# Proceedings of the American Physical Society

MINUTES OF THE CINCINNATI MEETING, DECEMBER 1–2, 1933

THE 187th regular meeting of the American Physical Society was held at the University of Cincinnati, Cincinnati, Ohio, on Friday and Saturday, December 1 and 2, 1933. The presiding officers were Paul D. Foote, President of the Society, and J. H. Van Vleck.

The Netherland-Plaza Hotel was the headquarters and the Society's dinner was held there on Friday evening with seventy-six guests in attendance. President Foote presided and the after-dinner speakers were S. J. M. Allen, Arthur H. Compton, K. K. Darrow, L. T. More and Raymond Walters, President of the University of Cincinnati. The meeting was in celebration of the opening of the new Physics Laboratory. The Basic Science Laboratory was also open for inspection.

On Saturday afternoon a joint meeting was held with the American Mathematical Society in a symposium on *Spinor Analysis*. The speakers were Otto Laporte and Oswald Veblen. At one of the regular sessions L. T. More read a very interesting character sketch of Isaac Newton based on his recent research in England on this subject.

*Meeting of the Council.* At its meeting on Friday, December 1st, the Council approved the transfer of one member to the grade of fellow. Twenty-five candidates were elected to membership. *Transferred from membership to fellowship:* Harold M. Mott-Smith. *Elected to membership:* Clete Adams, Richard Bär, Robert B. Barnes, Willard F. Bartoe, Catharine M. Bergen, B. Edwin Blaisdell, John Paul Blewett, Walter L. Bond, George H. Burnham, W. F. Busse, Richard E. Carlson, Carl N. Challacombe, Sydney Chapman, Forrest F. Cleveland, Franklin S. Cooper, Clyde B. Crawley, Eugene Feenberg, C. E. Hablutzel, Jr., T. M. Hahn, Hirosi Hukusima, Theron W. Kilmer, Jr., Motoharu Kimura, Robert B. King, Andrew McKeller, A. O. C. Nier, Dwight O. North, Harold T. Olson, W. G. Penney, R. G. Piety, J. H. Plummer, Emil G. Purdom, Raymond Ricard, Severn Rinkob, Preston Robinson, Milward T. Rodine, William G. Shepherd, Brian O. Sparks, Ray L. Sweeny, Theodore A. Te Grotenhuis, Hiroshi Tsubota, Eugene E. Warner and Martin C. Watson.

The regular scientific session consisted of thirty-four papers, four of which, numbers 1, 14, 18, and 30, were read by title. A complete list of authors and abstracts will be found in the following pages.

W. L. SEVERINGHAUS, *Secretary*

## ABSTRACTS

**1. On a Formula to Determine the Direction of the Extraordinary Ray in a Uniaxial Crystal, Derived by a Method of Analytical Geometry.** ROBERT V. BAUD, *Beaver Falls, Pa.*—The design of certain optical instruments necessitates the determination of the optical path of light rays through various substances which quite often offers difficulties, one of which may be the requirement of extreme accuracy. The graphical solution is not satisfactory when such a requirement exists due to the fact that the point of tangency of the wavefronts cannot be located accurately, even though the drawing be made to as large a scale as ordinary drafting accommodations permit. An analytical solution becomes therefore desirable in this case. As none of the standard texts contain such a solution, not even for the comparatively simple case of plane of incidence and principal plane coinciding, the author has endeavored to find one for this case that is not so complicated as the one given by Johannson in his book on *Petrographic Methods*. In deriving the formula the steps made in solving the problem graphically by means of Huyghen's construction were analytically formulated. Let $\beta$ be the angle of incidence, $\theta$ the angle between the direction of the

extraordinary ray and a line perpendicular to the optical axis, $\alpha$ the angle between the crystal face and the optical axis, $n_1$ the index of refraction for rays perpendicular to the optical axis, $n_2$ the index for parallel rays, the derived formula reads as follows:

$$\theta = \arctan \frac{\cos \alpha - k(n_1/n_2) \sin \alpha}{\sin \alpha + k(n_2/n_1) \cos \alpha},$$

in which $k$ is the value as determined by

$$k = (1/\sin \beta)(n_1^2 \sin^2 \alpha + n_2^2 \cos^2 \alpha - \sin^2 \beta)^{\frac{1}{2}}.$$

**2. A Photoelastic Method of Stress Evaluation in Structures Involving Two Parallel Systems of Plane Stresses.** WALTER H. HAUPT, *University of Cincinnati. (Introduced by S. J. M. Allen.)*—To find stresses in each of two parallel plates in a model, polarized light is caused to vibrate in a plane corresponding to stress direction in the first plate, whereupon it reaches the second plate as plane polarized light. The image can then be analyzed directly for stresses in the second plate. To obtain stress directions for any given point of the two plates, white polarized light is transmitted through both, and the nicols are rotated until there is achromatic transmission. The nicol setting will then give the stress directions. When the stresses are parallel in the two plates the insertion of a half-wave plate between them with axis at forty-five degrees to stress direction will reverse the effect of the first plate from plus to minus. The images with and without the half-wave plate will give the value of the sum and difference of the two stress effects.

