Electrical Resistivity of Europium and Ytterbium*

M. A. CURRY, S. LEGVOLD, AND F. H. SPEDDING
Institute for Atomic Research and Department of Physics, Iowa State University, Ames, Iowa
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Electrical resistivity measurements on europium and ytterbium metals from 1.3° to 300°K are reported. Europium exhibits a sharp peak in its resistivity at 90°K which must correspond to its magnetic ordering temperature. The shape of the peak indicates antiferromagnetic ordering below 90°K. Ytterbium has no sharp anomalies in its resistivity.

INTRODUCTION

LOW-TEMPERATURE electrical resistivity measurements on a number of rare-earth metals have been reported by James *et al.*,[1] Legvold *et al.*,[2] and Colvin.[3] Room temperature resistivities for all the rare earths except europium and terbium have been reported by Bridgman.[4] The electrical resistivities from 1.5°K to room temperature for europium and ytterbium are reported here.

Eu and Yb are apparently divalent metals with much lower densities than the other rare-earth metals. Eu is bcc with a lattice constant of 4.5820 A at room temperature and its density[5] is 5.245 g/cm^3, as compared with 7.9 g/cm^3 for its neighbors. Paramagnetic data of Klemm and Bommer[6] show 8.3 Bohr magnetons per atom and similar data of Henry la Blanchetais and Trombe[7] show 7.9 Bohr magnetons per atom. In the case of Yb, the crystal structure at room temperature is fcc with $a_0=5.49$ A, and the density is 6.959 g/cm^3 as reported by Spedding *et al.*[8] Lock[9] has reported magnetic susceptibility studies of Yb and states that the atoms have zero magnetic moment and that the $4f$ shell is completely full.

PROCEDURE AND RESULTS

The experimental apparatus used in this study consisted of a heat leak chamber for temperature control and is described elsewhere.[3] No corrections for changes in sample size due to contraction have been made in the determination of the resistivities reported here.

The results of spectrographic analyses for metallic impurities are as follows. Europium: trace impurities of Ca and Mg. Ytterbium: trace impurities of Ag, Cr, Mg, Mn, Pb, Si, Ti, and Y; minor impurities of Al, Ca, Cu, Fe, and Ta. All other metal impurities not listed were not detected by this method. The samples were not analyzed for nonmetallic impurities because reliable analytical methods have not been perfected. However, the metals were redistilled and the amount of these impurities should be small.

Europium metal was prepared by heating Eu_2O_3 with La metal in a vacuum and then distilling the metal at 1500°K. A wire of the metal was extruded to an average diameter of 0.037 inch. The results of the resistivity measurements on Eu are displayed in Fig. 1. At 145°K a minimum appears in the curve and seems to correspond to the point at which the $1/\chi$ *vs* T plot departs from a Curie-Weiss law as reported by Henry la Blanchetais and Trombe.[7] They found a paramagnetic Curie point at 108°K and a field dependence of the magnetic susceptibility below 104°K. A sharp peak in

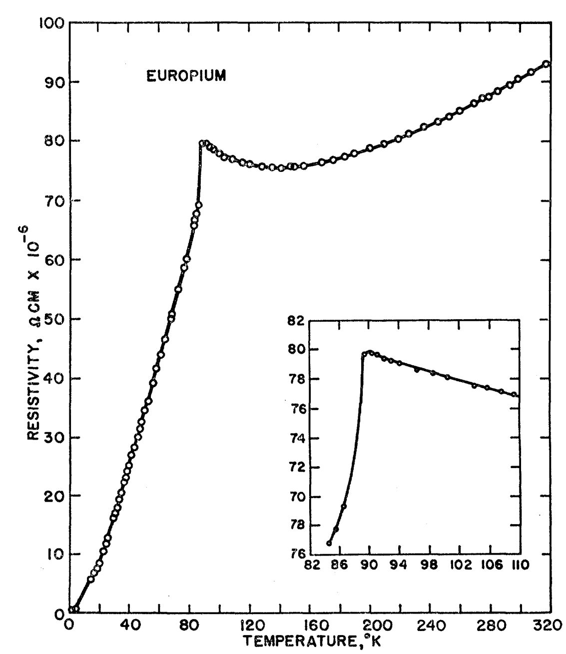

FIG. 1. Electrical resistivity of europium *vs* temperature.

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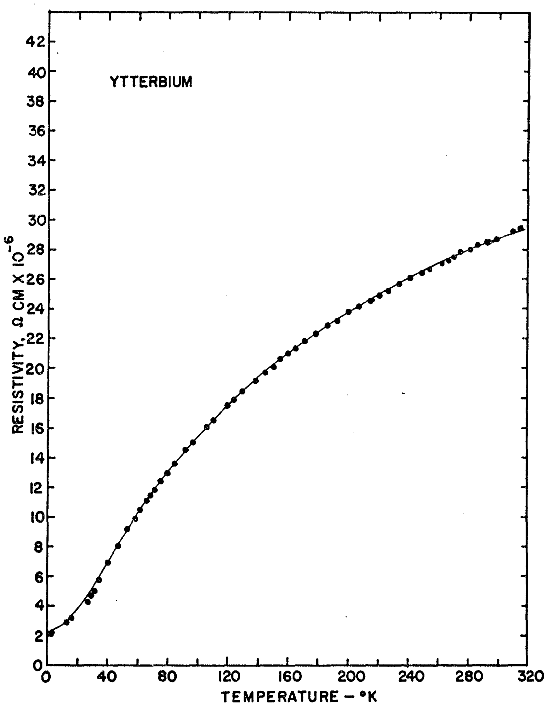

FIG. 2. Electrical resistivity of ytterbium *vs* temperature.

the resistivity of Fig. 1 occurs at 90°±0.3°K, which must be the magnetic ordering temperature for europium metal. Below this temperature the resistivity drops rapidly. The shape of the peak in the resistivity is like that for holmium[3] at the Néel point and this suggests that europium is antiferromagnetic below 90°K. A residual resistivity of 0.5×10^{-6} ohm-cm indicates a very low total impurity content for the sample used in these measurements.

The ytterbium sample studied was a polycrystalline rod approximately two inches in length and $\frac{3}{16}$ inch in diameter. Figure 2 shows that the resistivity of Yb did not follow a linear relationship with temperature below room temperature. No magnetic anomalies were seen as was expected from the fact that the $4f$ shell is full for Yb. Room-temperature resistivity was found to be lower than for any of the other rare earths. The result is in good agreement with Spedding *et al.*[5] who reported an ice temperature resistivity of 27×10^{-6} ohm cm, and with Bridgman's[4] room-temperature value of 30×10^{-6} ohm cm. In measurements on Yb it was noted that the resistivity was dependent on the previous thermal history of the sample.

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