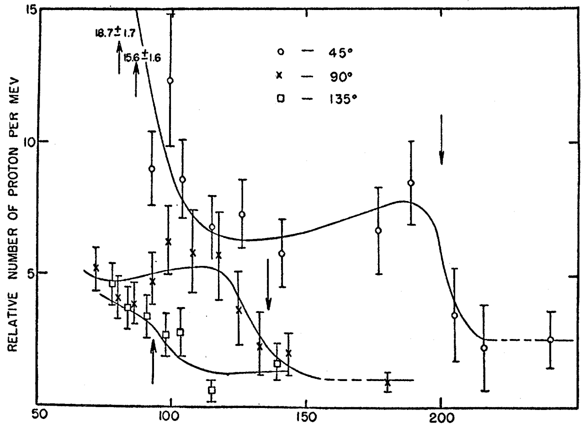

FIG. 1. Differential cross section per photon for the photodissociation, as a function of the photon energy.

the angle $\theta$ between the direction of the ejection and the incident beam, and the energy $k$ of the photon which caused the dissociation.

Putting $k=320$ Mev in this relation we get 93, 136, and 200 Mev for the maximum energy of protons at 45, 90, and 135 degrees, respectively.

The energy spectra obtained are shown in Fig. 1. These spectra show well defined cutoffs at the proton energies 95, 135, and 200 Mev, coinciding closely with the expected values. This seems to indicate that these protons are actually the photoprotons produced by the splitting of a deuteron into a proton and a neutron by the absorption of a photon.

Assuming the bremsstrahlung spectrum to be proportional to $1/E$, we can compute from the results shown in Fig. 1, the differential cross section per photon for the photodissociation as a function of the photon energy. The result is given in Table I.[2] In the 45-degree case one can see the dependence of the cross section on photon energy in a fairly wide range. Below 150 Mev it decreases rather steeply with increasing energy, and at about 150 Mev it begins to flatten out and then starts to increase again with increasing energy.

TABLE I. Differential cross section as a function of photon energy in the laboratory system.

| | Energy of photon in Mev | Diff. cross sec in microbarns | | Energy of photon in Mev | Diff. cross sec in microbarns |
|---|---|---|---|---|---|
| 45° | 133 | 14.4±1.8 | 90° | 158 | 2.7 ±0.6 |
| | 144 | 12.8±1.9 | | 178 | 2.4 ±0.7 |
| | 152 | 6.6±1.8 | | 194 | 2.4 ±0.7 |
| | 162 | 10.7±3.0 | | 211 | 3.4 ±1.0 |
| | 170 | 6.9±2.2 | | 226 | 5.1 ±1.3 |
| | 189 | 5.4±2.1 | | 248 | 5.2 ±1.7 |
| | 205 | 6.5±2.3 | | 272 | 5.5 ±1.3 |
| | 228 | 5.0±2.6 | | | |
| | 285 | 8.0±3.8 | 135° | 250 | 0.99±0.27 |
| | 304 | 12.3±4.0 | | 272 | 0.99±0.35 |

The angular distribution in laboratory system shows a fairly strong forward asymmetry. The same trend can be seen in the center-of-mass system.

The total cross section was roughly estimated by multiplying the differential cross section at 90° by $4\pi$. Below 150 Mev, where no data for 90° was available, the cross section was assumed to be proportional to the differential cross section at 45°. Table II shows the results. The errors indicated are those referred to the relative values. Referring to the absolute value, the error might be as large as a factor of 3. Comparing with Schiff's theoretical values given in Table II, one should rather consider that the experimental values are compatible with the theoretical values below 150 Mev, which is the upper limit of the validity of the theory set by Schiff himself. Above 150 Mev the cross section does not decrease as the straightforward extrapolation of Schiff's curve does. Recently, Gilbert and Rose[3] at this Laboratory studied the photodissociation of the deuteron in nearly the same energy range as the present work, using a counter technique. For the dissociation at photon energies of 200 and 250 Mev in the c.m. system, they obtained total cross sections which are about twice as large as the present values. Because of the relatively large error involved in both experiments, the results should be regarded as in agreement with each other.

TABLE II. Total cross section as a function of photon energy.

| Energy of photon in lab. system | Energy of photon in c.m. system | Total cross section in $10^{-29}$ cm$^2$ | Theoretical value (Schiff), in $10^{-29}$ cm$^2$ |
|---|---|---|---|
| 133 | 125 | 6.2±0.5 | 2.3 |
| 158 | 146 | 3.4±0.8 | 1.6 |
| 178 | 163 | 3.0±0.8 | |
| 194 | 176 | 3.0±0.9 | |
| 211 | 191 | 4.3±1.2 | |
| 226 | 202 | 6.4±1.7 | |
| 248 | 220 | 6.6±2.2 | |
| 272 | 239 | 6.9±1.7 | |

The increase of the photodissociation cross section above 150 Mev may be explained by the increasing importance of the absorption of a photon with emission and reabsorption of a virtual meson in the energy range above the meson threshold. It is hoped that the experimental evidence given here may provide a more direct and more stringent test for the different types of meson theory, than has been the case with experiments in the low energy region, where the comparison of the theory with the experiments was made more or less indirectly, as far as the meson theory is concerned.