**3. On the Comparison of Theoretical and Measured Hall Coefficients.** K. K. SMITH AND N. A. HEDENBERG, *Northwestern University.*—From Kapitza's data, N. H. Frank calculated (Zeits. f. Physik **64**, 652, 1930) the coefficient $C$ in his formula $\Delta\rho/\rho = BH^2/(1+CH^2)$, where $\rho$ is the resistivity in the *presence* of the field. He found that $\rho(C)^{\frac{1}{2}}$ is *less* than the Hall coefficient, $R$ (from tables), for bismuth and antimony. But Bellia's measurements (Zeits. f. Physik **74**, 655, 1932) on bismuth, and Barlow's on antimony show the reverse. We have made measurements of resistivity and Hall coefficient for each of two bismuth plates at room temperature in fields varying from 1000 to 13,000 gauss. When $H=0$, the resistivities are $\rho_0 = 14.2\times10^4$ e.m.u. and $12.8\times10^4$. For each plate $C$ (found graphically) is $1.3\times10^{-8}$ gauss$^{-2}$. Since the largest values of $R$ are $-7.4$ and $-2.6$ e.m.u., $\rho(C)^{\frac{1}{2}}$ is greater than $R$. It appears that so far as this comparison is concerned, bismuth and antimony are like all the other metals for which Frank published calculations. We have recalculated $C$ from Kapitza's data for the eight metals Cu, Ag, Au, Zn, Al, Cd, Sb, Bi. The result is an upward revision of Frank's values of $\rho(C)^{\frac{1}{2}}$. The discrepancy between the two sets of values is accounted for by noting that Kapitza plotted $\Delta\rho/\rho_0$, not $\Delta\rho/\rho$.

**4. Nonmetallic Conducting Films.** S. BLOOMENTHAL, *R. C. A.-Victor Co., Camden, N. J.*—Immutable conducting films, which adhere to any clean solid, have been formed from synthetic resin solutions holding finely ground carbon in suspension. Values of surface resistivity (Maxwell Treatise on E. & M., II, p. 287) for uniformly thin films were secured in the range 10 to $5\times10^5$ ohms referred to unit area of surface. When the thickness is held constant, the resistivity depends mainly upon the proportion of binder present and the kind of carbon used. The experimental error in repeating values of resistance is about $\pm20$ percent when the same suspension is used, and somewhat higher when a second suspension, prepared identically, is used. The dependence of resistance upon resin content of the film appears to be in accord with the views of Frenkel (Phys. Rev. **35**, 1604, 1930) concerning gap contacts, and in definite disagreement with the classical Maxwell-Rayleigh theory for composite conductors. The behavior of various types of carbon, when used in the films, can be predicted qualitatively from electrical measurements made upon powdered samples subjected to high pressure.

**5. The Scattering Coefficients of X-Rays at Short Wave-Lengths.** S. J. M. ALLEN, *University of Cincinnati.*—The mass absorption coefficients $\mu/\rho$ of homogeneous x-rays have been measured for elements from hydrogen to uranium and down to $\lambda=0.05$A. Very especial care was taken to ascertain the impurities in each sample, so proper corrections could be made. This is very important for the light elements. An empirical law was used to calculate $\tau/\rho$, the photoelectric coefficient. $\sigma/\rho = \mu/\rho - \tau/\rho$ was then calculated and reduced to electronic absorption. The values $\sigma_e$ so obtained are shown in the following table for different elements at certain wave-lengths from $\lambda=0.005$A to 0.417A. Below $\lambda=0.05$A the data are from $\gamma$-ray absorption, and some few x-ray results of other experimenters. The results seem to me to be very interesting and important. For all elements at any $\lambda$, $\sigma_e$ is constant and agrees very closely with that calculated from the Klein Nishina formula up to $Z=10$–15, when there is a rapid increase (excess scattering) for the heavier elements. This phenomenon for x-rays is identical with that noticed for $\gamma$-rays of radioactive bodies. Excess scattering in the case of $\gamma$-rays has been ascribed by many experimenters to

*Electronic Scattering Coefficient $\times10^{27}$.*

| | *γ-rays and x-rays* | | | | *x-rays* | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Element | 0.005A | 0.010A | 0.025A | 0.050A | 0.064A | 0.098A | 0.130A | 0.200A | 0.417A |
| H | 128 | 195 | 270 | 380 | 410 | 460 | 530 | 620 | 640 |
| Li | | | | | 410 | 460 | | 570 | 620 |
| Be | | | | | | | | 580 | 600 |
| B | | | | | 440 | 480 | | 570 | 590 |
| C | 128 | 197 | 270 | 390 | 420 | 460 | 500 | 550 | 570 |
| N | | | | | | | | 540 | |
| O | | 195 | | | 420 | 460 | | 520 | 540 |
| Ne | | | | | | | | 530 | |
| Na | | | | | 430 | 490 | | 540 | 550 |
| Mg | | | | | 410 | 470 | | 540 | 540 |
| Al | 129 | 197 | 270 | 380 | 420 | 490 | 510 | 530 | 550 |
| S | 128 | 198 | 270 | | 420 | 460 | | 600 | 600 |
| Cl | | | | | 430 | 500 | | 660 | 680 |
| A | | | | | | | | 700 | |
| Ca | | | | | 430 | 510 | | 720 | 820 |
| Fe | 133 | 203 | 280 | 430 | 450 | 575 | 670 | 900 | 1000 |
| Cu | 134 | 206 | 290 | 450 | 470 | 700 | | 1400 | 1500 |
| M | | | | | | | | 1600 | |
| Mo | | | | | 1000 | 1600 | | | |
| Sn | 145 | 213 | 400 | 900 | 1300 | 2400 | 3200 | 5000 | 5500 |
| Pb | 172 | 300 | 950 | 2700 | 3500 | 4500 | 4100 | | |

nuclear absorption. Is the similar phenomenon here shown for x-rays at much greater values of $\lambda$ to be explained in the same manner? I do not attempt to answer that, but simply present the facts.

