Proceedings of the American Physical Society

MEETING AT CHICAGO, DECEMBER 1 AND 2, 1944

THE 263rd meeting of the American Physical Society was held in the Museum of Science and Industry at Chicago on Friday and Saturday, the first and second of December, 1944. The registration came to one hundred and twenty-six. President Dempster assumed the functions of the Local Committee; the gratitude of the Society is due him for the arrangements and to the Museum of Science and Industry for the excellent facilities which they put at our disposal without charge.

The meeting was distinguished by a symposium of fourteen invited papers on spectroscopy. The Secretary acknowledges with thanks the aid of R. S. Mulliken, H. H. Nielsen, and O. Struve in seeking and finding speakers able in these difficult times to illustrate so many of the facets of spectroscopy, and expresses the thanks of the Society to the speakers themselves. Their names and the titles of their papers are appended to these minutes. At one of the sessions opportunity was provided for the planning of the proposed Division of Spectroscopy, and many and valuable were the opinions and the suggestions which were received.

Twenty-six contributed papers were submitted for the meetings; the abstracts are printed hereinafter.

The dinner of the Society was held at the Windermere West Hotel on Friday evening with an attendance of almost one hundred. The after-dinner speakers were P. Klopsteg, J. Franck, R. S. Mulliken, and H. H. Nielsen, Mr. Klopsteg speaking of the scientific institutions of Australia and the other three on the topic of the Division of Spectroscopy.

The Council met on Friday afternoon, and elected to Fellowship two candidates and to Membership the unprecedented number of no fewer than one hundred and eighty-two candidates; their names follow. The Council further appointed an Organizing Committee for the Division of Spectroscopy composed of K. K. Darrow, G. R. Harrison, R. S. Mulliken, and three more to be selected by those three. The Council further authorized, in response to numerous petitions, the formation of a Division of Chemical Physics in the Society, and appointed as its Organizing Committee the following: O. Beeck, F. G. Brickwedde, K. K. Darrow, J. E. Mayer, R. S. Mulliken, and O. K. Rice.

The Society has lost through death the Fellows and Members here listed: John M. Adams, H. A. Clark, Milo A. Durand, Sir Ralph Fowler, and F. W. Stallmann.

Advanced from Membership to Fellowship: M. L. Huggins.

Elected to Fellowship: W. T. Szymanowski.

Elected to Membership: A. R. Anderson, D. L. Anderson, D. E. Andrews, Jr., John Angus, D. A. Baldwin, T. F. Ball, N. H. Barbre, J. S. Barlow, Stanley Bashkin, J. R. Beatty, Richard Bellman, A. L. Bennett, Theodore Berlin, Marietta Blau, S. D. Bloom, J. C. Boonshaft, I. B. Born, John Bowman, L. L. Boyarsky, I. R. Brenholdt, W. G. Brock, C. J. Burbank, E. A. Burrill, F. X. Byrnes, Leon Camp, R. R. Carhart, C. W. Christensen, R. J. Christensen, H. H. Q. Chun, W. H. Clohessy, B. L. Cohen, R. E. Corby, N. H. Coy, W. S. Cramer, Lawrence Cranberg, J. A. Crawford, L. L. Cruise, O. R. Cruzon, J. R. Curry, H. W. Curtis, Jack Dainty, E. B. Dale, S. L. Dart, J. R. Davis, E. S. Dayhoff, W. B. Denny, P. M. Doty, W. W. Drake, L. F. Drummeter, G. E. Dewell, B. G. Eaton, C. J. Engle, L. C. Erich, W. F. Fairbank, Abraham Fineman, M. D. Fiske, E. R. Fitzgerald, Harold Fleisher, E. P. Fricke, M. M. Freundlich, J. A. Galvin, W. C. Geer, M. I. Goldberg, Oscar Goldman, J. E. Goldman, P. C. Goldmark, L. S. Goodman, Kathryn Greene, Jack Greenfield, R. M. Hadley, W. C. Hall, E. A. Hamacher, W. A. Hargreaves, S. P. Harris, C. W. Harrison, J. R. Holmes, Leroy Hughbanks, H. W. Hunter, E. C. Y. Inn, B. A. Jacobsohn, A. T. Jaques, D. G. Jelatis, R. R. Johns, H. C. Johnson, Christian Johnston, J. F. Kane, Rockwell Kent III, M. J. Klein, R. W. Koza, Arnold Kramish, G. L. Krieger, F. W. Kuether, W. A. Ladd, J. R. Laugham, Martha H. Lawson, Boris Leaf, Irvin Levin, Harold Levine, J. W. Lewis, W. F. Libby, P. J. Loatman,

