

with wave vector difference Q , represent the electron and hole Fermi surfaces, and the Coulomb attraction between electrons and holes is described by a single parameter V . Mathematically the model is very similar to the BCS model for superconductivity, and so is the resulting expression for the transition (Néel) temperature, which reads:

$$k_B T_N = E_B \exp(-1/\lambda), \quad (3)$$

where E_B is of the order of the band width and $\lambda = VN(0)$, $N(0)$ being the density of states at the Fermi level.

From the experimental results mentioned in the introduction^{2,7} it is clear, that the effect of pressure and that of reducing the electron/atom ratio by alloying on the Néel temperature of Cr are very similar. In view of the result (3), this is not surprising: in fact α and β of eqs. (1) and (2) can be considered to be the first coefficients in a power-series expansion of $\lambda^{-1}(n, p)$.

Recently Rice *et al.*¹⁴ devised a model, based on an assumption regarding the joint density of states function, which predicts the concentration and pressure dependence of T_N , eqs. (1) and (2), correctly. The joint density of states, a function of two energy variables, x and y , is defined as:

$$N_Q(x, y) = \sum_k \delta[x - \frac{1}{2}(\epsilon_k^e - \epsilon_{k+Q}^h)] \delta[y - \frac{1}{2}(\epsilon_k^e + \epsilon_{k+Q}^h)],$$

where $\epsilon_k^{(e,h)}$ is the single-particle energy in the electron (hole) band. If the two bands are identical, N_Q is almost independent of x and is proportional to $\delta(y)$. The model of Rice, Halperin, Barker and McWhan is defined by:

$$N_Q(x, y) = C_1 \phi_1(y) + C_2 \phi_2(y), \quad (4)$$

where $\phi_1(y)$ is sharply peaked at $y = 0$ and $\phi_2(y)$ has appreciable values only for $y > k_B T_N$. It has been shown¹⁴, that if C_1 and C_2 vary linearly with the electron/atom ratio and pressure, eqs. (1) and (2), respectively, are obtained from (4).

The experimental results quoted above^{2,7} can be considered to justify the model for N_Q , eq. (4). However, since the implications of the model regarding the band structure are not obvious, it is altogether not clear whether C_1 and C_2 are to be taken as constants plus linear combinations of n and p ,

$$C = C_0 + C_n n + C_p p, \quad (5)$$

or: a "cross term" proportional to np is also allowed. In terms of the expansion of $\lambda^{-1}(n, p)$ in (3), the question reduces to that of the importance of the term:

$$\frac{\partial^2(\lambda^{-1})}{\partial n \partial p} \Delta n p. \quad (6)$$

In the measurements of Trego and Mackintosh²) and McWhan and Rice⁷), the quadratic terms proportional to $\partial^2(\lambda^{-1})/\partial n^2$ and $\partial^2(\lambda^{-1})/\partial p^2$, respectively, were found to be negligible within the experimental error, but as in the experiments T_N was measured varying the electron concentration *or* the pressure, the importance of the cross term (6) cannot be ruled out by their evidence. It is only through the simultaneous variation of electron concentration *and* pressure that one can decide upon the importance of the term in eq. (6).

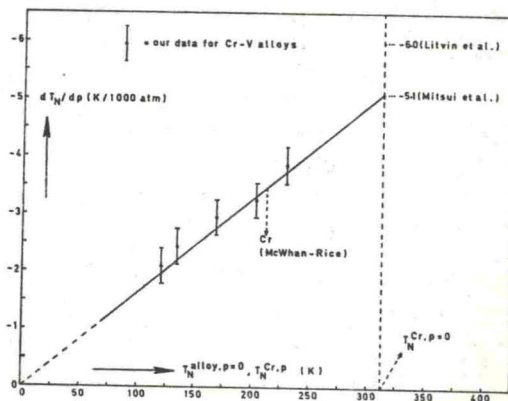


Fig. 5. dT_N/dp as a function of T_N (for Cr-V alloys in the limit $p \rightarrow 0$). The solid line represents the measurements of McWhan and Rice on pure chromium.

In fig. 5 we have plotted the slopes $(dT_N/dp)_{p \rightarrow 0}$, given in table I, versus the transition temperature T_N . The linearity of $(dT_N/dp)_{p \rightarrow 0}$ vs. T_N within the experimental error, together with the exponential dependence of T_N on concentration shown in fig. 3, proves that $(dT_N/dp)_{p \rightarrow 0}$ varies exponentially with concentration. This is what one expects from previous measurements^{2,7}): uniting (1) and (2) in the most straightforward way we have

$$T_N^{\text{alloy}, p} = T_N^{\text{Cr}, p=0} \exp[\alpha(n_{\text{alloy}} - n_{\text{Cr}}) + \beta p],$$

and hence

$$(dT_N^{\text{alloy}, p}/dp)_{p \rightarrow 0} = \beta T_N^{\text{Cr}, p=0} \exp[\alpha(n_{\text{alloy}} - n_{\text{Cr}})] = \beta T_N^{\text{alloy}, p=0}.$$

Note that inserting a cross term of type (6) in the exponent, or, equivalently, allowing for the concentration dependence of β would contradict our experimental results. The slope of the straight line fitted to the points in fig. 5 gives thus β for all concentrations including pure Cr. The small scatter of our points around the line representing the results of McWhan and Rice⁷),