Digital Computer Laboratory
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SUBJECT: GROUP 63 SEMINAR ON MAGNETISM, LIII

To: Group 63 Staff

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In the previous lectures we have considered the case of negative interaction of the ferrite sublattices ($\epsilon = -1$) when $\lambda \neq \mu$. Let us now consider the special case $\epsilon = -1$, $\lambda = \mu = 0.5$. In this case, the two lines CK and SD become a single line satisfying the equation $\alpha = \beta$, and lines CE and SH coincide. Thus the $\alpha\beta$ plane of figure 118 is reduced to the form shown in figure 121.

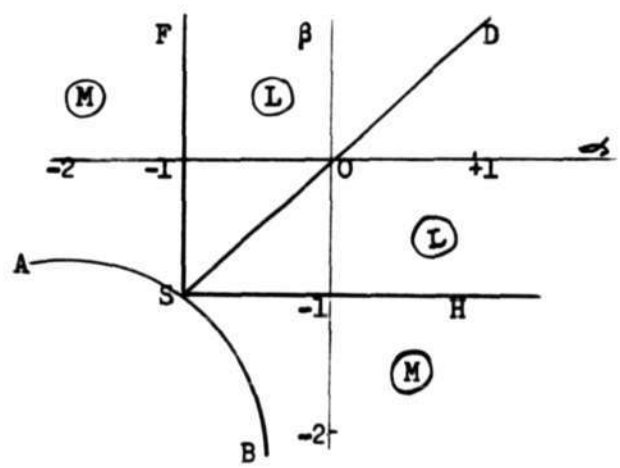

FIGURE 121

$\alpha\beta$ plane when $\lambda = \mu$

In regions ASF and BSH the spontaneous magnetization curves are of type M (see figure 119). At absolute zero temperature in region ASF,

$$I_{bs} = M \text{ and } I_{as} = -\frac{\mu}{\lambda\alpha} M = -\frac{M}{\alpha}$$

(from equation LII-1). Therefore $I_s = \frac{M}{2}(1 + \frac{1}{\alpha})$. Similarly, in region BSH,

$$I_s = \frac{M}{2}(1 + \frac{1}{\beta})$$

In region FCE, $I_{as} = I_{bs} = M$ at absolute zero temperature. Therefore, $I_s = 0$ at $0^{o}K$. However, since the variation of I_{as} and I_{bs} with temperature is not the same when $\alpha \neq \beta$, a net spontaneous magnetization will appear at higher temperature. Thus the magnetization curve in this region will appear as shown in figure 122.

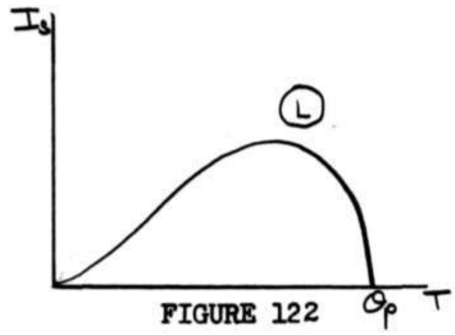

FIGURE 122

Antiferromagnetism

If $\alpha = \beta$ we are on the line SD of figure 120. In this case $\vec{I_{as}}$ and $\vec{I_{bs}}$ vary identically with temperature, and since they are oppositely directed the net magnetization will remain identically zero throughout the temperature range. This is the essential property of antiferromagnetism, which was discussed in meeting 34.

The law of paramagnetism was found to be (equation XLIX-14)

$$\frac{1}{\chi} = \frac{T}{C} + \frac{1}{\chi_0} - \frac{\sigma}{T-\theta}$$

Along line SD of figure 121 $\frac{\sigma}{T-\theta} = 0$ and the straight line relationship

$$\frac{1}{\chi} = \frac{T}{C} + \frac{1}{\chi_0}$$

holds in the paramagnetic temperature region.

Since $\frac{1}{\chi_0} = n(2\lambda\mu - \lambda^2\alpha - \mu^2\beta) = \frac{n}{2}(1-\alpha)$ for the case $\alpha = \beta$ and $\mu = \lambda = 0.5$

$$\frac{1}{\chi} = \frac{T}{C} + \frac{n}{2}(1-\alpha) \qquad \text{LIII-1}$$

The asymptotic Curie temperature θ_a was defined as the point at which the extrapolated line defined by equation LIII-1 cuts the temperature axis. That is,

$$0 = \frac{\theta_a}{C} + \frac{n}{2}(1-\alpha).$$

Therefore

$$\Theta_a = -\frac{nC}{2}(1-\alpha) \qquad \text{LIII-2}$$

The magnetization law given by equation LIII-1 holds only above the Curie point Θ_p which was defined (equation XLIX-18) as

$$\Theta_p = \frac{nC}{2}\left[\lambda\alpha + \mu\beta + \sqrt{(\alpha\lambda-\mu\beta)^2 + 4\lambda\mu}\right]$$

when $\alpha = \beta$ and $\lambda = \mu = 0.5$ this can be rewritten as

$$\Theta_p = \frac{nC}{2}(\alpha + 1) \qquad \text{LIII-3}$$

On substituting this temperature value into equation LIII-1 it is seen that $1/\chi = n$ when $T = \Theta_p$. The curve of the inverse susceptibility versus temperature will then appear shown in figure 123.

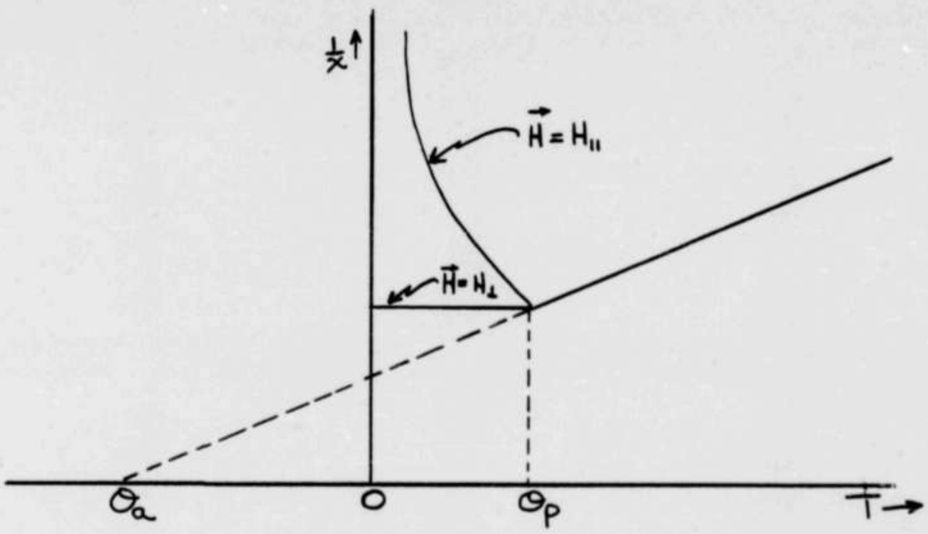

FIGURE 123

The behavior of the susceptibility below the Curie temperature, as indicated by the lines labelled $H_{\parallel}$ and $H_{\perp}$, has been discussed at meeting 34.

Signed A. L. Loeb

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ALL/NM:jrt

cc: Group 62 (25)

Approved DRB
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