M. J. Lun, W. B. Lurie, W. F. Main, E. A. Marx, J. E. Mayer, W. S. McAfee, F. T. McClure, W. J, McGonnagle, E. S. McKee, K. A. McMurtrio, Edward Melkonian, R. P. Miller, William Miller, D. J. Montgomery, J. R. Morgan, F. S. Mortimer, Nathan Most, H. R. Molton, R. E. Mueser, H. M. Muncheryan, J. D. Orndoff, Eleanor Oshry, Alfred Owyang, Murray Peshkin, R. P. Peterson, R. L. Platzman, R. V. Pound, W. W. Pratt, William Primak, Wilfrid Rall, D. H. Ransom, R. R. Rau, W. C. Redman, R. B. Reddy, G. W. Renner, R. C. Reed, F. G. Rest, D. P. Riley, H. L. Ritter, F. L. Roth, Paul Rudnick, Stanley Ruthberg, D. S. Sakon, A. L. Schawlow, R. E. Schofield, A. H. Sharbaugh, M. J. Sheehy, W. A. Sisson, V. D. Snyder, K. H. Sommermeyer, Anthony Sperduto, R. E. Stephens, D. W. Stewart, J. L. Stewart, W. G. Stroud, Mrs. George Sutton, Preston Taulbee, E. A. Taylor, R. W. Treharne, P. S. Turner, Douglas Venable, G. C. Wallick, H. F. Webster, R. A. Weiss, A. M. Weitzenhoffer, G. F. Welch, R. M. Whaley, D. H. Wilkinson, F. H. Willis, J. M. Willson, W. F. Witzig, Victor Wouk, Dorothy Wrinch, K. K. Wyckoff, Sidney Visner, T. F. Young, L. W. Zabel, M. G. Zabetakis, Henry Zatzkis, Paul Zilczer, Kurt Zuber.

KARL K. DARROW, *Secretary*

SYMPOSIUM ON SPECTROSCOPY

Address of Welcome by K. K. DARROW.

Forbidden Lines in the Laboratory: the Past and the Future. S. MROZOWSKI, *University of Chicago.*

Partial Selection Rule for Sensitized Fluorescence. J. G. WINANS, *University of Wisconsin.*

Some Features of the Spectroscopy of the Atmosphere. O. R. WULF, *University of Chicago.*

Double-Bond Absorption in the Vacuum Ultraviolet. J. R. PLATT, *Northwestern University.*

The Near Ultraviolet Absorption of Pyridine Vapor. H. SPONER, *Duke University.*

Spectroscopic Properties of Chlorophyl and Porphyrines. E. RABINOWITSCH, *Massachusetts Institute of Technology.*

Measurements of Line Width in the Infra-Red Spectra of CO_2, N_2O, and NH_3. A ADEL AND E. F. BARKER, *University of Michigan.*

The Infra-Red Absorption Spectrum of Deutero-Methyl Chloride. A. H. NIELSEN, *University of Tennessee,* AND H. H. NIELSEN, *Ohio State University.*

Degenerate Modes of Vibration and Perturbations in Polyatomic Molecules. W. H. SHAFFER, *Ohio State University.*

Absorption Spectra of the Planets. N. BOBROVNIKOFF, *Perkins Observatory.*

Progress in the Interpretation of Stellar Spectra. O. STRUVE, *Yerkes Observatory.*

The Lines of Hydrogen and Oxygen in Stellar Atmospheres. S. CHANDRASEKHAR, *Yerkes Observatory.*

Physical Problems Related to the Hydrogen and Helium Lines in Stellar Spectra. M. K. KROGDAHL, *Yerkes Observatory.*

The Absorption Laws for Gases in the Infra-Red. J. R. NIELSEN, *University of Oklahoma,* V. THORNTON AND E. BROCKDALE, *Phillips Petroleum Company.*

ABSTRACTS OF CONTRIBUTED PAPERS

E1. A Simple Counting System for Alpha-Ray Spectra. S. ROSENBLUM AND W. Y. CHANG, *Princeton University.*—When several tungsten wires are stretched parallel in front of a brass plate, it is found that each wire answers alpha-particles very well but is not affected by strong beta- or gamma-rays. Hence each wire behaves as an alpha-ray counter. The voltage of the plate relative to each wire is about negative 3000 v, when the distance of each wire from the plate is 1.5 mm, the operation taking place in air of atmospheric pressure. The conditions of reliable operation have been carefully examined and well defined. If a capacity of about 500 cm is connected across each counter, the power output of even a single power tube is high enough to operate a mechanical counter. Removal of the capacity needs an amplifier of the multivibrator type to actuate a Cenco high voltage impulse counter, but reduces the resolving time of each counter considerably. The interference between the different counters can be eliminated by erecting aluminium walls between any two adjacent wires. When the system of counters is made airtight and each wire is properly coupled to an amplifier of the above type, they can be used in a deflection chamber under the action of the magnetic field to determine the alpha-ray spectra. The counter voltage should be well stabilized. The distribution form of the Po alpha-particles determined by these counters agrees well with that obtained from the photographic line (see the other abstract by W. Y. C.).

E2. A Study of the Alpha-Ray Spectra by the Cyclotron Magnet. W. Y. CHANG, *Princeton University.*—An alpha-ray magnet spectrograph has been constructed, consisting of the Princeton cyclotron magnet and a Plexiglas deflection chamber, in which the alpha-particles can be bent into a semicircle of 75-cm maximum diameter. A balance has been devised to measure the magnetic field, which is sensitive to about 1 in 10,000. A non-linear deflection coil has been used to indicate the variation of the field and can also be employed to control directly the magnetic field by

allowing a light spot reflected from the mirror of the coil to fall on to a twin photo-cell, which then regulates the current of the generator exciting field. Three methods of detection have been used according to the different strengths of the sources. They are, namely, the ordinary photographic method, the counting method, and the method of photographic tracks. The counters, specially developed for this purpose, consist of eight tungsten wires stretched in front of a brass plate and are described in another abstract. By using the track method a source of one microcurie or smaller can be detected. The forms of the energy distribution of the Po alpha-particles have been determined, respectively, by these three methods and agree fairly well with one another. The half-width is smaller than $\frac{1}{2}$ mm, i.e., about 0.01 Mev. Hence according to the dimensions of the chamber, two lines separated by 0.01 Mev can be resolved. The intensities a few mm away from the maximum are practically zero, being quite different from the results of Roy Ringo.*

* Roy Ringo, Phys. Rev. **58**, 942 (1940).

