

It was found that the expansion ratio 1.2 is a sharp threshold value. Any expansion below this value produces supersaturated vapor of CO₂ without precipitation. Expansions above 1.2 produce abundant showers of CO₂ crystals. The threshold value increases slightly with lowering of the initial temperature of the chamber. There is an appreciable increase in the number of crystals formed with an increase of the expansion ratio up to 1.4. Above 1.4 the density of showers appears constant. All crystals grow sufficiently to have an appreciable rate of falling. The chamber is clear of all crystals within a maximum of 4 seconds after any expansion. Irradiation of the chamber with x-rays has no effect on the sublimation threshold, nor does it appreciably affect the number of particles formed.

The experiments provide straightforward evidence for the existence of a genuine sublimation process and also for the existence of a definite sublimation threshold. They also indicate that this sublimation threshold is defined primarily in terms of an expansion ratio and not of temperature.

With the same apparatus nitrogen and oxygen were investigated. Expansions were performed in a chamber precooled to the region of the nitrogen triple point and containing saturated vapor of the investigated gas in a helium atmosphere.

Both vapors show very low condensation thresholds. With oxygen even the smallest expansions (in a helium atmosphere free from condensation nuclei) produce dense fog. The threshold expansion ratio for condensation of nitrogen is 1.005. Dense fog produced at this threshold value indicates that the number of active condensation nuclei is of greater order of magnitude than the number of ions in the chamber. The fog has a consistency similar to C. T. R. Wilson's fogs obtained with water vapor, with expansion ratios above his cloud threshold (1.38).

Below their triple points both vapors form homogeneous, stable supercooled droplet clouds. The first crystals of solid nitrogen in nitrogen droplet clouds were observed at an expansion ratio of 5. In oxygen even higher expansion ratios, up to 10, failed to produce crystals.

* This work was carried out under a grant from the Defense Research Board of Canada.

¹ B. M. Cwilong, *Nature* **155**, 361 (1945); *Proc. Roy. Soc. (London)* **A190**, 137 (1947).

² E. M. Fournier d'Albe, *Quart. J. Roy. Met. Soc.* **75**, 1 (1949).

³ A. W. Brewer and H. P. Palmer, *Nature* **161**, 312 (1949).

⁴ C. Salmon and B. M. Cwilong, *New Zealand Sci. Rev.* **8**, 78 (1950).

Photocontrolled Low Frequency Dielectric Dispersion*

J. ROSS MACDONALD

*Armour Research Foundation, Illinois Institute of Technology,
Chicago, Illinois*

(Received December 5, 1951)

PHOTOCONTROLLED dielectric dispersion has been observed in *F*-centered alkali halide crystals at room temperature. Most of the measurements were carried out on KBr single crystals which had been initially *U*-centered and then colored photochemically with Co⁶⁰-radiation, but the effect has also been verified with additively colored KBr and KI single crystals.

To allow observation of photoeffects, metallic electrodes were either painted or evaporated on opposite crystal faces and incident light directed through the crystal between the electrodes or through one (half-silvered) electrode into the crystal. No significant differences were observed in the behavior of these two types of specimens. Measurements of crystal admittance with or without illumination were carried out over the range from 25 to 10,000 cps and enabled the complex dielectric constant of the crystals to be computed.

In the dark, it was found that crystal dark-currents were purely reactive within the precision of the measurements. The dark dielectric constant of the KBr crystals was found to be about 5,

independent of *F*-center concentration and frequency over the ranges measured. These are expected results; the crystals are good insulators since their ionic conductivity is negligible at room temperature.

On strongly illuminating a crystal with light in its *F* absorption band, it was found that the total crystal current at low frequencies increased by a factor of from 5 to 50 over the dark current and was still largely reactive. This photocurrent depended strongly on *F*-center concentration and light intensity. On determining the real part of the dielectric constant ϵ' and the loss factor ϵ'' , it was found that these quantities exhibited dielectric dispersion behavior, with ϵ' a maximum at zero frequency and ϵ'' a maximum in the low audiofrequencies. No appreciable frequency-independent photoconductivity was observed. Typical results found for a KBr crystal with 1.4×10^{16} *F*-centers per cm³ were a maximum value of ϵ' at zero of 500 and a maximum of ϵ'' of 142 occurring at 85 cps. Applying a theory developed by Fuoss and Kirkwood¹ for large molecules with permanent dipoles having a distribution of relaxation times, it has been found possible to fit experimental ϵ'' and ϵ' curves quite well, whereas equations based on a single relation time will not fit the data at all.

Preliminary measurements of photocurrent as a function of *F*-center concentration and light intensity at a single frequency showed that the photocurrent varied approximately with the square root of these quantities. Further measurements of ϵ' and ϵ'' as functions of frequency have shown, however, that the preceding results were caused by a shift in the frequency at which the maximum of the ϵ'' curve occurred toward higher frequencies with increasing *F*-center concentration or light intensity, without an appreciable change in the maximum values of ϵ' and ϵ'' themselves. These results suggest that the effect may be largely the result of Maxwell-Wagner type losses associated with the photoconductivity of a crystal under illumination. No polarization effects have been observed: the photocurrent obeys Ohm's law up to the maximum field strength applied, 500 volts/cm, and the insertion of a 300-volt dc battery in series with the applied ac voltage has no effect on the results. This work will be more fully discussed in a later paper.

* Research carried out in part under Signal Corps contract.

¹ R. M. Fuoss and J. G. Kirkwood, *J. Am. Chem. Soc.* **63**, 385 (1941).

$L(L+1)$ Correction in the Spectra of the Iron Group

GIULIO RACAH

Hebrew University, Jerusalem, Israel

(Received November 12, 1951)

IT was recently pointed out by Trees¹ that the agreement between the theoretical formulas and the experimental data in the *d*⁵s configuration of Mn II and Fe III is greatly improved by the addition of a correction term of the form $\alpha L(L+1)$. We verified that this correction is also very important in many other spectra of the iron group, and that the values of α obtained by least squares from different spectra are very consistent.

It is the purpose of this letter to show that this effect may be explained by the sole mathematical assumption that the deviations from the theoretical formulas in the *n*-electron configurations are the sum of the deviations of the interaction of each couple from the corresponding formulas. It is, however, not easy to justify this assumption, as the linearity property, which holds for every first-order effect, is not expected to hold for the deviations from Slater's formulas, which are generally considered to be the result of second-order effects.

It is known that the spectra of the configurations *d*² do not fit Slater's formulas very well;² but if we introduce two correction terms $\alpha\varphi_1(L)$ and $\beta\varphi_2(L)$, where φ_1 and φ_2 are any functions of *L*, it will be always possible to represent exactly the five terms of *d*², as we have now five free parameters.