**6. Electron Diffraction from Vacuum-Sublimated Layers.** K. LARK-HOROVITZ, E. M. PURCELL AND H. J. YEARIAN, *Purdue University.*—The material for investigation is condensed in a high vacuum onto a volatile substance (camphor, naphthalene, etc.) held at liquid air temperature. By letting the volatile support evaporate after the desired thickness is reached it is possible to obtain thin, free films of the condensed material of varying thickness without using any dissolving agent as it is necessary in other methods. In this way films of zinc and zinc sulfide have been obtained. The electron diffraction pattern of zinc agrees with the x-ray diffraction pattern and shows no irregularity in the intensity distribution as compared with the corresponding x-ray pattern except for the first two lines. Zinc sulfide in thin layers forms colloidal particles; in thicker layers it is crystalline and the position of the lines agrees with the x-ray pattern. The intensities however are different in a similar way as reported previously in the case of ZnO. Copper, when deposited in this way, forms films of either pure cuprous oxide ($Cu_2O$) or a mixture of copper and cuprous oxide. The intensity distribution of the $Cu_2O$ pattern agrees with the intensity distribution of the corresponding x-ray pattern.

**7. Electron Scattering in Methane, Ethylene and Acetylene.** A. L. HUGHES AND J. H. MCMILLEN, *Washington University, St. Louis, Missouri.*—Scattering coefficients for elastic collisions between electrons and molecules of these gases have been measured. Electron energies employed were from 10 to 800 volts for methane, to 100 volts for acetylene and to 225 volts for ethylene. Evidence for interference effects between the electron waves scattered by individual atoms within a molecule was indicated by the presence of maxima in the curves for the ratios of the scattering coefficients for $C_2H_4$ and $CH_4$ (also for the pair $C_2H_2$ and $CH_4$) expressed as functions of scattering angles. The ratios were also computed by the well-known formula for the intensity of the resultant waves emitted by a molecule, *viz.*,

$$\Psi^2 = \sum_1^n i \sum_1^n j \, \psi_i \psi_j (\sin x_{ij}/x_{ij}),$$

where $\psi_i$ and $\psi_j$ are the electron wave amplitudes due to the atoms $i$ and $j$, and $x_{ij}$ is a parameter involving the distance apart of the atoms. Fairly satisfactory agreement between experiment and calculations was obtained for the ratios for $C_2H_4$ and $CH_4$, provided that we assume that the scattering is done by the H atoms alone. But to get fairly satisfactory agreement in the case of $C_2H_2$ it was necessary to assume that the C atoms contribute their full share to the scattering.

**8. Refocussing of Electron Paths by Means of a Magnetic Field.** W. E. STEPHENS AND A. L. HUGHES, *Washington University, St. Louis.*—It is well known that, when electron paths diverge from a point in a magnetic field, they are refocussed when they have turned through 180°. This is a particular case of a more general relation. Consider a uniform magnetic field bounded by two planes, meeting at any angle, the magnetic field being parallel to the line of intersection of the two planes. Consider a third plane passing through the line of intersection and symmetrically orientated with respect to the other two planes. If a beam of electrons diverges from any point on this plane so that the central ray falls perpendicularly on the nearer face of the magnetic field and is then deviated by the magnetic field so that it emerges perpendicularly from the second face of the magnetic field, then all electron paths in a plane perpendicular to the three planes and diverging from the starting point, refocus at a point whose position in the third plane is the image of the starting point. The formula for the departure from perfect refocussing has been derived. The refocussing property has been verified experimentally. Refocussing of this type should be useful experimentally when the original 180° type of refocussing is inconvenient.

**9. Some Aspects of Electromagnetic Forces and Waves.** F. W. WARBURTON, *University of Kentucky.*—The force on a beam of cathode rays in a magnetic field due to conduction currents, developed from Weber's energy equation of moving charges, is equal to that obtained classically, provided the velocity of the conduction electrons is small compared with the velocity of the cathode particles. On the other hand, the contribution of neighboring electron orbital currents to the magnetic force on an electron in an orbit is half the classical value. An equal force acts on the nucleus. The relation of this to the gyromagnetic anomaly is considered. An error in the derivation of electric waves from Weber's energy equation (Phys. Rev. **44**, 319, 1933) is eliminated, making the wave equation read

$$\frac{\partial^2 A}{\partial r^2} = \frac{\mu\epsilon}{c^2}\frac{\partial^2 A}{\partial t^2} - \frac{\mu\epsilon v \sin^2\theta}{c^2 r \cos\theta}\frac{\partial A}{\partial t} - \frac{9\mu e' v' \sin\theta \sin\theta' \cos\gamma}{c r^3 \cos\theta},$$

where $A$ is the magnitude of the vector potential; $v'$, $v$ the velocities of electrons in source and absorber; $\theta'$, $\theta$ the angles between $v'$ and $r$, $v$ and $r$; and $\gamma$ the angle between the planes $v$, $r$ and $v'$, $r$. This equation is invariant under a Galileian transformation.