E3. The Nuclear Excitation of Silver. MARCELLUS L. WIEDENBECK, *University of Notre Dame.*—The excitation of silver[1] has been studied in the region from the threshold for the process to 3.3 Mev. The thick target x-ray[2] excitation curve was obtained by the direct bombardment of an argon (90 percent)-ether (10 percent) counter with a silver cathode. This curve shows sharp increases in slope when the maximum energy of the x-rays reaches a new energy level. These levels indicate that the threshold for the process $Ag+\gamma \rightarrow Ag^*$ is 1.18 ± 0.03 Mev and higher activation levels were also found at 1.59, 1.95, 2.32, 2.76, and 3.13 Mev, respectively. The decay period of the metastable state was obtained from a curve extending over 6 half-lives and was found to be 40.4 ± 0.2 sec. The excitation was also obtained by direct electron bombardment of silver in the process $Ag+e_{v_1} \rightarrow Ag^*+e_{v_2}$.

[1] Alvarez, Helmholtz, and Nelson, Phys. Rev. **57**, 600 (1940).
[2] J. R. Feldmeier and G. B. Collins, Phys. Rev. **59**, 937 (1941).

E4. A "Fast" Gamma-Ray Transition. ROSALYN S. YALOW AND M. GOLDHABER, *University of Illinois.*—We have continued the investigation of the "fast" gamma-ray transition, first detected by O'Neal and Scharff-Goldhaber[1] through the presence of a "tellurium-like" satellite among the Sb x-rays emitted in the decay of Te^{121}. This decay leads to two excited states of Sb^{121}, of 0.23-Mev and 0.61-Mev energy. These energies, determined by absorption of the gamma-rays in several elements, are in good agreement with the energies found by Hales and Jordan[2] for the internal conversion electrons from Te^{121}. By studying the coincidences between the x-ray satellite and the internal conversion electrons we could show that the transition from the 0.23-Mev level to the ground state is the "fast" transition, taking place before the K-electron captured by Te^{121} is replaced. Its internal conversion coefficient is surprisingly large, >0.5, though one K-electron is missing! The mean lifetime of this state is $<2\times10^{-17}$ sec. and the corresponding half-width >30 ev. The transition from the 0.61-Mev level to the ground state is "slow," and its half-width <1 ev.

[1] R. D. O'Neal and G. Scharff-Goldhaber, Phys. Rev. **62**, 83 (1942).
[2] E. B. Hales and E. B. Jordan, Phys. Rev. **64**, 202 (1943).

E5. Attempt to Detect Nuclear Resonance Absorption of Gamma-Rays. GERTRUDE SCHARFF-GOLDHABER, M. GOLDHABER, AND ROSALYN S. YALOW, *University of Illinois.*—Since past attempts to discover nuclear resonance absorption with ThC″ gamma-rays were unsuccessful, it seemed of interest to search for resonance absorption with a gamma-ray which appeared to be particularly suited for such an experiment: the 0.23-Mev gamma-ray[1] emitted from an anomalously wide level of Sb^{121}, resulting from the decay of Te^{121}. However, we were unable to detect a nuclear absorption of this gamma-ray in Sb; if present it is <3 percent of the atomic absorption and at least a hundred times smaller than expected. A search was therefore made for a low lying excited state of Sb^{121}, but no gamma-rays above 10 kev were found. If the 0.23-Mev transition leads to the ground state of Sb^{121}, a new factor must be responsible for a shift of the gamma-ray line from the resonance position. As this "fast" gamma-ray is emitted with one K-electron missing, while it would have to be absorbed in a neutral Sb^{121} atom, it may be that the interaction of the nucleus with the "hole in the K-shell" leads to a considerable shift of the nuclear level from its "normal" position.

[1] See preceding abstract by R. S. Yalow and M. Goldhaber.

E6. Radiation Widths of Highly Excited Nuclei. M. GOLDHABER, *University of Illinois.*—Recent evidence for a wide low energy level in a medium weight nucleus (Sb^{121}) appears to be difficult to reconcile—within the framework of the compound nucleus theory—with the sharp states found for resonance capture of slow neutrons. In that theory the existence of sharp resonance states, $\sim$9 Mev above the ground state, is ascribed to the "slowness" of gamma-ray transitions, as observed for some heavy radioactive nuclei. For medium weight nuclei it may be necessary to treat the sharp "initial capture state" formally as a particular state of the combination Z^M+n rather than as one of the many states of the highly excited compound nucleus Z^{M+1}. If such a view were taken many experimental results would have to be reinterpreted. In particular, the empirical rule that sharp resonance states are predominantly found for nuclei of odd mass number, may take on new significance. For an odd M nucleus the magnetic interaction with a neutron is comparable in magnitude to the energies found for neutron resonance. For even M nuclei this interaction is usually absent. This correlation suggests that the influence of the magnetic forces on the position and width of the "initial capture state" may be important.

