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MAGNETIC PROPERTIES OF AMORPHOUS CERIUM-COBALT ALLOYS

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Abstract. - Magnetic experiments were carried out on amorphous Ce-Co alloys in order to investigate the effect of structural disorder on the electronic configuration of cerium. Comparison with the Y-Co and Th-Co amorphous alloys leads to the conclusion that Ce ions remain strongly mixed-valent in the disordered phase.

In cerium-transition metal compounds, cerium often exhibits unusual properties, like valence fluctuations or Kondo effect, which result from the strong hybridization between 4f and conduction electrons. The aim of this paper is to study the influence of structural disorder on the anomalous electronic configuration of cerium in such compounds. We present magnetic measurements of the Ce_xCo_{1-x} amorphous alloys, and we show that the strongly intermediate valent state encountered in the different crystalline compounds ($CeCo_5$, $CeCo_3$, $CeCo_2$) is basically preserved in the disordered phase.

The Ce_xCo_{1-x} amorphous alloys were prepared by coevaporation onto liquid nitrogen cooled substrates in ultra high vacuum condition (10^{-8} Torr during evaporation). The samples were characterized by electron microscopy and were found to be amorphous on a wide composition range ($0.16 \leq x \leq 0.45$). The magnetic measurements were carried out on a Foner magnetometer with a maximum field of 20 kOe.

In figure 1, the low-temperature (4.2 K) magnetizations are reported as a function of the applied field for several Ce_xCo_{1-x} amorphous alloys. The magnetic properties are dominated by the strong cobalt contribution and all samples are found to be ferromagnetic with a saturation moment which decreases with increasing cerium content. In figure 2, the composition

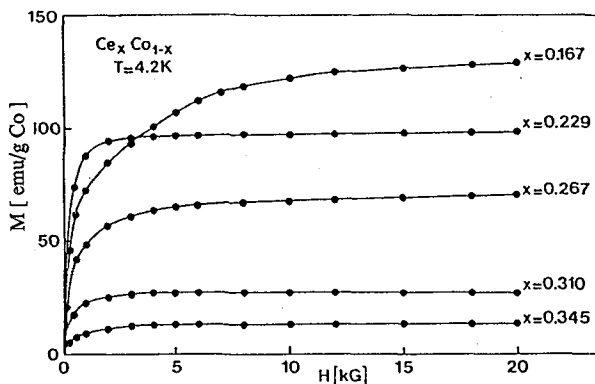


Fig. 1. - Low-temperature magnetizations for several Ce_xCo_{1-x} amorphous alloys.

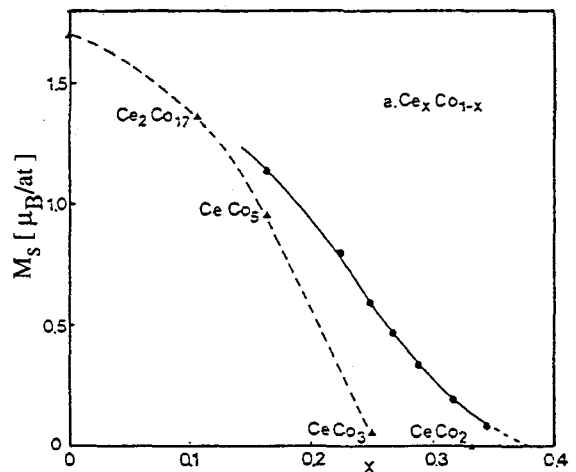


Fig. 2. - Composition dependence of the saturation magnetizations in the amorphous alloys and in the corresponding crystalline compounds.

dependence of the saturation magnetizations in the amorphous alloys are plotted, and we compare them with the values reported for the corresponding crystalline compounds [1, 2]. The amorphous alloys were found to have saturation moments greater than those of their crystalline counterparts. This behaviour was already observed in cobalt based systems [3] and was generally explained in terms of modification of charge transfer [4]. Indeed, because of the respective electronegativity of rare-earth (RE) and cobalt, there is a charge transfer from RE into the 3d band of cobalt, leading to a progressive decrease in the cobalt moment when the RE content increases. Owing to the lower density in the amorphous structure, this charge transfer is reduced with respect to the crystalline compound which results in a greater moment in the disordered alloys.

Although the magnetic properties are dominated by the transition metal contribution, it is nevertheless possible to obtain information concerning the electronic configuration of cerium. As demonstrated in a systematic study of palladium or nickel based com-

pounds by photoemission measurements [5], the filling of the transition metal d band depends on the nature of its partner (electronegativity and valency). Then, the Pd 4d derived band in the Th-Pd system is filled up for a lower concentration than in the La-Pd system. A similar situation is expected in cobalt systems. The magnetic moment reflects the number of d holes in the cobalt band and then characterizes the contribution of the RE to the band structure. We present, in figure 3, a comparison between the composition dependence of the saturation moment in three series of amorphous systems: Y_xCo_{1-x} , Th_xCo_{1-x} alloys studied by Buschow [6] and our Ce_xCo_{1-x} alloys (yttrium and thorium have three and four conduction electrons respectively). We observed that the magnetization moment of a Ce_xCo_{1-x} alloy is very similar to the value obtained for the Th_xCo_{1-x} alloy of same composition. This result suggests that the cerium ions contribute to the band structure like "tetravalent" ions as they do in the crystalline compounds. The electronic configuration of cerium is characterized by a strong hybridization of the 4f state with the conduction electrons and

is not sensitive to the local environment. This effect contrasts with the situation observed in weak intermediate valent compounds ($CeSi_2$, $CePd_3$) or Kondo systems ($CeSn_3$) where the trivalent configuration is stabilized in the amorphous alloys [7, 8].

This insensitivity to structural disorder is partially confirmed by high energy spectroscopy measurements, especially X-ray absorption on the cerium L_{III} edge, carried out on these alloys [7]. We have found that the average values of the cerium valency are quantitatively the same in ordered $CeCo_5$ and disordered phase ($V = 3.3$). This value is in good agreement with those obtained for all "tetravalent" compounds [9]. The high energy experiments have shown that cerium never exhibits a tetravalent configuration, its valence saturates to 3.3. Nevertheless, there is no disagreement with thermodynamic measurements: the cerium 4f electron is completely delocalized but keeps a partial f character.

Acknowledgments

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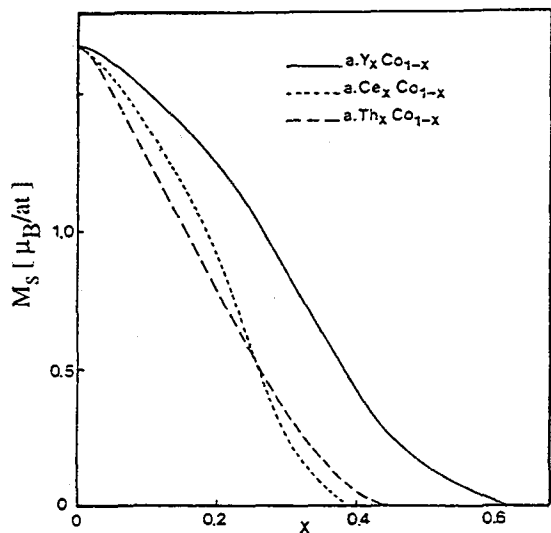


Fig. 3. - Comparison between the composition dependence of the saturation moment in amorphous Y_xCo_{1-x} , Th_xCo_{1-x} [6] and Ce_xCo_{1-x} alloys.

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