**10. Spectral Distribution of the Photoflash Lamp.** W. E. FORSYTHE AND M. A. EASLEY, *Lamp Development Laboratory, General Electric Company, Cleveland, Ohio.*—The distribution in the spectrum of the total quantity of radiation from the photoflash lamp has been measured by using a glass spectrometer with two 60° prisms and also the large crystalline quartz double monochromator[1] as the dispersing instrument and the measurements at the receiving slit made by means of a photoelectric tube connected to a very high sensitivity galvanometer. The values for the different wave-length intervals with the glass spectrometer were reduced to relative energy values by comparison with measurements made with the same instrument on the spectral energy distribution of a high intensity

tungsten lamp of known color temperature. The transmission of the quartz instrument and the spectral sensitivity of the photoelectric cell used with it were known so that the galvanometer deflections could be expressed in relative energy values directly. The distribution for the range measured agrees very well with data published by Ives[2] and his co-workers on the spectral distribution of energy in the spectrum of aluminum oxide when heated by means of a gas flame. The shape of the curve in the visible spectrum was found to be about the same as that of a black body at 3500°K.

[1] R. S. I. **4**, 289 (1933).
[2] J. Frank. Inst. **186**, 585 (1918).

**11. Double-Coated Schumann Films.** H. P. KNAUSS AND R. V. ZUMSTEIN, *Ohio State University.*—Hopfield's method (J. Opt. Soc. Am. **22**, 488, 1932) of preparing Schumann plates employs commercial photographic plates which are fixed and washed, to serve as a base for the Schumann emulsion. We have found that it is possible to precipitate a thin Schumann emulsion directly on the sensitive emulsion of Eastman 33 plates, thereby obtaining plates which are fast not only in the Schumann region, but also up to the long wave-length limit of the plates used. Plates so made have been compared with others prepared according to Hopfield's directions, as well as with Eastman ultraviolet sensitive plates, and plates sensitized with Eastman's ultraviolet sensitizing solution. A condensed copper spark in air was used as a source, with a small quartz spectrograph as a dispersing instrument. Plates of all four types were found to be practically alike in sensitivity for the extreme ultraviolet. Sensitivity for longer wave-lengths is an advantage only in using overlapping orders for comparison of wave-lengths.

**12. The Spectrum of Rubidium in Mercury Arc.** I. A. BALINKIN AND D. A. WELLS, *University of Cincinnati. (Introduced by S. J. M. Allen.)*—This is a continuation of the previously published work on the spectra of potassium and sodium in a specially designed mercury-arc lamp. Various low percentages of rubidium, $\frac{1}{4}$ to 2 percent, were introduced into the same type of mercury lamp and the spectra photographed in the visible and ultraviolet regions. Under proper conditions, 1.45 amp. and 40.0 volts, the lamp operates with full Rb glow, mercury lines being almost completely suppressed. The reduction in intensity of Hg lines is far greater in the visible than in the ultraviolet. The luminous efficiency of the Rb-Hg amalgam lamp has also been determined and compared with that of a similar lamp containing only mercury. The blackening of the glass so noticeable in lamps containing K and Na was absent in Rb mercury amalgam lamps.

**13. Emission and Absorption from the $2\,^3P_0$ Metastable Level in Mercury.** M. L. POOL AND O. W. PRASHUN, *Ohio State University.*—Mercury vapor at room temperature in the presence of nitrogen was optically excited by the total radiation from two mercury arcs. For nitrogen pressures from 1 to 200 mm the emission of the "forbidden line" 2656.6 ($1\,^1S_0-2\,^3P_0$) gradually increased in intensity. From 200 to 760 mm the intensity remained constant. When the intensity of the exciting radiation was reduced to one-half, the emission also decreased about one-half. The intensity of the 2537 line behaved similarly. The lines 5461, 4077, 3340, 2893, and 2752 showed a decrease in emission of only a little more than one-half when the excitation was decreased one-half. A decrease to one-fourth might be expected. The absorption of 2967 ($2\,^3P_0-^3D$) was found to be very strong up to 100 mm and then to decrease with further increase of nitrogen. The ratio of the emission from the $2\,^3P_0$ level to the absorption from that level indicated that the transition probability between the $2\,^3P_0$ and $1\,^1S_0$ levels increases rapidly with nitrogen pressure. The 4800 band due to $Hg_2(2\,^3P_0)$ increases in intensity with increase in nitrogen pressure from 200 to 760 mm and also increases in intensity with decrease of exciting energy.

**14. Hydrogen-Isotope Effect in the OH Bands, λ3064 and λ3121.** R. W. SHAW AND R. C. GIBBS, *Cornell University.*—Bands arising from the isotope of hydrogen of approximate mass 2 in the OH molecule have been photographed under high dispersion for the cases of the (0, 0) and (1, 1) vibrational changes. The spectrum was obtained by exciting in a Wood type discharge tube the vapor from a sample of "heavy" water which was made available to us through the courtesy of Professor G. N. Lewis. A concave grating of twenty-one feet radius of curvature and 30,000 rulings per inch was used in a stigmatic mounting. A high dispersion instrument is advantageous since, for the vibrational transitions under consideration, the main branches of these bands of the heavy isotope are completely overlapped by those of the lighter isotope. Precise wave-lengths of the band lines have been obtained and a rotational analysis has been made. It is of interest to note that the width of the spin doubling for the heavy isotope is greater than for the ordinary OH molecule. Moreover the separations in the former case do not contract as rapidly for large values of $K$ as they do in the latter case.

**15. Search for TiO Isotope Bands.** H. P. KNAUSS, H. M. STRONG AND H. L. JOHNSTON, *Ohio State University.*—A carbon arc in air, fed with powdered $TiO_3$, was used as a source of TiO bands, and a search was made for bands of a molecule containing a predicted isotope, $Ti^{46}$. (J. Am. Chem. Soc. **53**, 2866, 1931.) The (1—0) band at 4955A gave promise of showing an isotopic shift, but the expected isotopic band was not observed. The spectrograms were taken in both first and second orders of a 21-foot grating. This does not exclude the possibility of the existence of $Ti^{46}$, since it is known (King and Birge, Astrophys. J. **72**, 251, 1930; Jenkins, Proc. Amsterdam Akad. **35**, 1212, 1932) that an arc is not a favorable source for observing isotopic bands.

