(c) *The Transition Temperature* T_λ

The data on 30 points are given in Table III. The determination of the relative density and pressure has been described above and the concentration was determined by the summation of the various conversion rates over the time periods of the different pressures. The concentration c given is the combined error of the conversion rate and the spread of the concentration over the lines taken. The error is an increasing function of pressure due to the increase in the conversion rate with higher pressure. The temperature T_λ is the intercept mentioned above. There is appreciably more scatter in the determination of T_λ by the techniques mentioned above than by specific heat data,[28,16] because in NMR data T_λ is obtained by extrapolation while in specific heat experiments it is directly seen by a maximum in C_p.

Using the empirical relation between T_λ and c at one atmosphere [Eq. (1)] and the functional dependence on the density [Eq. (2)] it is possible to determine the value of the ratio $V(\rho)/V(\rho_0)$ for a given density. This ratio is plotted on a logarithmic scale (Fig. 8) and it is found that one has approximately

$$\frac{T_\lambda(\rho,c)}{T_\lambda(\rho_0,c)}=\frac{V(\rho)}{V(\rho_0)}=\left(\frac{\rho}{\rho_0}\right)^{2.0}. \qquad (9)$$

Hence the empirical relation between T_λ, ortho concentration and relative density is given by

$$T_\lambda=(\rho/\rho_0)^{2.0}[-1.23+3.78c] \quad \text{for} \quad 0.6\leqslant c\leqslant 0.75. \qquad (10)$$

Empirically speaking, the exponent 2.0 indicates a composite dependence of the potential on distance as R^{-6}. This is in rough agreement with interactions due to quadrupole and Van der Waals forces. In Fig. 8 we also give the ratio $T_\lambda(\rho,c)/T_\lambda(\rho_0,c)$ determined from the specific heat data of Ahlers and Orttung.[16] Their data

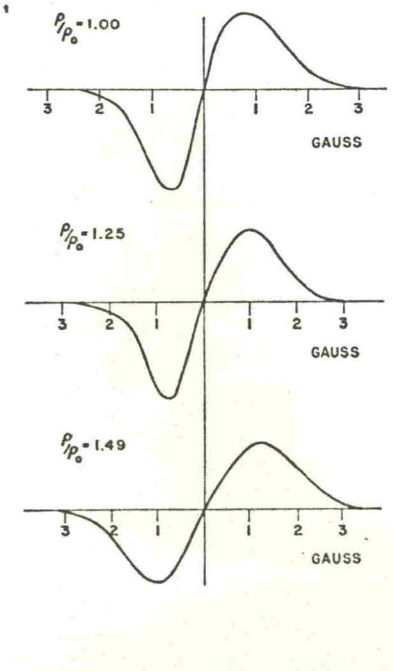

FIG. 9. Derivatives of the D_2 line as a function of relative density at 4.2°K.

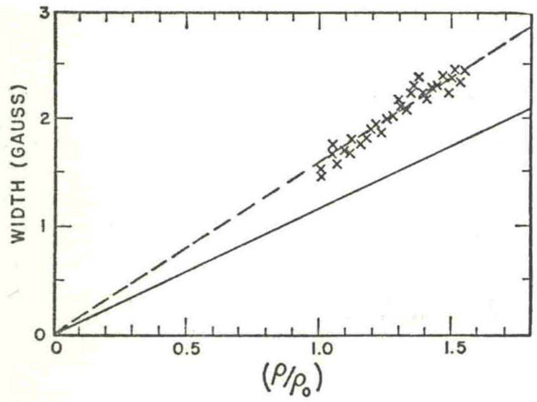

FIG. 10. Linewidth of D_2 as a function of relative density at 4.2°K. The solid line is that calculated for the hcp lattice (Ref. 25) according to the theory of second moments and the empirical relation (11).

are consistent with ours within the combined experimental error. McCormick[15] reported one transition point, 3.1°K at 2300 atm, without indicating the concentration. According to Eq. (10), one estimates $c=0.71$ for this pressure. Depending on the time elapsed at one atmosphere and at 2300 atm, this would be possible if the data were taken between one and two hours after cooling the H_2 to 4.2°K. This point is thus compatible with the results of our work. As mentioned before, Smith and Squire[6] reported no change in a transition temperature of 1.57°K from zero to 216 atm. However, if the data were taken in steps with increasing pressure over a period of time, the ever present conversion would change the concentration c and thus the expected transition temperature. Hence the effect of the increased density would be partly compensated for by the decreased concentration. This may account for their failure to observe a change in T_λ.

B. Deuterium

The derivative of the deuterium line is shown in Fig. 9. There is a slight departure from antisymmetry about the center which is not due to any saturation. This effect tends to disappear at high densities as shown in this figure. The integrated D_2 lines have a shape much closer to Gaussian than to those of H_2. Evaluation of the second moment and the linewidth for several densities gives the empirical relation

$$\Delta H=(2.0\pm0.1)M_2^{1/2}(h/g\beta)\ (\text{G}). \qquad (11)$$

The linewidth was found to be independent of temperature below 4.2°K at all densities. A plot of ΔH versus relative density is given in Fig. 10. While the scatter is relatively large compared to the change observed, the data roughly follow the straight line:

$$\Delta H=1.6(\rho/\rho_0)\ (\text{G}). \qquad (12)$$

Hence the data would extrapolate to approximately zero linewidth for zero density. This shows that, according to