Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the

## Paramagnetic Saturation in a Single Crystal

Jean Becquerel and one of us developed a method, which allows one to study the paramagnetic saturation in the direction of the optical axis of crystals by observations of the Faraday-effect.<sup>1</sup> If the basic level is doubly degenerate, the magnetic moment belonging to this level in the direction of the axis can be determined from the curvature of the graph which represents the magnetic rotation as a function of H/T.

This method has been applied to several (mostly natural) crystals, but as yet no check with direction susceptibility measurements has been obtained, the only available data on saturation curves being measurements on crystal powders.2

We now have determined the magnetization of a monoaxial single crystal of dysprosium ethylsulphate as a function of temperature and field strength, in two directions: the optical axis and a secondary axis perpendicular to it.

We found that at the temperatures of liquid helium the magnetization curve in the first direction has the form of a hyperbolic tangent, with a magnetic moment of 5.7 Bohrmagnetons. This is in excellent agreement with the optical measurements, which gave 5.66 Bohr-magnetons. In the direction perpendicular to the axis a susceptibility of about  $1.2 \times 10^{-3}$  was found which was almost independent of the temperature, and which showed merely a beginning of saturation at the highest fields. This is exactly what is to

fifteenth of the preceding month; for the second issue, the first of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

be expected theoretically for a doubly degenerate basic level, if the crystalline field shows a deviation from cylindric symmetry. Whether the susceptibility varies in the plane perpendicular to the axis has not yet been investigated.

At higher temperatures other levels than the basic level are occupied. At 14° the susceptibilities differ about 10 percent, a beginning of saturation being observable in the direction of the axis; at 20° the difference is but 3 percent. At 64° the ratio of the susceptibilities has increased to 1.30. This ratio slowly increases further to 1.33 at about 200°, and decreases then to about 1.25 at 290°. The susceptibility in the direction of the axis is always the larger. Between 20° and 290° the susceptibility perpendicular to the axis follows approximately Curie's law, with a magneton number of about 91 Bohr-magnetons. The susceptibility in the direction of the axis follows a more complicated law.

The investigations will be continued and extended and we also hope soon to give the accurate absolute values.

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<sup>1</sup> Comm. Leyden 193<sup>a</sup>, 204<sup>a</sup>, 211<sup>b</sup>, 211<sup>c</sup>, 218<sup>a</sup>. <sup>2</sup> Comm. Leyden 173<sup>e</sup>, 222.

## Molecular Rotation in Ice at 10°K. Free Energy of Formation and Entropy of Water

In two brief notes Mecke and Baumann<sup>1a, b</sup> have announced an interpretation of several of the rotation-vibration bands of the water molecule. With the assistance of these data we have made a preliminary calculation of the entropy and free energy of water by means of the Sackur-Tetrode equation. Although there are still small uncertainties in the molecular constants, we may nevertheless obtain quite accurate values. These and other values have been compared with the low temperature calorimetric measurements on ice. It has been possible to show that the facts are consistent with lack of equilibrium between ortho and para water in ice and indicate rotation of ortho water in ice.

Although small deviations occur in comparing the spectroscopic data with the relation  $I_1 + I_2 = I_3$  which holds for the principal moments of inertia of planar molecules, we prefer to accept this equation with  $I_2 = 1.907 \times 10^{-40} \,\mathrm{g\cdot cm^2}$ molecule<sup>-1</sup>, and  $I_3 = 2.985 \times 10^{-40}$ . The absolute entropy

of gaseous water is found to be 47.92 cal. deg.<sup>-1</sup> mole<sup>-1</sup> at 298.1°K and 1 atmosphere. In making this calculation the symmetry number of water was taken as 2. The entropy value which corresponds to that usually used in thermodynamic calculations, namely the absolute entropy less the effect of nuclear spin, is found to be  $47.92 - R \ln 4 = 45.17$ e.u.

Combining this value with H<sub>2</sub>, S<sub>298.1</sub>=31.23 e.u.<sup>2</sup> and O<sub>2</sub>,  $S_{298,1} = 49.03$  e.u.<sup>3</sup> we obtain  $\Delta S_{298,1} = -10.58$  e.u. Rossini<sup>4</sup> gives  $\Delta H_{298,1} = -68,313$  cal.  $\cdot$  mole<sup>-1</sup> for the formation of liquid water from the elements. For gaseous water

<sup>2</sup> Giauque, J. Am. Chem. Soc. 52, 4816 (1930).

<sup>3</sup>Giauque and Johnston, J. Am. Chem. Soc. 51, 2300 (1929).

<sup>4</sup> Rossini, Bur. Standards J. Research 6, 1 (1931).

<sup>&</sup>lt;sup>1</sup> Mecke and Baumann (a) Naturwiss. 20, 657 (1932). (b) Phys. Zeits. 33, 833 (1932).