**16. Infrared Spectra of Acetylene Containing $H^2$.** H. M. RANDALL AND E. F. BARKER, *University of Michigan.*—About 5 cc of acetylene gas was generated from a sample of "heavy" water generously supplied by Professor

G. N. Lewis. The infrared spectra show relatively few molecules of $C_2H_2^1$, and nearly equal concentrations of $C_2H^1H^2$ and $C_2H_2^2$. The molecules with equal H atoms have only two active fundamental vibrations, designated $\nu_3$ and $\nu_4$ (Cf. Sutherland, Phys. Rev. **43**, 883, 1933). The spectrum of the unsymmetrical molecule is much richer, all of the five fundamental vibrations and their combinations being active. A sufficient number of bands may be observed to provide a complete description of the potential function, assuming it to be independent of nuclear influences, and the moments of inertia may be obtained from the rotational structure. Thus the interatomic distances and forces are uniquely determined. The alternation of line intensities in the bands of $C_2H_2^2$ provides a measure of the nuclear spin of $H^2$. The long wave (perpendicular) bands have been observed with a prism spectrometer of very good resolving power, the prism being of KBr. The positions of the zero branches are as follows:

$\nu_4$ ($C_2H_2^1$) 729 (13.7$\mu$). $\nu_4$ ($C_2H^1H^2$) 679 (14.7$\mu$).

$\nu_4$ ($C_2H_2^2$) 520 (19.2$\mu$). $\nu_5$ ($C_2H^1H^2$) 541 (18.5$\mu$).

The bands of higher frequency are being measured with the grating spectrometer.

**17. Isotope Shift in Magnesium.** R. F. BACHER AND R. A. SAWYER, *University of Michigan.*—The spectrum of Mg I was excited in a hollow cathode tube at low current density. The lines in the region 4500A to 9000A were studied with a Fabry-Perot type interferometer used in conjunction with a Hilger E1 spectrograph. λ4571 ($3s^2\ ^1S_0-3s3p\ ^3P_1$) was found to have a strong central component and a much fainter component at about +0.083 cm$^{-1}$. The diffuse series lines ($3s3p\ ^1P_1-3s$ nd $^1D_2$) were observed to show structure. The first two members λ8807 and λ5528 show two components which according to preliminary measurements have separations 0.085 cm$^{-1}$ and 0.065 cm$^{-1}$, respectively. Since for the singlet diffuse series lines it may be shown that any structure due to the presence of a nuclear moment is negligible, the structure is attributed to isotope shift. Magnesium has three isotopes 24, 25 and 26 present in the ratio 7 to 1 to 1. If the displacement is due only to a mass effect it may be shown from the work of Bartlett and Gibbons (Phys. Rev. **44**, 538, 1933) that the three isotopes are expected to give rise to three lines almost equally spaced. It is believed that if the isotopes are present in the amounts given above, the presence of the third isotopic component would have been clearly apparent in the first two members of the diffuse series.

**18. The Effect of Heat on the Intensity of Mercury Lines and Bands.** J. G. WINANS, *University of Wisconsin.*—A reduced achromatic image of a quartz tube containing mercury was projected on the slit of a quartz spectrograph by a concave aluminum mirror. A discharge was produced in the tube through external electrodes by a low voltage Tesla coil. The mercury vapor pressure was controlled by a Bunsen burner. The center of the tube was heated by a blow torch. Comparison of center and edge of the spectrum obtained showed the effect of heat. The changes in intensity of $Hg_2$ bands were the same as the well-known effects in fluorescence. In addition the continuous spectrum from 2650–2536 was shown to follow the 3300 band in intensity changes. The reversals of the 2540 band and 2536 line were diminished by heat, the intensity correspondingly increased. Several unidentified bands were completely destroyed by heat. Others appeared only at the electrodes. The weakening by heat for the mercury arc lines was a maximum at about 340°C. Measurements of the relative intensities from heated and unheated regions were made by the photographic method. With one or two exceptions all lines originating from a given excited state showed the same weakening. From a sample plate $I_{hot}/I_{cold}$ equals 4% for $2\ ^3S$, 24% for $3\ ^3S$, 15% for $4\ ^3S$, 16% for $5\ ^3D$, 7% for $6\ ^3D$, 9% for $7\ ^3D$, and 12% for $8\ ^3D$. One set of lines appeared only in the heated portion. These were tin lines. The experimental part of this work was done at Massachusetts Institute of Technology.

**19. A Physico-Chemical Theory of Excitation and Inhibition.** N. RASHEVSKY, *Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.*—In various physical theories of nerve excitation it is usually assumed that the concentration of an exciting substance at the cathode must reach a certain threshold value for the excitation to occur. The substance is naturally identified with some cation. It is, however, known that only monovalent cations excite; the bivalent inhibit, and it is their ratio which determines the excitation. Hence a more general theory must consider the variations of concentration of two substances under the action of the current—one exciting, the other inhibiting. This is done in the present paper. A good agreement with a number of experimental data is found. In particular, the excitation at the anode by closing a current becomes intelligible in a very simple manner. The theory of two substances can be extended to the central excitation and inhibition, and gives a simple explanation of the "rebound phenomenon."