E7. Effect of Nuclear Electric Quadrupole Moment on the Energy Levels of a Diatomic Molecule in a Magnetic Field. BERNARD T. FELD AND WILLIS E. LAMB, *Pupin Physics Laboratories, Columbia University.*—In molecular beam experiments[1] performed on diatomic molecules of zero electronic spin, effects were observed which seemed to indi-

cate an electrical interaction between the nucleus and the rest of the molecule. It was suggested that these effects are caused by an interaction between a nuclear electrical quadrupole moment and the electric field of the molecule. We have calculated the energy level system and expected molecular beam resonance spectrum for heteronuclear molecules in which one nucleus has quadrupole moment and the other zero spin. The calculations were carried out, by the use of perturbation theory, for nuclear spins 1 through 9/2 in weak and strong magnetic fields. It is shown that the observed effects could be owing to a nuclear electric quadrupole moment. Analysis of unpublished data on resonances in LiF give for Li^7 the value $qQ=1\times10^{-21}$ erg (Q is the nuclear electric quadrupole moment; q, a quantity, depending on the distribution of charge in the molecule, which must be independently calculated). This may be compared with 0.3×10^{-21} erg for D in HD and D_2.[2]

[1] Kusch, Millman, and Rabi, Phys. Rev. **55**, 1176 (1939).
[2] Kellogg, Rabi, Ramsey, and Zacharias, Phys. Rev. **57**, 677 (1940).

E8. Neutron-Proton Scattering and the Meson Theory of Nuclear Forces. J. M. JAUCH, *Palmer Physical Laboratory, Princeton University.*—The ratio $R=\sigma(\pi)/\sigma(\pi/2)$ of the scattering cross section for 14-Mev neutrons on protons has been calculated assuming for the interaction the expression which results from the charge symmetrical meson theory with two kinds of mesons of masses κ and $\mu(\mu>\kappa)$. The previously determined values for the coupling constant and the mass ratio μ/κ[1] are used. The value of the ratio R is essentially determined by the sign of the interaction in P states. The sign is such as to give repulsive forces for the charge symmetrical theory. Numerical calculations have been carried out to an accuracy for R of $\sim1\%$ for all states of angular momentum ≤2. The effect of the higher states can be estimated with an approximation method and is found to be negligible. The result is $R=1.11$. This value is at variance with the recently determined[2] ratio of 0.52 ± 0.03 for the same energy. This discrepancy supported by other similar calculations[3] is a strong argument against any charge symmetrical meson theory.

[1] J. M. Jauch and Ning Hu, Phys. Rev. **65**, 289 (1944).
[2] E. Amaldi *et al.*, Naturwiss. **30**, 582 (1942).
[3] L. Hulthén, Arkiv f. Mat. Astronom. o. Fysik **29**, No. 33 (1943); B. Ferreti, Nuovo Cimento [XXI] **1**, 25 (1943); J. Schwinger and W. Rarita, Phys. Rev. **59**, 556 (1941).

E9. The Influence of the Recoil of Heavy Particles on the Nuclear Potential Energy. J. LEITE LOPES, *Princeton University.*—An attempt to improve the value of the quadrupole moment of the deuteron in Schwinger's mixed meson theory of nuclear forces[1] was made by taking into account the recoil of the nucleons during the emission and absorption of mesons. The interaction energy operator of the system proton-neutron was calculated by perturbation theory and represented by an integral operator in momentum space. In the pseudoscalar and vector symmetrical theories the tensor force has a singularity of the type $1/r^4$ in configuration space; in Schwinger's mixture it has a singularity of the form $1/r^3$. This singularity still remains if relativistic terms are considered, even if recoil is neglected. An evaluation of the quadrupole moment of the deuteron is therefore only possible with a cut-off procedure and this would make unimportant the relativistic and recoil contributions as well as the mixed theory itself.

[1] J. M. Jauch and Ning Hu, Phys. Rev. **65**, 289 (1944).

E10. The Adaptation of the Cauchois Spectrograph to Artificial Radioactive Sources. J. E. EDWARDS, M. L. POOL, AND F. C. BLAKE, *Ohio State University.*—To identify x-rays emitted by an artificial radioactive source it is usually necessary to distinguish x-ray wave-lengths characteristic of two neighboring elements. The feeble x-rays from such sources can be photographed with a curved crystal spectrograph. Quartz and mica crystals have been used in the transmission (Cauchois) type curved crystal spectrograph to photograph characteristic $K\alpha$ and $K\beta$ x-ray lines from radioactive sources. Quartz crystals adapted to this type of spectrograph by DuMond and Watson were found to be most efficient for the longer wave-length range of the instrument from about 0.7A to 1.9A. Mica crystals proved to be more efficient for shorter wave-lengths from about 0.36A to 1A. Spectrographs with curvatures of 8″ and 15″ were used with both mica and quartz crystals. Broad sources resulting from chemical separations may be used in this type spectrograph. Line sharpness is decreased by the broad source but the $K\alpha$ lines of two neighboring elements are easily identified. The characteristic silver x-rays associated with the decay of 6.7-hour $Cd^{107,109}$ were photographed with a mica spectrograph. The nickel x-rays associated with the decay of Cu^{64} have been identified by use of a quartz spectrograph.

