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HALL EFFECT IN AMORPHOUS $La_{0.8}Ga_{0.2}$

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Résumé.- On a mesuré le coefficient de Hall de l'alliage amorphe $La_{0.8}Ga_{0.2}$, aux températures de l'hélium liquide, de l'azote liquide, et à température ambiante. R_H varie entre + 8,9 à température ambiante et + 11 à 4,2 K en unités $10^{-11}\ m^3/As$. Ces valeurs de R_H sont en accord avec la valeur publiée de + 6,15 pour le métal liquide pur au contraire de la valeur publiée de - 8,0 pour le La.(dhcp) cristallin.

Abstract.- The Hall coefficient for the amorphous transition metal alloy $La_{.8}Ga_{.2}$ has been measured at LHe, LN_2 and room temperatures. R_H varies from + 8.9 at room temperature to + 11 at 4.2 K in units of $10^{-11}\ m^3/As$. The values of R_H are consistent with the literature value for the pure liquid metal in contrast to the literature value of -8.0 for crystalline dhcp La.

The electronic structure of highly disordered systems such as amorphous and liquid metals constitutes a fundamental problem in condensed matter physics. For alloy systems which can be prepared in the metastable amorphous phase a wider range of experimental techniques for determination of the electronic properties is available than is for liquid metals. Spurred by efforts to develop high temperature superconductors many amorphous metal systems have been discovered and their properties catalogued. Early work dealt mainly with amorphous simple metals, a-SM (non-transition and non-rare earth metals) and resulted in a good picture of their properties. The electronic properties of a-SM are understandable in terms of the simple free electron model. Superconductivity in a-SM is described in terms of the strong-coupling theory, and, as described in the excellent review article by Bergmann, /1/, the very strong electron-phonon interaction was believed to be a fundamental property of disordered systems.

Until recently the experimental data for amorphous transition metals, a-TM, has been sketchy. Rather complete studies of two amorphous La alloy systems, $La_{1-x}Au_x$, /2/, /3/, and $La_{1-x}Ga_x$, /4/, which illustrate the dramatic differences between the a-TM and a-SM are now available. As expected the free electron model cannot describe the relatively large electronic density of states in these a-La alloys, but quite unexpectedly the electron-phonon interaction in these amorphous alloys was found to be relatively weak. Measurements of the Hall coefficient , R_H, of one of these a-La alloys, $La_{.8}Ga_{.2}$, are reported in this paper. Since R_H for liquid La is reported to be positive /5/, whereas that for the dhcp crystalline solid is reported to be negative and of the same magnitude as that expected for a free electron metal, /6/, these measurements may be expected to provide a sensitive indication of the extent to which the electronic structure of these "splat-cooled" amorphous foils corresponds to that of the liquid.

The Hall probe was stamped in the shape shown in figure 1 from a piece of the same $La_{.8}Ga_{.2}$ splat-cooled foil used in the specific heat measurements described in reference /4/. The length

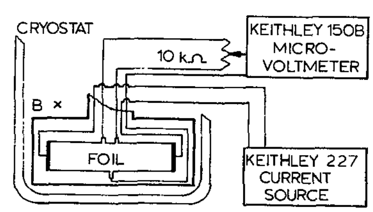

Fig. 1 : Experimental configuration

of the foil is 10 mm, its width 2 mm, the separation between the Hall voltage connections on the upper side 0.4 mm, and its thickness 0.0575 mm. The

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sample was pressed against a thin mica sheet which was varnished to a copper block and sealed in a chamber filled with helium exchange gas. The current lead connections were made by a copper bar mechanically clamped across the ends of the foil. The Hall voltage leads were mechanically pressed against the three small tabs. The probe was inserted into a conventional glass dewar system suspended in the two inch gap of a conventional electromagnetic which provided a maximum field of 12.3 kOe. Measurements were made with the probe at room temperature and with it immersed both in liquid nitrogen and liquid helium.

A Keithley Model-227 constant current source was used to provide a DC-current of approximately 0.5 A. With the field off a 10 kΩ potentiometer was balanced to electrically align the opposing voltage probes, and the Hall voltage in presence of the field was measured with a Keithley Model 150 B microvoltmeter. The system was tested with a sample stamped from a thin brass foil which gave a negative R_H of the magnitude expected for CuZn alloys. The relative accuracy of the measurements at the different temperatures is approximately ± 5 % and was determined by the stability of the electrical alignment of the Hall voltage probes. The absolute accuracy of R_H is about ± 20 % and is determined by estimated uncertainty in the thickness measurement of the foil resulting from the irregular surface characteristic of splat-cooled samples.

The measured values of R_H + 8.9, + 10, and + 11 in units of $10^{-11} m^3/As$ at 300 K, 78 K, and 4.2 K, respectively. For comparison the value for a well annealed dhcp crystalline sample is - 8.0 at 300 K, /6/. The value for the pure liquid is + 6.15 at the melting point (1195 K). A bcc crystalline phase with R_H = + 5.0 is observed from 1141 K to the melting point. At 1141 K R_H drops to + 1 after transformation to the fcc phase and decreases linearly with temperature to become negative at about 795 K, /5/. A reasonable extrapolation of values of R_H for the amorphous alloy to 1200 K would give a value of + 7 ± 2.

The agreement in sign and approximate magnitude of R_H for a-$La_{.8}Ga_{.2}$ with that for molten La suggests a strong correspondence between the liquid and the amorphous phase. Although the agreement with the high temperature bcc phase is also reasonable, x-ray studies of a-La alloys indicate that the samples are not bcc polycrystalline, /7/. At present there is no theory which predicts a positive Hall coefficient for liquid or amorphous metals. If the accuracy of the thickness measurements can be sufficiently improved, a study of R_H for different a-La alloys should provide information which may be useful in the development of such a theory.

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