**20. A Physico-Mathematical Theory of Organic Form.** N. RASHEVSKY, *Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.*—In a series of previous papers, the author has studied the thermodynamical properties of cells and cellular aggregates. From these investigations it follows that various forces, both attractive and repulsive, must exist between cells. An attempt is made in this paper to determine the general arrangement which the cells will assume under the influence of those forces in the early embryonic stages, when cells can move comparatively freely one with respect to another, and when the general shape of the future organism becomes determined. Depending on the values of various cell constants, forms are in this way obtained, which correspond in general with various forms of the animal kingdom.

**21. The Effect of Soft X-Rays on the Germination of Wheat Seeds.** HARRIS M. BENEDICT AND H. KERSTEN, *University of Cincinnati. (Introduced by Dr. Allen.)*—Wheat seeds were irradiated with the characteristic $K$ lines of copper for various lengths of time, sprouted between

blotters and the diastase activity, the reducing sugar content, the respiratory rate, and the percentage of water in the seedlings determined. Those irradiated for five seconds showed an increase in both diastase activity and sugar content. Those irradiated for a longer time showed a decided and progressive decrease in these two substances as well as a decrease in the other quantities determined.

**22. The Lethal Action of Radiant Energy on Living Cells.** FRANCIS F. HEYROTH AND JOHN R. LOOFBOUROW, *Basic Science Research Laboratory, University of Cincinnati.*—The existence of a frequency threshold for the lethal action of radiant energy on living cells is discussed. Four changes which may be induced in the cell by radiant energy are pointed out as possible mechanisms of the lethal action: (a) the destruction of cell enzymes, (b) the precipitation of colloidal materials, including proteins, (c) changes in the permeability of cell membranes, and (d) the destruction of compounds of the cell nucleus. The first possibility seems to be ruled out by evidence which shows the threshold frequencies for the destruction of enzymes to be different from that for lethal action on cells. The second and third possibilities require future investigation. The fourth is shown to be of great importance, particularly in the action of radiant energy on certain types of cells, by comparison of the ultraviolet absorption spectra of nuclear materials with curves of bactericidal power against wave-length, and by comparison of the frequency thresholds for destruction of nuclear materials with those for the bactericidal action of light.

**23. The Ultraviolet Absorption Spectra of Certain Compounds Derived from Living Cells.** FRANCIS F. HEYROTH AND JOHN R. LOOFBOUROW, *University of Cincinnati.*—The ultraviolet absorption spectra of aqueous solutions of the pyrimidines derived from cell nuclei are characterized by a band extending from 2300 to 3100A, with the maximum at approximately 2600A, and apparently the result of the fusion of three or more finer bands. By comparing the absorption of 15 related compounds, various features of the effect of molecular constitution upon absorption are made evident. Saturation of the ethylene linkages of these ring compounds results in a loss of selective absorption. In those unsaturated compounds which, as e.g., barbituric acid, exist in solution in tautomeric equilibrium, the magnitude of the 2600A absorption is greater than in those compounds of fixed structure. The introduction of a second or third double linkage into the ring lessens the magnitude of the selective absorption. The effects of substitution upon these unsaturated 6-membered heterocycles depend both upon the position and nature of the substituents. The replacement of a hydrogen atom of position 5 of uracil by the hydroxyl group produces isobarbituric acid in which the absorption is shifted 200A toward the longer wave regions. Weighting the ring shifts the absorption toward longer wave regions. When this is done in position 5, it also decreases the molecular extinction values, but if the weighting group is attached at a position other than 5, it usually increases the absorption. Highly purified vitamin-$B_1$ preparations have absorption spectra apparently identical with those here discussed.

**24. The Near Infrared Absorption Spectrum of Crystalline "Calciferol" (Vitamin D).** ELIZABETH SHELOW, *Basic Science Research Laboratory, University of Cincinnati. (Introduced by J. R. Loofbourow.)*—Crystalline "calciferol," regarded by the English workers as being pure vitamin D, was prepared by the method of Askew, *et al.* It was dissolved in purified carbon tetrachloride and its infrared absorption spectrum determined. The persistence of bands at 1.55$\mu$ and 2.05$\mu$, which are identified with the alcohol group, and the similarity of the general form of the absorption spectra curves of "calciferol" and ergosterol (its photochemical precursor), indicated the isomeric relationship of the two substances.

**25. The Detection of Vitamin A by Means of the Magneto-Optic Apparatus.** G. M. WISSINK AND JAY W. WOODROW, *Iowa State College, Ames, Iowa.*—The magneto-optic apparatus of Allison was modified somewhat so as to determine the positions of the minima. A large number of samples of materials were tested and a characteristic minimum was found for all substances investigated which contained vitamin A. This minimum was at 392. on a scale equivalent to that used by Allison. Materials which gave this minimum included cod-liver oil and Haliver oil, the juices from spinach, orange and tomato, egg yolk solution, and irradiated carotene, all of which contain vitamin A. This minimum was not obtained with strongly irradiated cod-liver oil, pure carotene, peanut oil and Wesson oil. The minimum for cod-liver oil became much less prominent after bubbling air through it.