E11. Radioactive Zirconium and Columbium. M. L. POOL AND J. E. EDWARDS, *Ohio State University.*—Extended observations on the decay of Zr^{93} and Cb^{93} show a genetical relationship between these two isotopes. Zr^{93} is characterized by a half-life of 67.8 days, a gamma-ray of 0.85 Mev, a strong β-ray of 0.29 Mev, and a weak one of 0.8 Mev. The ratio of the intensities is approximately 8. Cb^{93} is characterized by a half-life of 38.7 days, a gamma-ray of 0.78 Mev, and soft electrons of 0.140 Mev. The gamma-radiation from Zr^{93} rises in intensity with time after a chemical separation of the Cb^{93}; the β-radiation, however, decreases. Cb x-rays have been observed by absorption and also by photography in a curved crystal spectrograph. The ratio of the number of x-rays to that of γ-rays is approximately $\frac{1}{2}$. A new reaction Y^{89} (α, n) Cb^{92} gives Cb^{92} very strongly. The half-life is 10.1 days. A gamma-ray of 1.1 Mev is emitted. X-rays have been established by absorption measurements and are about as intense as the γ-rays. By the spectrograph these x-rays are shown to be those of Zr.

E12. Progress in the Determination of the Number of Artificially Produced Radioactive Atoms. J. D. KURBATOV AND M. H. KURBATOV, *Ohio State University.*—A determination of the number of atoms obtained by some means of activation requires the development of a method for

quantities less than 10^{-8} gram. A possible solution of this problem has been tested using the adsorption phenomena of divalent ions on different hydrous oxides. The method consists in obtaining adsorption isotherms for known minute quantities of divalent ions under conditions such that the exponent in the activated adsorption equation is considerably below unity; then an unknown initial quantity can be found from the adsorption ratio. The adsorption constants have been evaluated for radium since a technique is known for its accurate determination in quantities of less than 10^{-8} gram. The investigations have been extended to obtain the adsorption isotherms of minute quantities of barium and strontium using the radioactive tracers Ba^{133} and Sr^{89}. However, it has been found experimentally that with conventional quantities of adsorbent, that is more than 10 mg, the exponent in the adsorption equation became unity for quantities of Ra, Ba, and Sr below 10^{-6} gram and the fraction of ions adsorbed was constant. Thus, to evaluate minute quantities of Ra, Ba, and Sr it appears necessary to use the adsorbents, ferric hydrous oxide or manganic oxide (IV), in quantities less than 10^{-4} g.

F1. The Hardy Coefficient for Instrument Oil. S. BLOOMENTHAL, *Automatic Electric Company.*—The method of inclination, ascribed to W. B. Hardy, appears to be the most straightforward of many ways for comparing lubricants. The coefficient of static friction μ for glass on glass was measured by the inclination method on an apparatus which functions automatically. A number of instrument oils, suggested as possible substitutes for genuine porpoise jaw oil, which is unobtainable at the present time, were tried. Addition of only 1 percent glyceryl monoricinoleate to a pure lubricating fluid caused a decrease in μ from 0.26 to 0.13 because of boundary layer formation. The disclosure on last August 15 by G. E. Barker of the composition of a non-spreading synthetic instrument oil, made available to the public by the Elgin National Watch Company, is noteworthy in this connection. This oil contains a stable aralkyl ether with an aliphatic chain of at least five carbon atoms and a benzene nucleus connected to the ether oxygen atom. μ for M56A Elgin Watch Oil was found to be 0.17 when 100 grams total load is used. This compares with $\mu=0.26$ for a light oil derived entirely from petroleum.

F2. Equations of State and Phase Changes in Films on Liquids and Solids. WILLIAM D. HARKINS AND GEORGE JURA, *University of Chicago and Universal Oil Products Company.*—Oil films on water seem not to be stable unless they are monomolecular but adsorbed films on solids may be monomolecular but more generally are multimolecular in the sense that they may attain thicknesses *equivalent* to from five to ten or even more molecular layers. Monolayers on water exhibit three condensed and three non-condensed phases, or six in all. The relation between film pressure (π) and molecular area (σ) is linear ($\pi=b-a\sigma$, equivalent to $\log p/p_0=B-A/v^2$) for any condensed phase, but for liquid intermediate or expanded films or for gaseous films the equations are more complicated. At sufficiently low temperatures films adsorbed on solids are often condensed at the higher vapor pressures, but gaseous at very low pressures. At higher corresponding temperatures either liquid expanded or liquid intermediate phases may occur. Phase changes which are first order in three dimensions usually become second order in two dimensions, though in the latter the condensation of a vapor may be either first or second order.

F3. The Effect of the Subphase upon the Properties of Physically Adsorbed Films. GEORGE JURA AND WILLIAM D. HARKINS, *University of Chicago and Universal Oil Products Company.*—Almost all theoretical approaches to the problem of the physical adsorption of gases on the surfaces of solids have assumed a negligible interaction between the solid and the film. Recent careful experimental work shows that this is incorrect. A few effects which show this are listed. (1) When the effective cross-sectional area of nitrogen on 100 solids is calculated it is found that three maxima are obtained at 14.0, 15.2, and 16.2A². It is found that in some cases at least there is a relation between the area exhibited and the composition or the crystal structure of the solid. (2) The film of propyl alcohol on barium sulphate is monomolecular, but polymolecular on anatase (titanium dioxide) and quartz. The thickness of the film is related to the lattice constants of the solids. (3) The transition from a gaseous to an intermediate film is first order at 1000A² per molecule for one solid while for another of the same crystal structure and particle size, the transition is found to be second order at 50A² per molecule.