The author wishes to thank Professors McMillan and Helmholz, and R. S. White and W. S. Gilbert for discussions as well as for their generosity in placing their plates at the author's disposal.

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[1] The exposure had been made originally by R. S. White and others of this laboratory to investigate the photomeson production in deuterium [Bull. Am. Phys. Soc. **26**, No. 8, 22 (1951)].

[2] The relatively large error in the 45° case compared to the other cases came from the ambiguity involved in the background.

[3] W. S. Gilbert and J. W. Rose, Phys. Rev. (to be published).

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## Silver-Activated Alkali Halides

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THE earliest investigation of the silver-activated alkali halides appears to have been made by Smakula.[1] His data show a single sharp absorption band peaking at 2100A in NaCl:Ag. The most recent study of these phosphors is evidently by Kato,[2] who investigated the emission as well as the absorption spectra. Kato's absorption data agree very well with Smakula's. He observes that excitation into the characteristic silver ion absorption band in NaCl:Ag produces two emission bands, one peaking at 2490A and a second at 4000A.

We have found, as shown in Fig. 1, that three absorption bands appear in NaCl upon the introduction of ionic silver. These bands lie at 2095A, 2170A, and 2295A. The absorption measurements were made with a split-beam, frequency selective, single detector, automatic recording spectrophotometer[3] on single crystals grown by the Kyropoulos technique from NaCl-AgCl melts. Figure 2 is a photograph of the emission of the NaCl:Ag upon excitation into each of the three absorption bands. For this measurement

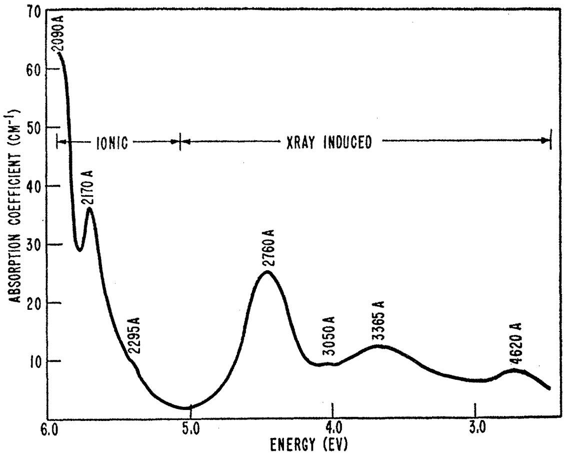

FIG. 1. Spectral absorption of x-rayed NaCl:Ag.

the output of a quartz envelope H-4 mercury lamp was monochromatized by a Gaertner quartz monochromator. The monochromatic light then impinged upon a plaque of powdered NaCl:Ag, the fluorescence of which was photographed with a Gaertner quartz spectrograph. Excitation with ultraviolet light of 2100A wavelength and below produced only the 2500A emission; excitation with 2170A light produced predominantly 2500A emission but also some 4000A emission, while 2270A excitation produced a stronger emission of 4000A light than of 2500A light.

In order to determine whether the observed emissions were caused by different excited states of the same center or to two or more types of centers, absorption measurements were made on a series of single crystals containing varying amounts of ionic silver. Figure 3 shows a plot of the observed absorption coefficient for the 2170A and the 2295A bands plotted against the mole ratio of silver to sodium. Superimposed on this graph is a plot of the number of paired silver ions, calculated on the assumption of a random distribution of these ions. The shape of the 2295A curve agrees well enough with the calculated curve for pairs to indicate that this absorption and resulting emission at 4000A are due to pairs. The 2170A absorption is apparently not due to pairs but to individual silver ions.

The above data are a part of a more extensive study of Ag-activated alkali halide systems. It has been found[4,5] that these systems are radio-photoluminescent, i.e., NaCl:Ag luminesces under near ultraviolet light after exposure to x-rays or gamma-rays. The new absorption bands observed after x-raying NaCl:Ag are shown in Fig. 1 (at 2760A, 3050A, 3365A) together with the *F*-band at 4620A. A more complete study of this system will be reported in a forthcoming paper.