**26. The Magneto-Optic Method of Chemical Analysis.** FRANCIS G. SLACK AND JAMES A. PEOPLES, JR., *Vanderbilt University, Nashville, Tenn.*—Attempts to reproduce the time-lag measurements and chemical analyses of Allison (Phys. Rev. **29**, 161, 1927; J.A.C.S. **52**, 3796, 1930), on an apparatus constructed and adjusted by a former staff member of Alabama Polytechnic Institute, have failed. The attempts followed a practise period in the laboratory of Dr. Allison where it is believed the observers learned to recognize "minima." Minima of light which appeared the same as those seen at Auburn were observed in our own laboratory but all objective attempts to correlate their occurrence with the position of the trolleys failed. Similar minima were observed with the coils and cells completely removed when the light was readjusted to its usual intensity. Experiments were tried in which a second spot of light was produced beside the normal spot. This light from a steady source and not affected by the magnetic fields was adjusted to the same color and intensity as the normal spot. No type of change in intensity was observed for one spot which did not appear similarly for the second spot. The intensity changes observed in our laboratory are ascribed to physiological and psychological effects.

**27. On Spinors and Their Significance in Modern Physics.** OTTO LAPORTE,* *University of Michigan.*—The significance of vector and tensor analysis in physics lies in the isotropy of space. The meaning of tensors as quantities generating representations of the 3 or 4-dimensional

rotation group is emphasized. Symmetry conditions among tensor components have as consequence the decomposition of the representation into its irreducible parts. From examples taken from various domains of physics one gains the impression that only those quantities which generate irreducible representations have physical significance. The best way to obtain irreducible representations of the rotation group is to transform spherical harmonics. An entirely new class of quantities was introduced into physics through the study of the spin of the electron. In order to prove the invariance in form of the Pauli or Dirac wave equations with spin, a new transformation law had to be assumed for the wave functions. It was found that these spin wave functions transform, not according to ordinary representations of the 3 or 4-dimensional rotation groups, but according to representations of the unitary group which was shown by Weyl to be isomorphic to the rotation group. The unitary group furnishes just twice as many representations as the ordinary rotation group; they may be regarded as two-valued representations of the rotation group. Upon a suggestion of Ehrenfest, van der Waerden developed a formalism, spinor analysis, which possesses all the advantages of tensor analysis but comprises both one- and two-valued representations. Covariance under Lorentz transformations is thus automatically restored for equations regardless of whether they contain wave functions or tensor quantities. A few applications of the spinor calculus to the Maxwell and Dirac equations are discussed.

*Invited paper.*

**28. Spinor Analysis.** OSWALD VEBLEN, *The Institute for Advanced Study, Princeton, New Jersey.*—A spinor is a physical object which has components which transform linearly, not only in response to changes of coordinates, but also in response to changes of gauge and of spin frame. The spin transformations are determined by arbitrary four-rowed matrices with complex elements. The spinors therefore have an interpretation in complex three-dimensional projective geometry. This interpretation points the way to a formal theory which can be developed without reference to the geometry which suggests it. In addition to these ideas drawn from projective geometry, the general theory of spinors contains a theory of covariant differentiation modeled on that of tensor analysis. For the application to relativity the general theory of spinors has to be specialized by introducing certain invariant spinors. These fundamental spinors extend the formal theory by providing a scheme of raising and lowering spin indices and shifting to "conjugate" indices and back again. They also provide for translating any tensor expression into spinor form. Thus introduced, the spinors are merely a new mathematical tool for the relativity theory involving no new physical assumption. The equations of Dirac appear as differential equations of a particularly simple type, and new physical considerations enter the discussion for the first time when we try to interpret these equations.

*Invited paper.*

**29. A Rotating Flashometer.** W. E. FORSYTHE AND M. A. EASLEY, *Lamp Development Laboratory, General Electric Company, Cleveland, Ohio.*—To study the time constants of the photoflash lamp a rotating photographic flashometer was designed. The cylinder carrying the photographic film was of such a diameter and as used for the most part, rotated at such a speed that 1/20 of an inch represented very accurately 1/1000 of a second. The shutter is opened and the current turned on through the lamp by using the contact mechanism of an oscillograph. A hard rubber cylinder with 6 v threads having the center v thread made of metal is used and two insulated contact brushes are dropped onto the thread of the insulated part and thus contact made when the threads on this rotating commutator move these contact brushes to the metal part and then after one rotation the two brushes pass beyond the metal portion and break the contact. The first contact brush opens the shutter in front of the particular part of the camera being used and then a short time after the second brush closes the lamp circuit. By means of cams and sliding contacts the contact brushes are returned to their neutral positions ready to be dropped on to the commutator for the next lamp.

**30. Rotation in Polyatomic Crystals.** HARALD H. NIELSEN, *Ohio State University.*—A generalization of the work of Pauling (Phys. Rev. **31**, 430, 1930) and Stern (Proc. Roy. Soc. **A130**, 551, 1931) on rotation in diatomic crystals to embrace rotation also in polyatomic crystals has been considered. The rotating configurations are treated as symmetric tops under the influence of the crystal fields. The potential energy is assumed expandable in spherical harmonics of the required symmetries. This discussion treats only cases where terms of higher order than the first in the potential energy are small and may be thought of as perturbations on the original system. The first term may be seen always to be a function only of $\theta$ in the usual Euler notation, multiplied by a parameter of magnitude $\mu$. The problem has been solved where $\mu$ is small and where $\mu$ is large, in the first case by the method of perturbations on the symmetric rotator and in the second case by the method of perturbations on the isotropic oscillator in two dimensions. For $\mu$ small the solutions are expandable in hypergeometric functions, while for $\mu$ large, they are expansions of associated Laguerre polynomials. While solutions definitely valid for intermediate values of $\mu$ have not yet been obtained, it is possible to predict how energy levels where $\mu=0$ go over to energy levels where $\mu=\infty$.

