Invalidity of Vonsovsky's Results on the Ferromagnetic Anomaly of the Work Function

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(Z. Naturforsch. **31 a**, 1424 [1976]; received August 19, 1976)

The theoretical result on the ferromagnetic anomaly of the work function by Vonsovsky and Sokolov is shown to be invalid. A consistent derivation within this model leads to no anomaly at the Curie point.

In 1951 Vonsovsky and Sokolov [1] derived a ferromagnetic anomaly in the electron workfunction (WF) Φ at the Curie point T_c. Their theoretical result was used in the interpretation of experimental data on the WF of Ni by Comsa et al. [2] and Hölzl and Porsch [3]. A change in the temperature dependence $\Delta\Phi/\Delta T$ at T_c was expected, but not found in [3].

The theoretical derivation [1] of an anomaly in the WF is based on the s-d model of ferromagnetic metals by Vonsovsky [4]. Their result [1] can be written as

$$\Phi(y) = W - \varepsilon_\beta (1 - \delta_1 y^2) \tag{1}$$

with

$$\varepsilon_\beta = 4\pi^2 a^2 \beta \left(\frac{3n}{8\pi}\right)^{2/3} \quad \text{and} \quad \delta_1 = \frac{2}{3} k_1 \frac{\beta'}{\beta} - \frac{1}{9} k_1{}^2 .$$

The constant parameters β, β' and k_1 are explained in the s-d model [4], a is the lattice constant, n the density of the 4s-electrons, y represents the spontaneous magnetisation of the 3d-electrons, which is assumed to be the main part of the total magnetisation. y vanishes for $T > T_c$ thus giving rise to a change in the temperature dependance of WF at T_c. W is the depth of the 4s-electrons potential well for $T > T_c$.

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In the ferromagnetic state the 4s-electron gas is represented by two components of polar spin orientations denoted $\pm$. The potential wells of the components then are defined by [1]

$$W_\pm = \Phi + \xi_\pm . \tag{2}$$

Using the expressions given in Vonsovsky's paper [4] we calculate the chemical potentials of the two components to be

$$\xi_\pm = \varepsilon_\beta \left(1 \pm \frac{\beta'}{\beta} y\right) (1 \pm k_1 y)^{2/3} .$$

Further reevaluation shows the following inconsistency in the mathematical treatment. The expansion of $\xi_\pm$ in (2) up to linear terms in y and making use of another form of (2)

$$\Phi = \tfrac{1}{2}(W_+ + W_-) - \tfrac{1}{2}(\xi_+ + \xi_-) \tag{3}$$

leads to the y^2-dependence of Eq. (1) only if the chemical potentials in the second term of (3) are developed not equally far but up to quadratic terms in y. No physical argument can be seen for an approximation of $\xi_\pm$ in two different ways and recombining the results thereafter. So (1) cannot be helpful in discussing experimental data on the T-dependence of WF in ferromagnets.

This reevaluation shows that even within Vonsowski's model no anomaly at $T = T_c$ can be expected. This result is in full agreement with the best experimental measurements by Hölzl and Porsch [3].

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