

a result of this the growing of crystals in a hydrogen sulfide atmosphere was tried.<sup>1</sup>

The size of the largest crystals that were obtained by hydrogen sulfide method was approximately  $2 \times 2 \times 10$  mm. Since there are two forms of zinc sulfide crystals, i.e., alpha-form or wurtzite and the beta-form or sphalerite, the crystals were examined with polarized light and were found to be of the alpha-form.

The optical absorption of the zinc sulfide crystals was measured with a photospectrometer at room temperature to determine the absorption cut-off. The data obtained are shown in Fig. 1. The absorption cut-off for the crystals was found to be at 3350 Å and they are entirely opaque below this. This agrees with the value for powders obtained by Gislof.<sup>2</sup> The absorption decreases until in the red and infra-red region the crystals are completely transparent.

The purity of the crystals was determined by subjecting them to ultraviolet light. The crystals showed no sign of phosphorescence and only in rare cases did they fluoresce. The fluorescence in these few cases was the typical blue fluorescence supposedly due to an excess of zinc atoms predicted by theory. In general the zinc sulfide crystals grown in a hydrogen sulfide atmosphere exhibited neither phosphorescence nor fluorescence which indicates a high degree of purity.

<sup>1</sup> D. C. Reynolds, M.S. thesis (unpublished), University of Iowa (1948).

<sup>2</sup> J. H. Gislof, *Physica* **6**, 84 (1939).

### The Thermal Neutron Scattering by Ammonium Chloride

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NEUTRON scattering has proved to be a very powerful means of investigating crystalline states, especially those containing hydrogen atoms.<sup>1</sup> The following experiments<sup>2</sup> were performed during the last war, and as we have no facilities for continuing the experiment, it seems appropriate to report here briefly what we did. The transformation of  $\text{NH}_4\text{Cl}$  at  $-30.8^\circ\text{C}$  has been interpreted as the mutation between the ordered and the disordered states in the orientation of the ammonium ions.<sup>3,4</sup> If this is the case it is to be expected that the diffractive scattering of thermal neutrons may not be the same for the two states. The transmission of thermal neutrons was measured as a function of the temperature of  $\text{NH}_4\text{Cl}$  ranging from about  $-70^\circ\text{C}$  to room temperature. The experimental arrangement was much the same as that of Beyer and Whitaker,<sup>5</sup> the scatterer being put in a Dewar vessel. The scattering cross section showed a maximum (or minimum in transmission) at the transformation point. It had somewhat larger values at higher temperatures as compared with the values below  $-30^\circ\text{C}$  as shown in Fig. 1. It is not an established

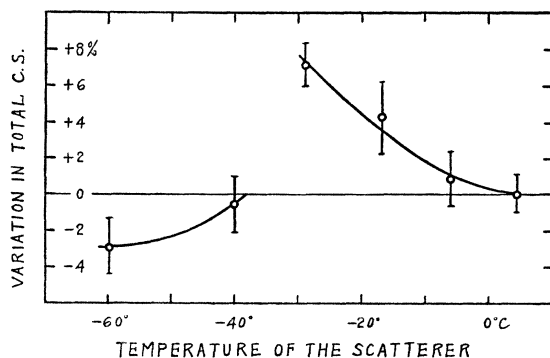


Fig. 1. Scattering cross section of thermal neutrons near the transformation point of ammonium chloride.

matter, however, to interpret the above results as the mutation between the ordered and the disordered state of the  $\text{NH}_4$  ions. The change in the secondary structure (the state of mosaic block or internal distortion) of the  $\text{NH}_4\text{Cl}$  crystal might cause the larger part, if not all, of the observed variation in the scattering, as we may naturally expect a lattice distortion of the crystal near the transformation temperature.<sup>6,7</sup> If this is the case, however, the scattering cross section must depend on the grain size of the powdered scatterer of  $\text{NH}_4\text{Cl}$  of the same temperature as in the case of a polycrystalline metal scatterer.<sup>8,9</sup> We measured the variation using scatterers of various grain size ranging from  $2 \times 10^{-4}$  to  $4 \times 10^{-1}$  cm, and found no change within the limits of error of  $\pm 2$  percent. This result implies that, contrary to perfect crystals such as  $\text{SiO}_2$ , the crystal of  $\text{NH}_4\text{Cl}$  belongs to an imperfect type such as those of sulfur and lead<sup>10,11</sup> and cannot show any variation in scattering cross section by internal distortion. Further experiments are desired, however, for the final conclusion. The author wishes to express his sincere thanks to Professor S. Nishikawa for his encouragement throughout this work. The author also wishes to express his gratitude to the Japanese Foundation for Cancer Research for the supply of radon.

<sup>1</sup> Shull, Wollan, Morton, and Davidson, *Phys. Rev.* **73**, 842 (1948).

<sup>2</sup> M. Kimura, *Proc. Imp. Acad. Tokyo* **19**, 244 (1943).

<sup>3</sup> J. Frankel, *Acta Physicochimica* **3**, 23 (1935).

<sup>4</sup> T. Nagamiya, *Proc. Phys. Math. Soc. Japan* **24**, 137 (1942).

<sup>5</sup> Beyer, Whitaker, *Phys. Rev.* **57**, 976 (1940).

<sup>6</sup> M. Kimura and R. Hashiguchi, *Proc. Phys. Math. Soc. Japan* **25**, 530 (1943).

<sup>7</sup> See reference 2, p. 152.

<sup>8</sup> See reference 6, p. 495.

<sup>9</sup> F. C. Nix and G. F. Clement, *Phys. Rev.* **68**, 159 (1945).

<sup>10</sup> F. Rasetti, *Phys. Rev.* **58**, 321 (1940).

<sup>11</sup> M. Kimura and J. Akutsu, *Sci. Pap. Inst. Phys. Chem. Research* **38**, 63 (1940).

### The Shape of the Rossi Curve

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THE second maximum of the Rossi curve, first observed by Ackemann and Hummel,<sup>1,2</sup> was investigated in greater detail some time ago in our laboratory.<sup>3,4</sup> These experiments led to the conclusion that the second maximum indicates production of a special kind of shower differing from cascade showers in origin and properties: (1) most, if not all, of these showers contain two particles only, (2) the shower particles are probably mesons, (3) the angular spread is small (around  $10^\circ$ ), (4) the showers are produced by the meson component of cosmic rays, (5) the cross section for production is approximately proportional to  $Z$ .

Cloud-chamber experiments,<sup>5,6</sup> as far as they go, have confirmed these results with regard to points (1) to (4), and to absolute rate of production. On the other hand, several investigators using counter arrangements obtained more or less divergent results.<sup>7-9</sup>

We have started fresh experiments with a counter arrangement much more effective than the original one (Fig. 1). Showers are recorded by the two crossed counter trays *A*, *B*. Fourfold coincidences between two counters each are recorded. The angular spread is determined by the diagonal distance between the intersecting squares of the four counters. A third counter tray, *C*, is arranged above the shower-producing lead layer. Connections between *C* and *A*, *B* can be made in different ways, so that the showers are recorded either (a) by ionizing as well as non-ionizing rays or showers (tray *C* removed), or (b) by showers of at least three ionizing particles, or (c) by ionizing single particles, no second ionizing particle hitting tray *C*, or (d) by non-ionizing rays, no ionizing particle hitting tray *C*.

Experiments have so far been performed at an altitude of 100 meters under about  $290 \text{ g/cm}^2$  of concrete ceiling. We believe that all possible sources of misinterpretation of the results, as an in-