**31. The Absorption of Monochromatic X-Rays of Short Wave-Length.** T. M. HAHN, *University of Chicago. (Introduced by A. H. Compton.)*—With a Société Genevoise double crystal spectrometer and calcite crystals reflecting the K$\alpha'$ line of tungsten in the (1, 1) position, the mass absorption coefficients of paraffin, carbon, aluminum, copper, silver, tantalum, tungsten and lead were determined with a probable error of less than one percent in each case. By using the instrument with the first crystal removed as a single crystal spectrometer, the measurements were extended down to a wave-length of 0.139A. The values of the atomic absorption per electron calculated

from the above coefficients give values of the scattering coefficient $\sigma/\sigma_0$ as determined from the equation

$$\mu_a/Z = kZ^p\lambda^q + (\sigma/\sigma_0)\sigma_0$$

in good agreement with the theoretical value $1/(1+2\alpha)$.

**32. An Improved Technique for the Determination of Transmittancy by Means of the Hilger Rotating Sector-Photometer.** ANDREW DINGWALL, R. G. CROSEN AND H. T. BEANS, *Columbia University. (Introduced by W. L. Severinghaus.)*—The preliminary adjustment of the photometer and source with respect to the spectrograph is facilitated by using graduated scales with pointers, on the feet of the photometer, and on the spark stand. A series of spectrograms ranging from a sector setting of 0.00 to 0.4 is taken using distilled water in the cells. The cells are then filled with solution and solvent and the same series repeated, the variable sector settings being made on the solution. Microphotometer records are made at the desired wavelength on both halves of each spectrogram. From the results thus obtained a standard curve is constructed showing the relationship between sector setting and blackening of the plate. From this standard the transmittancy of the unknown solution may be obtained. A filter calibrated by the Bureau of Standards was used to check the method. Where sufficient observations are made agreement was found to within $\pm 0.5\%$. The measurements are at definite wave-lengths and it is not essential to have the two halves of the spectrograms in perfect adjustment. By constructing standard curves for chromium, using diphenyl carbazide to give colored solutions, the chromium content of human tumors was found to vary from less than 0.001% chromium to 0.25% of the tumor ash.

**33. On the Distribution of Ferromagnetism Among the Metals.** DAVID R. INGLIS, *Ohio State University.*—The essential condition for ferromagnetism, in Heisenberg's model, is that the wave functions of electrons in neighboring atoms overlap comparatively little near the nuclei, so as to make the negative term in the electrostatic exchange integral, the term involving attraction between nuclei and electrons, comparatively small and the exchange integral positive. Due to the angular distribution of electrons in an atom in a crystal, there is a tendency to limit ferromagnetism to crystals made of elements in the latter part of a period in the periodic table. To show this, we consider the $3d$-electrons that form an incomplete shell in the iron period. Further, we consider the case of a strong crystal field, expecting this to have some similarity to the actual intermediate case. In a field of cubic symmetry the five orientation states of a $d$-electron split into two sets of two and three (Bethe). The states of one set have the higher energy because their wave functions are small in the direction of the next nuclei. When an atom has more than enough $d$-electrons to fill the lower set of states (doubly, because of spin), only the spins of the electrons in the upper set are free. The wave functions of just these electrons are small near the next nuclei, so their exchange integrals tend to be positive, giving rise to ferromagnetism. The contrary tendency is found in the first part of a period. Slater has suggested that the right elements are apt to be theoretically ferromagnetic because the radial wave functions of their $3d$-electrons are comparatively small near the nuclei, but this tendency alone seems to be insufficient to explain ferromagnetism in iron. Numerical integration, with Slater's analytic interpolation of Hartree's radial functions, and the Fermi-Thomas atomic potential, evaluates the exchange integral as $5.1-8.1+1.8=-1.2\times10^{-12}$ erg. (1.8 is a second-order correction term). This gives paramagnetism, but, with the positive and negative terms so nearly balanced when reckoned with spherically symmetric wave functions, inclusion of the angular parts of the wave functions should easily suffice to bring about a ferromagnetic result.

**34. Possible Modifications of the Lorentz-Maxwell Field Equations.** (A preliminary report.) VIVIAN JOHNSON AND E. S. AKELEY, *Purdue University.* Instead of $f_i = F_{ij}J_j$, the classical equation for the force acting upon a charged particle in an electromagnetic field, we have assumed the equation $f_i = F_{ijk}J_jV_k$ from analogy to the gravitational equation. $F_{ijk}$ is a third order tensor whose components depend only upon the electromagnetic field. We have considered two possibilities, that the charge is invariant and that the charge transforms as the mass. We have just started to work on the first case. For a longitudinal electric field we obtained an equation $f_1 = e(F_{111}V_1^2 + 2iecF_{114}V_1 + E)$, which must approximately check $f_1 = eE$. It is possible to choose values so that the integrated curves for velocity fit within the limits of experimental error for the work we have checked, that of Perry (Phys. Rev. **36**, 904, 1930). We intend to continue our work on this case and obtain more definite results. For the second case, that in which the charge transforms, the problem is simpler and more closely analogous to the gravitational case. Our equation becomes:

$$f_i = (e/c)(c\overline{E} + \overline{V}\times\overline{H})_i + \sum_1^3 F'_{ijk}J_jV_k \quad (i, j \neq k).$$

Integrating this equation to find the path of a charged particle, we obtained results consistent with the available experiments. Experiments may be devised to give a closer check to our equation. We hope to find a set of equations corresponding to the Maxwell equations by using our results for $F_{ijk}$.