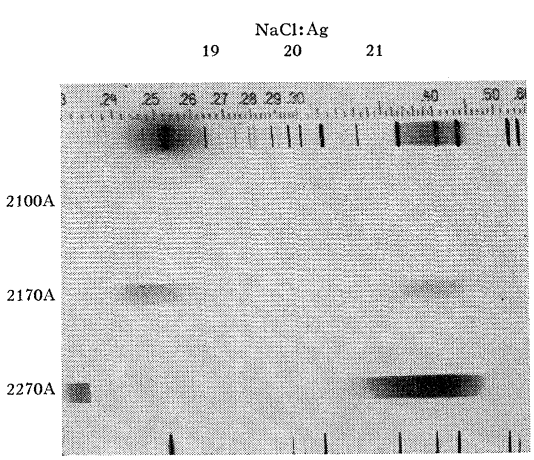

FIG. 2. Emission spectra of NaCl:Ag under various exciting wavelengths.

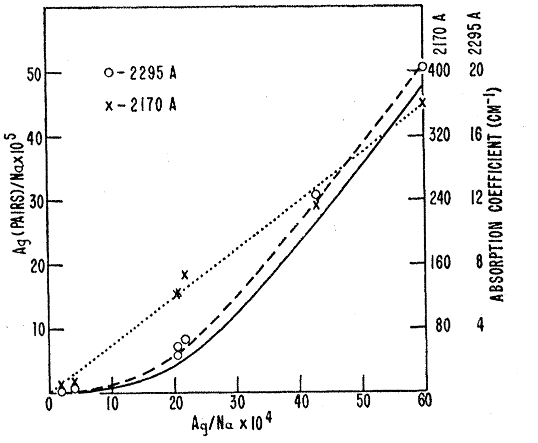

FIG. 3. Ratio of Ag pairs to Na (calculated) *vs* ratio of Ag to Na (experimental): solid curve. Measured absorption coefficient *vs* ratio of Ag to Na (experimental): dotted curves.

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[1] A. Smakula, Z. Physik **45**, 1 (1927).

[2] M. Kato, Sci. Papers Inst. Phys. Chem. Research (Tokyo) **41**, 113 (1943).

[3] H. W. Etzel (to be published).

[4] Weyl, Schulman, Evans, and Ginther, J. Electrochem. Soc. Japan **95**, 70 (1944).

[5] Schulman, Ginther, and Evans, "X-ray sensitive screen," U. S. Patent No. 2,524,839 (October 10, 1950).

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# Errata

**The Corbino Effect and the Change of Resistance in a Magnetic Field,** K. M. KOCH AND L. HALPERN [Phys. Rev. **82**, 460 (1951)]. The name of the second author was inadvertently omitted from the manuscript of the above-cited paper.

**Relativistic Corrections to the Lamb Shift,** MICHEL BARANGER [Phys. Rev. **84**, 866 (1951)]. The last published experimental value was erroneously stated to be 1061±2. It should have been 1062±5 Mc.

**Radiative Corrections to the Intensities for Hydrogen-Like Atoms,** T. TATI [Phys. Rev. **84**, 150 (1951)]. In the letter of the above title, I stated that if one takes into account the higher order field reaction, the transition probability between very near levels would become quite large. However, this conclusion was obtained by an incorrect neglect of terms[1] having the same order of magnitude as the fourth term of Eq. (2). If one adds these neglected contributions, one finds a vanishing matrix element for the process in the leading order.[2]

[1] This error was pointed out by Professor S. Tomonaga.

[2] This vanishing of the matrix element was pointed out by Dr. S. D. Drell in a private communication.

**Absorption Spectrum of GaCl,** FRANKLYN K. LEVIN AND J. G. WINANS [Phys. Rev. **84**, 431 (1951)]. On page 433, line 31, first column, the sentence beginning "The (0, 0) and (1, 0) bands of the 2440 to . . ." should read "The (0, 0) and (0, 1) bands of the 2440 to . . . ." On page 435, second column, the equation "$G(v+\frac{1}{2})=365.3(v''+\frac{1}{2})$ . . ." should

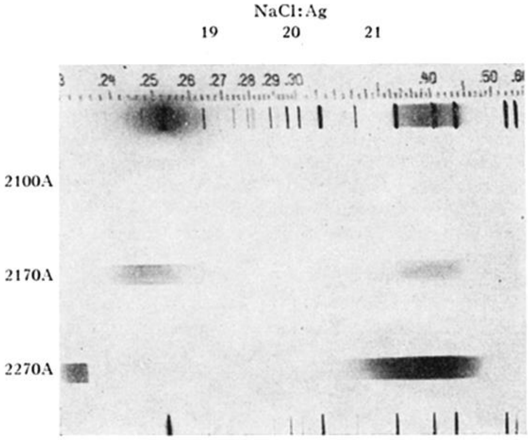

FIG. 2. Emission spectra of NaCl:Ag under various exciting wavelengths.