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Inelastic Scattering of Conduction Electrons in Dilute Silver-Manganese Alloys at Low Temperatures

THE method of Gruneisen-De Haas was recently employed by me¹ for the analysis of our thermal and electrical resistivity data at helium temperatures² on dilute silver-manganese rods (containing, respectively, 0.55, 0.32 and 0.14 atoms per cent of manganese in random solid solution) in transverse magnetic fields ranging from 0 to 25 kilogauss. This method of analysis yielded information regarding the variation of the electronic Lorenz parameter L_e with the magnetic field and the temperature, while, at the same time, effecting the separation of the measured thermal conductivity into its electronic and lattice components.

I wish to direct special attention to a result of that analysis: namely, that L_e , at liquid helium temperatures, dipped below the normal Sommerfeld value L_n ($= 2.45 \times 10^{-8}$ watt-ohm-deg.⁻²), attained a minimum, and approached the value L_n at temperatures close to 0° K.

In order to explain their own results (following those of Gerritsen and Linde³) on the electrical resistivity maximum in the case of dilute alloys of a noble metal with a small amount of a transition metal, Schmitt and Jacobs⁴ discussed the effects of inelastic impurity scattering of the conduction electrons^{5,6}. Since a co-operative magnetic transition is known to occur⁷⁻⁹ in such alloys, in this temperature region, the spin degeneracy of the impurity ion is thereby removed and the scattering process involving the spin flips of the conduction electron and the ion becomes inelastic^{4,10}.

The critical test for the existence of such an inelastic scattering would be in the thermal resistivity¹¹. The 'vertical' transitions of the electrons, to which heat conductivity is very sensitive, would result in an anomalous contribution to the electronic thermal resistivity. My results for the electronic thermal resistivity (w_e) of these alloys do exhibit this behaviour. The plots of $w_e T$ against T show this in the form of a pronounced 'peak'.

Taking $f = [(\rho_m/\rho_0) - 1]$, (where ρ_m stands for the value of the electrical resistivity maximum and ρ_0 for the value at $T \rightarrow 0$), as a measure of the maximum fractional contribution of inelastic impurity scattering, I obtain an estimated $f \approx 0.1$, in my silver-manganese rod specimens. This ignores any temperature-dependent contribution from elastic scattering by the impurity ions¹⁰.

For making the corresponding estimates in the case of the electronic thermal resistivity in these specimens, I write, $f' = \{[(w_e T)_m/(w_e T)_0] - 1\}$. Here, $(w_e T)_m$ and $(w_e T)_0$ stand for the values at the 'peak' and at $T \rightarrow 0$, respectively. From my plots of $w_e T$ versus T , we obtain $f' \approx 0.5, 0.6$, and 0.8 , in the order of decreasing manganese content.

The fact that inelastic impurity scattering makes such a large contribution to the electronic thermal resistivity of these alloys, while making only a small contribution to the electrical resistivity, accounts for the 'dip' in the value of L_e with respect to the normal value L_n . The further result that L_e seems to approach L_n at temperatures close to absolute zero (below $\approx 1^\circ$ K.) is explained by the fact that this inelastic scattering cannot occur at 0° K. Scattering, which would involve loss of energy by the electron, is not permitted since there are no lower electronic states available; scattering which would involve gain of

energy by the electron is also not possible since there are no ions in the excited states at 0° K. to transfer energy to the electron.

Full details will be published elsewhere.

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Breakdown Strength of Cæsium Iodide

Two crystal structures, both cubic, are found in the alkali halide group of compounds: (1) the 'sodium chloride type' of interpenetrating face-centred cubes, and (2) the 'cæsium chloride type' of interpenetrating simple cubes. All the group except cæsium chloride, cæsium bromide and cæsium iodide resemble sodium chloride at ordinary temperatures and pressures¹. Measurements of the breakdown strength of halides of the sodium chloride type have shown² that there exists a simple relationship between the breakdown field strength, F , and the interionic distance, a , given by $Fa^3 = 28(\pm 25 \text{ per cent})$ where F is measured in MV./cm. and a in Å. No previous work on the cæsium chloride type of halide has come to our notice.

In the course of some work on electro- and photoluminescence of crystals, the opportunity was taken to establish whether cæsium iodide obeyed this relationship. The crystals used contained about 0.1 per cent thallium (to make them better scintillators). This presence of foreign ions may raise the breakdown strength slightly above that of the pure crystal³, but it is unlikely that the increase will be greater than experimental error.

Two single crystals of cæsium iodide were used, each approximately 0.01 cm. thick. For this thickness, it is to be expected that 'intrinsic' breakdown will take place⁴. In one method of procedure, an aluminium point contact was used as one electrode and a metal plate the other, while in a second method a metal sphere of diameter 3 mm. was used as the first electrode. A film of water usually forms on cæsium iodide crystals and results in discharges around the edges. This was prevented by polishing the crystals in oil and keeping an oil film on the crystals during the experiments.