F4. Molecular Weights of Proteins as Determined by Light Scattering. W. HELLER AND H. B. KLEVENS, *Chemistry Department, University of Chicago.*—Molecular weights can be determined by light scattering by using either the theoretical principle of Mie[1]—light scattering is considered as an effect of material units—or the principle of Einstein[2]—light scattering is considered as an effect of fluctuations in concentration. Debye's recent equation based on the latter principle[3] could be verified on suspensions of polymers and on protein solutions by using a spectrophotometric-interferometric method (18-cm layer). The symmetry of radiation was tested by means of Tyndall spectra.[4] Aqueous solutions of egg albumin gave, for example, the following data (p_H: 4.65–4.68):

Immediately after preparation (4°C)	47,000±1500
24 hours later (4°C)	64,000±2000
72 hours later (4°C)	81,000±3000.

The ultracentrifugal and osmotic pressure data (literature) are 40,500–44,000 and 42,000–45,100, respectively. Similar agreement between light scattering and ultracentrifugal data was found for serum-albumin. It is apparent that the method is extremely sensitive towards aggregation (denaturation) of proteins. Symmetrically radiating polymer suspensions gave an agreement within 10 percent with ultramicroscopic data of H. Oppenheimer.

[1] Mie, Ann. d. Physik **25**, 377 (1908).
[2] A. Einstein, Ann. d. Physik **33**, 1275 (1910).
[3] P. Debye, J. App. Phys. **15**, 338 (1944).
[4] W. Heller and E. Vassy, Phys. Rev. **63**, 65 (1943).

F5. Diode Modulation. G. H. FETT AND A. D. BAILEY, *Department of Electrical Engineering, University of Illinois.*—It is shown analytically that a perfect diode in series with a pure resistance load is capable of producing frequency components required in amplitude modulation either when the effect of the diode is considered as a series of pulses analysed by means of Fourier series, or when the diode is considered as a synchronous commutator. The end result is identical in either case. The experimental verification of the mathematical result is given for a pure resistance load, and it is shown that if account is taken of the resistance of the diode the agreement is good. It is also shown that the maximum modulated output takes place when the load resistance is about equal to the diode resistance. The problem of the parallel resonant circuit load is discussed, and it is shown that the diode under these conditions behaves like a variable effective resistance, the magnitude of which is controlled by the magnitude and sign of the modulating signal in series with the carrier. When the Q of the load is high, complete modulation is obtained with about half of the signal voltage required with a resistance load.

F6. The Multiple Production of Mesotrons in Paraffin at High Altitudes. W. G. STROUD AND MARCEL SCHEIN, *University of Chicago.*—By modifications of a technique used in previous balloon flights,[1] more information regarding the production of mesotrons in the stratosphere has been obtained. The number of mesotron showers, involving three or more particles, under three and six cm of paraffin, have been measured and compared with the curve for the mesotron intensity as a function of atmospheric pressure. The results show that at altitudes between 13 and 16.5 km 10 percent of the recorded penetrating particles are accompanied by mesotron showers of at least three particles below the paraffin. The angular divergence of these showers is between 9 and 20 degrees. Showers of penetrating particles were also detected below 6 cm of paraffin plus an additional 8 cm of lead. It was found that in the above-mentioned altitude range more than 20 percent of the penetrating particles are accompanied by mesotron showers below the paraffin plus lead. Many of these showers were in coincidence with those below the paraffin only which demonstrates that a large fraction of the particles generated in the paraffin are able to penetrate 8 cm of lead.

[1] M. Schein, W. P. Jesse, and E. O. Wollan, Phys. Rev. **59**, 615 (1941); M. Schein, M. Iona, Jr., and J. Tabin, Phys. Rev. **64**, 253 (1943).

F7. Investigation of Bursts Observed in Two Thin-Walled Ionization Chambers. KONRAD L. KINGSHILL (introduced by Marcel Schein) AND LLOYD G. LEWIS, *University of Chicago.*—Coincidences in time between bursts of ionization occurring in each of two thin-walled ionization chambers were measured at Chicago. The apparatus used here was the same as that used at Echo Lake, Colorado (elevation 3100 meters). The cumulative size-frequency distribution curve for all bursts recorded in each chamber is essentially in agreement with the data obtained by previous investigators. The altitude comparison was made with the data obtained at Echo Lake. The ratio of burst rates found at Echo Lake and at Chicago for bursts caused by 50 or more cosmic-ray particles was approximately 10:1. This is in general agreement with Geiger-Mueller counter coincidence measurements. For bursts caused by more than 150 particles the corresponding ratio is 200:1. Since burst coincidence rates measured in two ionization chambers showed a similar altitude effect when the chambers were separated by a distance of 1 meter, it can be assumed that both the large single bursts and the coincidence bursts are caused by the same type of atmospheric shower. The rate of occurrence of burst coincidences was found to be very small in comparison to the rate for bursts occuring in a single chamber. This demonstrates that most of the atmospheric showers must have a very small lateral width of their region of high particle density. Provided that the cascade theory of showers is valid for electron energies higher than 10^{13} ev, it can be concluded that sea-level showers exhibiting such narrow high density regions (of 1-meter extension) cannot originate from primary electrons.

