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# Paramagnetic Resonance Absorption in Chrome Alum*

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Measurements have been made of relative values of the imaginary part of the high frequency susceptibility of both the ammonium and potassium salts of chrome alum at room temperature and of the potassium salt at 90°K. The value of the ground state splitting for each of the salts was then calculated using Weiss' theory.

RELATIVE measurements have recently been reported of the room temperature paramagnetic susceptibility of single crystals (both dilute and normal) of hydrated chrome ammonium alum and hydrated chrome potassium alum at 9375 mc/sec., for various orientations of the crystal with respect to the steady external magnetic field.[1] We wish to report relative measurements of the imaginary part X″, of the high frequency susceptibility for undiluted single crystals of both the above salts at room temperature, and of chrome potassium alum at 90°K.[2]

As in earlier experiments,[3] the experimental arrangement consisted of a low power, square-wave modulated oscillator part of whose output passed through a resonant cavity containing the alum crystal and was finally absorbed in a detecting crystal. The fundamental component of the alternating potential wave form appearing across the detector was amplified, rectified, and, after suitable "bucking out," displayed as a galvanometer deflection. It can be shown that this deflection is proportional to X″. This arrangement avoids certain complications which arise when the bucking out is done at the high frequency.[1]

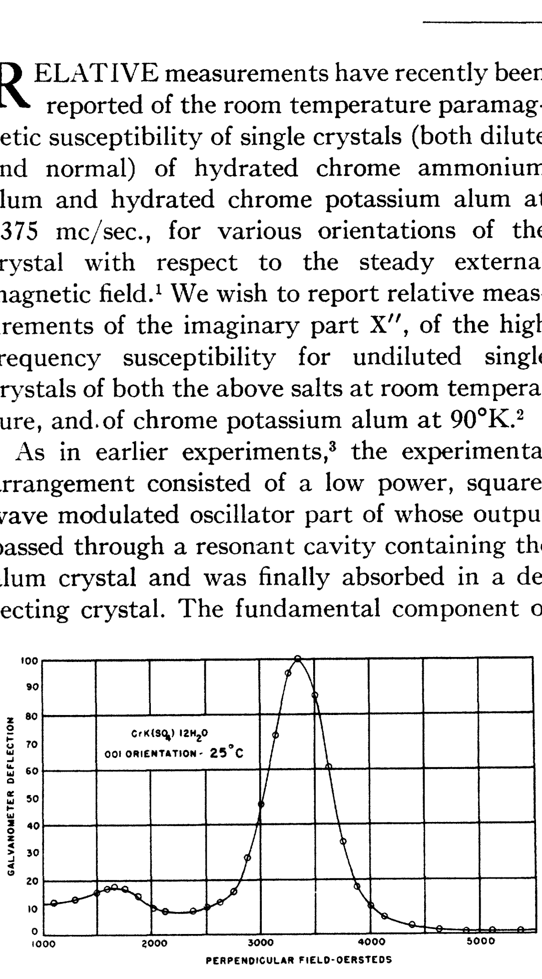

FIG. 1. Relative values of X″ for a chromium potassium alum single crystal at 9375 mc/sec. and 25°C. The crystal was oriented so that the perpendicular field was parallel to the 001 direction. The main peak is an unresolved doublet.

The absorption curves for chrome potassium alum at room temperature with the external magnetic field oriented so as to be parallel to the 001 and 111 directions of the crystal are shown in Figs. 1 and 2. The curve for the ammonium alum, 111 orientation, is shown in Fig. 3. The curve for the 111 direction of the potassium salt at 90°K is shown in Fig. 4. The ground-state splitting was calculated from Weiss' theory[4] in terms of the positions of the central, the low-field and the high-field peaks of Figs. 2, 3 and 4. Another value of the splitting may be obtained from the low-field peak of the 001 direction curve, using a theory due to Kittel[5] as well as that of Weiss. The splitting value derived from this peak, however,

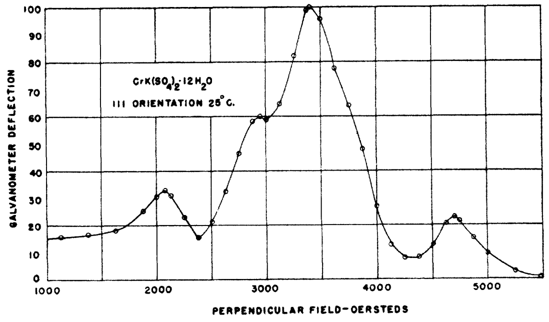

FIG. 2. Relative values of X″ for a chromium potassium alum crystal at 9375 mc/sec. and 25°C.

