THE ELECTRICAL RESISTIVITY OF BARIUM AND YTTRIUM AT HIGH PRESSURE*

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Electrical resistivity data suggest that yttrium and barium become d-metals under pressure. This behavior correlates with the pressure-induced superconductivity.

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Barium and yttrium only become superconductors at high pressure [1,2]. In attempting to understand such behavior, it is worthwhile investigating how various physical properties vary as the pressure is increased. In this connection, we present data on the temperature dependence of the electrical resistance (R) under pressure for these elements.

The four-probe, d.c. measurements were made using a Bridgman anvil technique described elsewhere [3]. The temperature was varied by heating the atmosphere surrounding the press, and the pressure was determined by superconducting transition of a sample in the cell or estimated from force applied.

Fig. 1 shows the yttrium data. Yttrium does not appear to undergo any polymorphic transition in the region studied; the superconducting transition temperature (T_c) is an increasing function of pressure from 1.3°K at 110 kbar, the lowest temperature obtainable in the equipment used. The feature of the data which we believe is significant is the increasing degree of negative curvature ($d^2R/dT^2 < 0$) in the curves as the pressure increases.

Fig. 2 shows the barium data. Barium undergoes a number of polymorphic transitions under pressure, the details of some of which are not clear [4–6]. In our experiment, T_c is about 1.4°K at 70 kbar and increases to 5.0°K at 140 kbar. We also see that d^2R/dT^2 becomes strongly negative as the pressure increases.

The curvature observed in the resistance curves is

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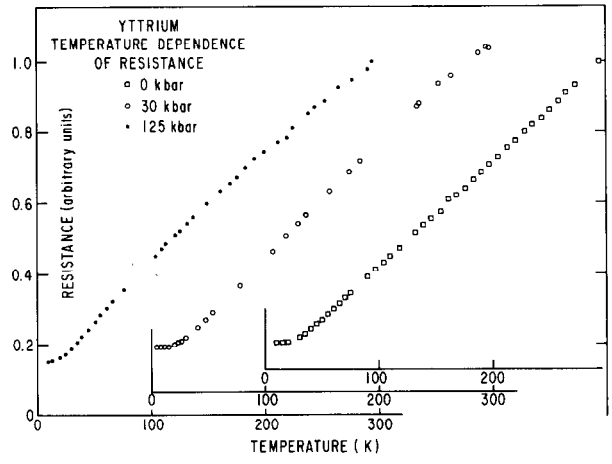

Fig. 1. 30 kbar pressure is estimate from force applied to pressure cell. 125 kbar pressure is estimated from T_c of yttrium.

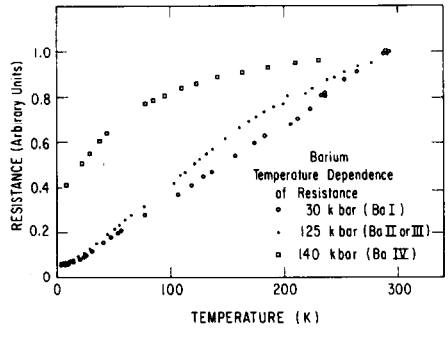

Fig. 2. 30 kbar pressure is estimate from force applied to pressure cell. 125 kbar pressure is estimated from T_c of barium. 140 kbar pressure is estimated from T_c of lead.

curves is not an experimental artifact, as can be seen from a comparison of the two 30 kbar curves taken simultaneously with samples in the same pressure cell. Such curvature is, in fact, generally observed in systems where s-d scattering is thought to be important [7]. This is evidence, therefore, in favor of the notion that pressure is squeezing in some d-electrons at the Fermi level in both barium [8] and yttrium.

We speculate further. The large curvature in the 140 kbar barium data is reminiscent of the resistivity of V_3Si and Nb_3Sn, for which the data were analyzed with a model consisting of a nearly empty (or full) high density of states d-band overlying an s-band [9]. Our data suggest that such a situation is being produced in barium--and perhaps yttrium--as the pressure increases.

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