F8. Investigation of Extensive Atmospheric Showers in the Stratosphere. P. AUGER, A. ROGOZINSKI, AND MARCEL SCHEIN, *University of Chicago.*—To measure the frequency of extensive atmospheric showers at high altitudes a counter apparatus of large linear dimensions (10 meter) was constructed and sent to the stratosphere. The essential part of the apparatus consisted of six large Geiger-Mueller counters (area 125 cm²) arranged in a horizontal plane. The maximum separation between counters was 7 meters. Another set of 4 small counters (area 15 cm²), separated by 50-cm distance, was placed in the middle between the large counters. Six different combinations of threefold coincidences were registered simultaneously. The coincidence circuits had a resolving time of 2×10^{-6} second and therefore chance coincidences could be neglected. The results show that from sea level to an altitude of 15 km the shower rate increases by a factor of 4 for showers of 2-m average spread and by a factor of 30 for showers of 50-cm average spread. It was also found that in the high altitude no coincidences occurred between the set of small counters and any of the large ones which was frequently the case at sea level. This demonstrates that at 15-km altitude the air showers consist of a very narrow and dense bundle of particles. According to the cascade theory these showers must be in the initial stages of their development.

G1. A Method for Obtaining Depolarization Factors of Raman Lines. FORREST F. CLEVELAND, *Illinois Institute of Technology.*—In many cases it is possible to determine the structure of a molecule by interpreting the Raman and infra-red spectra with the aid of the group theory selection rules for two or more assumed structures. To do this, one must know how many lines are depolarized (depolarization factor $=\rho=6/7$) and how many lines are polarized ($\rho<6/7$). This requires very precise values of those depolarization factors whose values are near 6/7 in order to decide whether these lines are polarized or depolarized. Consequently, the method previously used has been revised with a view toward more precise results. A 90° split-field, Polaroid disk

is placed in contact with the window of the Raman tube, with the dividing line horizontal, and is sharply focused on the slit of the spectrograph. A single exposure is made. Calibration marks corresponding to known relative intensities are placed upon each plate by use of a ground-glass screen and a small incandescent lamp. One-minute exposures are used for the calibration marks and correction for failure of the reciprocity law is made by use of information obtained in preliminary experiments. Intensities are obtained by use of a Gaertner microdensitometer. Results thus obtained for CCl_4 will be compared with data obtained by Reitz.

G2. Raman Spectrum of Dimethyldiacetylene. ARNOLD G. MEISTER AND FORREST F. CLEVELAND, *Illinois Institute of Technology.*—Raman frequencies, relative intensities, and depolarization factors were obtained for dimethyldiacetylene. The relative intensities and the depolarization factors were obtained with the use of a Gaertner microdensitometer. A tentative assignment was made of all the observed Raman frequencies assuming that the molecule has the symmetry D_{3h}'. The chain frequencies were established by comparison with Wu and Shen's[1] analysis of the vibrational spectrum of diacetylene. Crawford's[2] analysis of the dimethylacetylene Raman spectrum was used in determining the methyl group frequencies. Three cases of Fermi resonance were observed, but there were also two cases where only a single line was observed in spite of the fact that the frequency and symmetry conditions for resonance were satisfied. The carbon-carbon triple-bond frequency which appears at 2183 cm^{-1} for diacetylene is shifted considerably, appearing at 2264 cm^{-1} for dimethyldiacetylene.

[1] T. Y. Wu, *Vibrational Spectra and Structure of Polyatomic Molecules* (National University of Peking, Kunming, China, 1939), p. 259.
[2] B. L. Crawford, Jr., J. Chem. Phys. **7**, 555 (1939).

G3. A Difficulty in Analysis of Some ClO_2 Bands. J. B. COON, *Department of Physics, Indiana University.*—The rotational structure of the violet absorption spectrum of ClO_2 cannot be explained in terms of energy levels of a rigid, approximately symmetrical top. If these levels are used, an additional term linear in K is needed. The spectrum can, however, be explained using the levels*

$$F=\frac{B+C}{2}[L(L+1)-K^2]+Ak^2.$$

Replacing k by K gives levels of a rigid, approximately symmetrical top. Here the symbol A refers to the quasi-symmetry axis of the approximately prolate top model. L, K, and k refer, respectively, to the total angular momentum excluding spin, component of this along the axis, and the component of the angular momentum of molecular rotation along the axis. Though k is not integral, it is assumed that any change in k is integral. $\nu=F'-F''(\Delta L=\Delta K=\Delta k=0)$ was fitted to the observed Qq branches. Within a given band it was found that $2\Delta A$ is constant. Using constants of the spectrum, k was calculated and $k-K$ was found to be a positive constant within a given band, 1.68 for (000←000) band.

* H. Sponer and E. Teller, Rev. Mod. Phys. **13**, 75 (1941).

G4. New Evidence for the Magnetic Current. FELIX EHRENHAFT, *New York, New York.*—In a homogeneous electric field through which flows a constant electric current, a single magnetic pole circulates. If the single magnetic pole also bears an electric charge, this movement is a spiral (electrodynamics). Observation discloses that in a constant vertical homogeneous magnetic field, single test bodies move in a spiral path in gases as well as in liquids with velocities that are measurable in the dark field of the microscope. These velocities are of the order of 10^{10}–10^{12} smaller than the velocity of light, showing that they bear electric as well as magnetic charges (magnetodynamics). If they bear a magnetic charge alone, their movement is polar.* New experiments will be demonstrated in gases where the permanent magnet is used. Covering the vertical magnetodes of the electromagnet with glass caps, the opposing faces of which are fitted with platinum surfaces, one obtains in the space between the caps vertical homogeneous fields where the electric and magnetic force lines are parallel to one another. When the two fields are in action simultaneously a circulation of the liquid can be observed with the microscope and a twisting of the stream of electrically evolved gas bubbles rising from the lower platinum surface occurs. The direction of twist as well as the direction of circulation follows the rule of Ampere. New facts about magnetolytic processes will be given.

