II. ITINERANT ELECTRON FERROMAGNET MODEL

It is the purpose of this section to present an elementary theory, unifying several existing theories, of a single band, itinerant electron FM. In particular, we shall develop a theory, appropriate for 3-d electrons, for the Curie temperature, T_c, and its pressure derivative, $\partial T_c/\partial P$; and we shall show how estimates of the effective exchange, I, times the density of states at Fermi level, $N(\epsilon_F)$, can be made from the measurements of $\partial T_c/\partial P$. The theory presented here follows quite closely the earlier work of Wohlfarth,[9] Edwards and Wohlfarth,[10] Shiga,[13] and Wohlfarth and Bartel,[12] but includes details which have not been discussed in these earlier works.

For our model we assume that the exchange splitting is given by $nI\zeta$ where I is the effective intra-atomic exchange (accounting for the electron correlations) between the itinerant electrons, n is the number of d-electrons per atom, and ζ is the relative magnetization per electron arising from single-particle excitations. In the Stoner theory, the exchange splitting is $2k_B\theta'\zeta$ where $k_B\theta'$ is the molecular field approximation interaction; thus $k_B\theta' = 1/2\ nI$. The single particle excitations are described by the Stoner equations[9,10]

$$1/2\ n(1 \pm \zeta) = \int_0^\infty f(\epsilon,\eta^\pm)\ N(\epsilon)\ d\epsilon \quad , \tag{1}$$

where

$$f(\epsilon,\eta) = \left\{\exp\left[(\epsilon - \eta)/k_BT\right] + 1\right\}^{-1} \quad ,$$

and

$$\eta^\pm = \mu \pm 1/2\ nI\zeta \pm \mu_B H \quad .$$

Here μ is paramagnetic chemical potential, H is the applied magnetic field, and $N(\epsilon)$ is the density of states. In the limit as $T \to T_c$ such that $\zeta \to 0$ and

letting H = 0, we can expand the Fermi function exponentials in the expression for ζ, Eq. (1), and obtain the well known result

$$I \int_0^\infty N(\epsilon) \left| \frac{\partial f}{\partial \epsilon} \right|_{\substack{T=T_c \\ H=0}} d\epsilon = 1 \quad . \tag{2}$$

Within the framework of the model, Eq. (2) can be solved for T_c if $N(\epsilon)$ is known. Even if we don't know $N(\epsilon)$ we can solve Eq. (2) by use of the Sommerfeld expansion. To terms quadratic in T_c we obtain[14]

$$T_c^{\,2} = T_F^{\,2}(\bar{I} - 1) \,/\, \bar{I} \quad , \tag{3}$$

where

$$\bar{I} = I N(\epsilon_F) \quad . \tag{4}$$

Here $N(\epsilon_F)$ is the density of states per atom per spin at the paramagnetic Fermi level, and T_F is the effective degeneracy temperature defined by[9,10]

$$T_F^{\,2} = \left\{ \frac{\pi^2}{6} \, k_B^{\,2} \left[\left(\frac{N'(\epsilon_F)}{N(\epsilon_F)} \right)^2 - \frac{N''(\epsilon_F)}{N(\epsilon_F)} \right]^{-1} \right\} \quad , \tag{5}$$

where $N^{(m)}(\epsilon_F)$ is the m-th derivative with respect to energy evaluated at ϵ_F. The expression for $T_c^{\,2}$, Eq. (3), is identical to what one would obtain from the singularity in the exchange enhanced susceptibility where the F-integral of Lang and Ehrenreich[15] is expanded by means of a Sommerfeld expansion. In order for the system to be FM, we have from Eq. (3) the Stoner criterion, $\bar{I} \geq 1$.

The expression for $T_c^{\,2}$, Eq. (3), is general to the extent that we have not specified the origin or nature of I and we have not restricted $N(\epsilon_F)$. To find