CHANGE OF GINZBURG-LANDAU PARAMETER UNDER PRESSURE

E. FISCHER and J. L. OLSEN
Laboratorium für Festkörperphysik,
Swiss Federal Institute of Technology, Zürich, Switzerland

Received 15 February 1968

The Ginzburg-Landau parameter κ is changed by pressure. For an indium thallium alloy with 14% Tl and $\kappa = 0.82$ we find $\partial\kappa/\partial p = -4.6 \pm 2 \times 10^{-12}$ cm^2/dyn.

We have investigated the effect of approximately hydrostatic pressures up to 14000 bar on the Ginzburg-Landau parameter κ in indium alloys. κ is found to diminish with pressure as expected for a free electron metal.

Elliptical specimens of axial ratio 1 : 6 were enclosed in a container filled with paraffin and subjected to pressure at room temperature. The shift in superconducting transition temperature, T_c, was used to monitor the pressure, p, remaining when the pressure device was cooled to the temperature of liquid helium. Magnetization curves were taken at various temperatures below T_c using a conventional integrating method. Three values of κ were calculated from each magnetization curve. They are: κ_1 derived from H_{c2}/H_c, κ_2 calculated from $\partial M/\partial H$ near H_{c2} [1], and κ_3 derived from H_{c2}/H_{c1} using Harden and Arp's [2] calculation. In fig. 1 we show κ for In with 14 at.% Tl as a function of pressure for $T/T_c = 0.5$. From this curve we deduce $\partial\kappa/\partial p = -4.6 \pm 2 \times 10^{-12}$ cm^2/dyn and $\partial \ln \kappa/\partial p = -5.6 \times 10^{-12}$ cm^2/dyn.

According to Gorkov [3] and Goodman [4] κ is given by $\kappa = \kappa_0 + 7.5 \times 10^3 \rho\gamma^{\frac{1}{2}}$ where ρ is the resistivity of the material expressed in ohm·cm, and γ is the electronic specific heat factor. The accuracy of this prediction has recently been tested by us for a range of indium alloys [5]. In these alloys $\kappa_0 \approx 0.1$, so that the second term dominates. Neglecting κ_0 the volume derivative of κ becomes

$$\partial \ln \kappa/\partial \ln v = \partial \ln \rho/\partial \ln v + \tfrac{1}{2}\, \partial \ln \gamma/\partial \ln v \qquad (1)$$

For a free electron gas $\partial \ln\gamma/\partial \ln v = \frac{2}{3}$, while expansion experiments on indium give $\partial \ln\gamma/\partial \ln v \approx 3$. At room temperature $\partial \ln\rho/\partial \ln v = 1.2$ in indium, but no data are available for low temperatures. From a simple free electron model

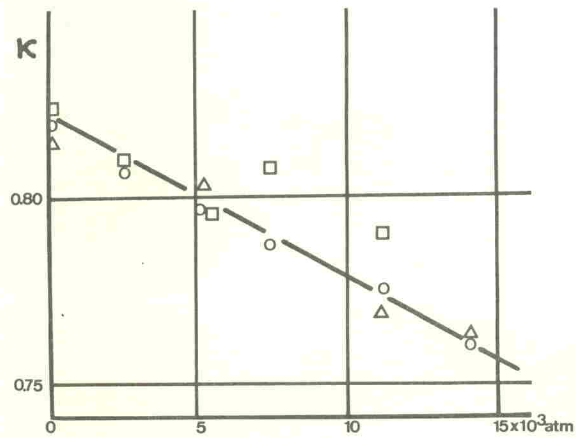

Fig. 1. Ginzburg-Landau parameter of In- 14 at.% Tl as a function of pressure. Δ - κ_1; □ - κ_2; ○ - κ_3.

Dugdale [6] points out that for the residual resistivity $\partial \ln \rho_0/\partial \ln v$ should lie between $+\frac{1}{3}$ and $+1$. We then expect $\partial \ln \kappa/\partial \ln v \approx 1$ for free electrons, and that it should be 2-3 for indium. Experimentally we find $\partial \ln \kappa/\partial \ln v = 2.2$. This is close to the estimate above.

Brändli and Enck [7] have calculated $\partial \ln \kappa/\partial p_{\parallel}$ from their measurements of magnetostriction in the mixed state in InPb alloys and also for our alloy. In both cases they find $\partial \ln \kappa/\partial p_{\parallel} = -1.6 \pm 0.5 \times 10^{-11}$ cm^2/dyn. This result is only compatible with our measurements if the influence of uniaxial stress perpendicular to the field direction is much smaller than that of stress parallel to it.

We are grateful to G. Brändli and F. D. Enck for allowing us to make use of their data prior to publication. Part of this work was supported financially the Schweizerischer Nationalfonds.

References

1. K. Maki, Physics 1 (1964) 21.
2. J. L. Harden and V. Arp, Cryogenics 3 (1963) 105.
3. L. P. Gorkov, Soviet Physics JETP 10 (1960) 998.
4. B. B. Goodman, IBM Journal Res. Devel. 6 (1962) 63.
5. E. Fischer, J. L. Olsen and H. P. Vieli, Phys. Letters 25A (1967) 261.
6. J. S. Dugdale in Physics of solids at high pressures. eds. C. T. Tomizuka and R. M. Emerick, (Academic Press, 1963) p. 16.
7. G. Brändli and F. D. Enck, Phys. Letters 26A (1968) 360.

* * * * *