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[3] R. L. Cummerow, D. Halliday, and G. E. Moore, Phys. Rev. **72**, 1233 (1947).

[4] P. R. Weiss, Phys. Rev. **73**, 470 (1948).

[5] C. Kittel, Phys. Rev. **73**, 155 (1948).

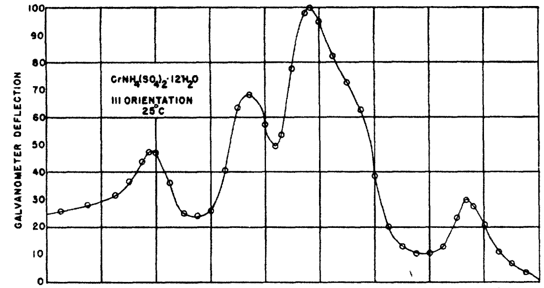

FIG. 3. Relative values of X″ for a chromium ammonium alum crystal at 9375 mc/sec. and 25°C.

is more sensitive to a small error in the peak position than is the case above.

It can be shown that, if one uses the value of $g$ (the Lande splitting factor) derived from the central peaks of Figs. 2, 3, and 4, the values of ground state splitting, $\delta$, computed from the theories of Weiss or Kittel, are independent of an error of a constant factor in magnetic field strength $H$. The value of $g$, however, does depend on an accurate knowledge of $H$. Our absolute fractional probable error in magnetic field measurement is about 0.6 percent.

Table I shows our results, based on measurements of 16 different crystals. The superscripts show the relative weights.

Our results for potassium alum at room temperature are in agreement with those of Bagguley and Griffiths[6] who obtain 0.12 $\text{cm}^{-1}$, using a similar method. As Weiss and collaborators[1] point out, differences between our results and theirs can probably be accounted for by differences in the nature of the interference effects between absorption peaks. Both groups agree that the ground state splitting for the ammonium alum is 10 percent greater than that for the potassium alum. Our low temperature result (0.18 $\text{cm}^{-1}$) is to be compared with the value 0.16 $\text{cm}^{-1}$ reported by Gorter,[7] using a different method.

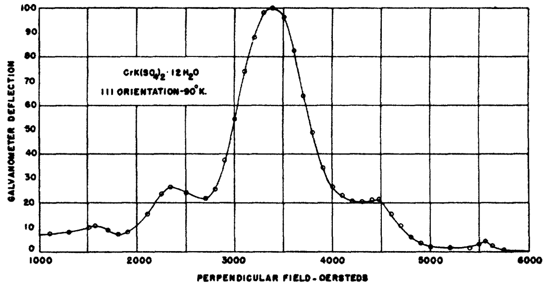

FIG. 4. Relative values of X″ for a chromium potassium alum crystal at 9375 mc/sec. and 90°K.

TABLE I. Computed chrome alum level splittings.

| Salt | Temperature | $g$ | Ground state splitting—$\text{cm}^{-1}$ Low peak 111 | High peak 111 | Low peak 001 | mean |
|---|---|---|---|---|---|---|
| K | 25°C | 1.97 | $.122^8$ | $.122^8$ | $0.127^1$ | .122 |
| K | 90°K | 1.98 | $.17^4$ | $.20^1$ | | .18 |
| $NH_3$ | 25°C | 1.97 | $.135^8$ | $.132^8$ | $0.143^1$ | .134 |

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[6] D. M. S. Bagguley and J. H. E. Griffiths, Nature **160**, 532 (1947).

[7] C. J. Gorter, *Paramagnetic Relaxation* (Elsevier Publishing Company, Inc., New York, 1947).