Over a series of experiments at room temperature using the first method, breakdowns occurred at fields which varied from experiment to experiment, due probably to the presence of local flaws in the crystal structure, the minimum and maximum fields at which breakdown occurred being 0.29 and 0.36 MV./cm.

With the second method, the corresponding limits were 0.20 and 0.40 MV./cm., and the average value was 0.32 (± 0.05) MV./cm.

The interionic distance for caesium iodide is 3.95 Å. (ref. 5). Then for this crystal $Fa^3 = 20 \pm 3$, in reasonable agreement with the value found for the sodium chloride type of crystal structure.

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ASTROPHYSICS

Trajectories of Chromospheric Disk Surges

As a result of the use of rapid sequence *H*-alpha cinematography, Lockheed Solar Observatory has collected a large quantity of data on disk surges during 1959 and 1960. Since January 1960, the band pass of the birefringent filter has been displaced 0.5 Å. to the blue or red of *H*-alpha. The increased contrast between active absorption features and the background in the wings of *H*-alpha has resulted in a greater ability to detect disk surges. The percentage of flares of all classes associated with observed surges increased from 11.4 per cent in 1959 to 20.4 per cent in 1960. Approximately 94 per cent of the total flares were sub-flares. During the two years, a total of 953 flare surge events were photographed at the Observatory.

The study of surges observed in the wings of *H*-alpha has permitted the identification of a new class of disk surges which are characterized by extremely intricate structures. Unlike the 'classical' disk surges which appear as straight brush-like extensions from flares¹, these dark surges, which we term 'complex surges', appear on single frames as irregular, dark mottles. Although material is clearly being ejected with typical velocities of 100 km./sec., the complex surges show little preferential direction of flow and have trajectories seemingly dominated by local force fields. Table 1 lists three large complex surges observed in 1960.

Table 1

Date 1960	Time Start (U.T.)	Time Max.	Extension	Mean velocity (km./sec.)	Associated position	Flare importance
May 9	0030	0052	0.13 R	69	S. 11 E. 04	1
Sept. 25	1817	1855	0.30 R	92	S. 18 W. 22	1
Nov. 20	1640	1655	0.19 R	77	N. 23 W. 45	1-

While viewing the off-band films of these events, particular attention was paid to the motion of the complex surges relative to the neighbouring bright coarse mottling. It was found that whenever the direction of flow was altered the dark surge material appeared to avoid the bright mottling. The surges with very complex structure were deflected many

times as the surge material appeared to flow along the lanes between the bright mottling.

The complicated trajectories of these surges may perhaps be understood in terms of magnetic fields in the coarse mottling. The kinetic pressure of surge material moving with a speed of 100 km./sec. with a density of 10^{11} protons per cm.³ would be balanced by the magnetic pressure of a field of about 20 gauss. The correspondence between magnetic fields of such magnitude and CaII plages was first established by the Babcocks², and has recently been corroborated by Howard³ and Leighton⁴. The boundaries of CaII plages appear to be contained by 10 gauss contours and the fields in such plages may reach as high as 200 gauss. The wings of *H*-alpha are not formed at the same height of the chromosphere as the centre of the CaII K line; however, bright mottling in the wings of *H*-alpha and CaII plages may well correspond to different heights in the chromosphere along continuous vertical magnetic columns.

Detailed work on the association between magnetic fields and the coarse mottling in the wings of *H*-alpha is needed; but it does appear that bright mottling is adjacent to large field gradients. Chromospheric filaments apparently lie between regions of opposite polarity², and when filaments are visible in the wings of *H*-alpha, they are generally bordered by bright mottling apparently identical to that which deflects the surges. Further work on the trajectories of disk surges is continuing as the observations reported here suggest that surges may be utilized as 'test particles' for the mapping of chromospheric and coronal magnetic fields.

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GEOLOGY and MINERALOGY

Origin of Igimbrites

A FIELD and laboratory study of the Ordovician ignimbrites of North Wales that has been in progress since 1953¹⁻³ has revealed certain limitations in Marshall's original hypothesis⁴ regarding the origin of this interesting category of rocks. These limitations have been apparent to workers elsewhere⁵⁻⁸. The evidence from North Wales, and much of the published evidence from North and South America, is categorically opposed, however, to the hypothesis of origin now proposed by Steiner⁹. As this new hypothesis is based on a petrological study of the type ignimbrites from the North Island of New Zealand, and involves the far-reaching conclusion that liquid immiscibility plays a large part in the petrogenesis of acid igneous rocks, a critical appreciation of Steiner's views is urgently required. A detailed petrological criticism is in preparation, and will be published in full elsewhere. In the meantime, it is appropriate to state that Steiner's conclusions appear to be based on a