The Rodbell–Bean P^*-T phase diagram contains $P^* = P - \alpha_l T/K$, where α_l is the thermal expansion coefficient and K is the compressibility. Their diagram would reflect the P^*-T curve through the $P^* = [4.6 + (\alpha_l T/K)]$ kbar line to predict a room-temperature paramagnetic⇄antiferromagnetic phase change near $[8 + (\alpha_l T/K)]$ kbar $= 11.8$ kbar. If such a transition exists below 12 kbar, it is not first-order. Further, reduction in temperature under $P=3$ kbar from the paramagnetic $B31$ phase at room temperature and 3 kbar gave no anomaly in the resistance down to 90°K. Since the high-pressure phase is magnetically ordered at 90°K, this means that the paramagnetic⇄magnetic-order transition in the high-pressure phase is not first-order. (The magnetic-order transition temperature for the high-pressure phase is not indicated in Fig. 3 since it is not clearly defined by a resistivity anomaly.) Therefore, it may be assumed that the high-pressure phase retains the $B31$ structure in the areas so designated in Fig. 3 and that there is no crystallographic phase change associated with magnetic ordering in the high-pressure phase.

III. DISCUSSION

A. Significant Observations

These results, together with the earlier study[6] of $MnAs_{1-x}P_x$ and the data of Table I, establish the

[8] As quoted by Ref. 3.

[9] D. S. Rodbell and C. P. Bean, J. Appl. Phys. Suppl. **33**, 1037 (1962).