* F. Ehrenhaft, Nature **154**, 426 (1944).

G5. Magnetic Saturation of Microscopic Particles. BROTHER GABRIEL KANE, *Manhattan College.*—Microscopic particles of nickel have been observed to move in the direction of the lines of force in a vertical homogeneous magnetic field when illuminated by a strong beam of light.[1] The velocity of the particles is a function of the field strength. The direction of motion reverses with a reversal of the magnetic field. For low field intensities, the velocity is directly proportional to the field strength. For higher intensities, the velocity either approaches a limiting value or reaches a maximum with increasing field and then decreases. Increase of field strength may even reverse the sense of direction of the motion. All of these motions can be accounted for if it is assumed that the force acting on a particle is qH, where q is the magnetic charge and H the effective field strength. The value of H is determined from the equation $H=H'-NI$ used for the macroscopic state. H' is the applied field, N the demagnetizing factor, and I the intensity of magnetization. N is a function of the field strength.[2]

[1] F. Ehrenhaft, Ann. de physique **13**, 151 (1940); Phys. Rev. **57**, 562 (1940); J. Frank. Inst. **230**, 381 (1940).
[2] Shuddemagen, Phys. Rev. **31**, 165 (1910).

G6. The Rotation of Electrolytes under the Influence of a Magnetic Field. CHARLES B. REYNOLDS, *Federal Communications Commission, New York, New York.*—The rotation of solutions of $CuSO_4$, H_2SO_4, and $FeCl_3$ under the

influence of a magnetic field has been reported.[1] The author has repeated this experiment using many additional electrolytes of ferro-, para-, and diamagnetic materials, organic and inorganic in nature. The experiments performed to determine whether or not the motions could be explained by the Lorentz force, $F=q(v\times H/c)$, or in terms of some other well-known theory, will be described. It will be shown that the rotations are not explained by the Lorentz force, concentration gradient, or pure electrochemical action. A satisfactory explanation can be shown if the existence of a magnetic current is assumed.

[1] F. Ehrenhaft, Bull. Am. Phys. Soc. 19, 3, 10 (June 23, 1944).

Proceedings of the American Physical Society

MEETING AT PASADENA, CALIFORNIA, DECEMBER 16, 1944

THE 264th meeting of the American Physical Society was held at the California Institute of Technology, Pasadena, California, on Saturday, December 16, 1944. The attendance varied from 90 to 125, the largest at any Pacific Coast meeting since the start of the war. Thus the trend of increasing numbers, started a year ago, continues in evidence. The audience was, however, almost exclusively from Southern California. Nearly 50 members and guests had luncheon together in Dabney Hall, the shift from the Athenaeum having been forced by war conditions.

The morning session opened at 9:30 A.M. and adjourned at 12:30 P.M. It was devoted to three invited papers, *viz:*

The Conceptual Content of the Quantum Theory, PAUL S. EPSTEIN, *California Institute of Technology.*

The Logical Foundations of Quantum Mechanics, HANS REICHENBACH, *University of California at Los Angeles.*

The 1944 Values of the Physical Constants of the Quantum Theory, RAYMOND T. BIRGE, *University of California.*

The afternoon session opened at 2 P.M. and adjourned at 4:30 P.M. Abstracts follow of the twelve contributed papers presented at that session. Number 10 was read by title.

R. T. BIRGE
Local Secretary for the Pacific Coast

ABSTRACTS OF CONTRIBUTED PAPERS

1. A Possible Cause of the Variability with Time of the Incoming Cosmic Rays at High Latitudes. ROBERT A. MILLIKAN, H. VICTOR NEHER, AND WILLIAM H. PICKERING, *California Institute of Technology.*—(1) We present new evidence that a new band of rays which we interpret as helium annihilation rays comes in vertically at about the predicted latitude. (2) We present a discussion of the possible composite character of the so-called silicon annihilation band and of the so-called oxygen annihilation band. (3) We bring forward an explanation of a possible cause of our observed variability in the incoming cosmic rays at high latitudes. (4) We make a new and more accurate determination of the value of the field sensitive and the non-field sensitive components of the incoming cosmic rays.

2. Some Recent Investigations on Hydrodynamic Stability. C. C. LIN, *Guggenheim Laboratory, California Institute of Technology* (Introduced by R. A. Millikan).—Recent investigations of the stability of two-dimensional parallel flows bring out that the physical mechanism underlying hydrodynamic stability in an incompressible fluid can be understood in terms of vorticity transfer.[1] In particular, the condition of vanishing curvature of the velocity profile in Rayleigh's criterion is identified with an extremum of vorticity distribution, and the physical picture describing the associated instability has been worked out in some detail. Conditions similar to Rayleigh's criterion have now been obtained for curved and axially symmetrical flows, and these can also be interpreted in a similar manner. Investigations of the stability in a compressible fluid are being carried out with the collaboration of L. Lees.

[1] Proc. Nat. Acad. Sci. (October, 1944).

3. Pressure Flow of a Turbulent Fluid between Two Parallel Infinite Planes. P. Y. CHOU, *Guggenheim Laboratory, California Institute of Technology* (Introduced by R. A. Millikan).—This investigation is based upon a general theory developed by the author: "On velocity correlations and the solutions of the equations of turbulent fluctuation."[1] Two solutions of the problem are given. The first is the