Proceedings of the American Physical Society

MINUTES OF THE SALT LAKE CITY MEETING, JUNE 15, 1933

THE 185th meeting of the American Physical Society was held in affiliation with the Pacific Division of the American Association for the Advancement of Science in Room 313, Physical Science Building, University of Utah, Salt Lake City, Utah, on Friday, June 15, 1933, with Professor Orin Tugman presiding and twenty members of the American Physical Society in attendance.

The Society voted to hold the 188th meeting of the American Physical Society on the Pacific Coast on Friday, December 15, and, if necessary, Saturday, December 16, 1933, at Stanford University, California. The Physical Society was entertained at luncheon on Friday in the Union building at the University of Utah and an informal dinner, attended by some ten members, was held in the evening. The program of papers in abstract form follows.

LEONARD B. LOEB, *Local Secretary for the Pacific Coast*

ABSTRACTS

1. High Terms in the Spectra N^{v} and O^{v}. WILLOUGHBY M. CADY, *California Institute of Technology.*—Certain plates exposed a year ago in the vacuum spectrograph previously described (Phys. Rev. **43**, 322, 1933) have now been analyzed. The source was a condensed discharge through air at a pressure of about 0.5 mm Hg, taking place in a quartz tube 9 cm long and of 2 mm bore. About fifty discharges of the 0.33μF condenser at about 25,000 volts sufficed for a good exposure between 105 and 350A, showing known lines of N^{iv}, N^{v}, O^{iv}, O^{v}, and O^{vi}. New lines have been identified, which fix thirteen new levels in N^{v}, and thirty-six in O^{v}. Thus most of the bright lines on the plates have been identified; e.g., of the hundred lines with an estimated intensity of 3 or more, only about one quarter remain unassigned.

2. Hyperfine Structure and Nuclear Moment of Columbium. NORMAN S. GRACE (Commonwealth Fellow) and STANLEY S. BALLARD, *University of California at Berkeley. (Introduced by Leonard B. Loeb.)*—King (Astrophys. J. **73**, 13, 1931) observed a wide hyperfine structure in the arc spectrum of columbium. He found that many lines were broad enough to contain six components and some possibly eight. A very rich columbium I spectrum was excited in a Schüler tube cooled in liquid air and photographed with a glass spectrograph crossed with Fabry-Perot etalons. Although it has not yet been possible to completely resolve the lines possessing most complex structure we have found λλλ4059, 4675 and 5344 to possess at least eight components and λ4672 eight and probably more components. From intensities and intervals it is concluded that $I \geqslant 7/2$ for columbium.

3. Hyperfine Structure of Molybdenum. NORMAN S. GRACE (Commonwealth Fellow) and KENNETH R. MORE, *University of California at Berkeley.*—Mo I lines were excited in a liquid air cooled Schüler tube and photographed with a glass spectrograph and silvered Fabry-Perot etalons. λλλ5507, 5533, 5571 ($4d^5\,5s\,{}^5S_2-4d^5\,5p\,{}^5P_{123}$) and λλλ5792, 5858, 5888 ($4d^4\,5s^2\,{}^5D_{2,\,3}-4d^5\,5p\,{}^5P_{1,\,2,\,3}$) with invar etalon separators, up to 20 mm showed no structure. With separators which were varied from 32 to 58 mm faint structure was observed in all of these lines. Aston reports for the isotopes of molybdenum, mass 92, 14.2 percent, 94, 10.2 percent, 95, 15.5 percent, 96, 17.8 percent, 97, 9.6 percent, 98, 23.0 percent, and 100, 9.8 percent. Thus one might expect hyperfine structure due to the isotopes of odd atomic weight by virtue of their mechanical and magnetic moments and also structure due to an isotope shift. The separations and intensities of the structure observed indicate that for at least one of the odd isotopes $I \geqslant \frac{1}{2}$, that the nuclear g-factors for both odd isotopes are small and that the isotope shift is extremely small. The very small magnitude of isotope shift observed in molybdenum in contrast with that observed in the spectroscopic homologue tungsten is of interest in connection with the theory of isotope shifts.

4. Hyperfine Structure and Nuclear Spin of Lanthanum. H. E. WHITE and O. E. ANDERSON, *University of California*

at Berkeley.—The arc spectrum of lanthanum was excited in a Schüler tube cooled in liquid air. Fabry and Perot etalons were used to investigate the hyperfine structure of line 6249.9A, which is the transition $^4G_{11/2}-{}^4F_{9/2}$. A 9 mm separator showed that this line had eight components. One of the authors, H. E. White (Phys. Rev. **34**, 1404 (1929)), from the work of Meggers and Burns suggested that the nuclear spin of lanthanum was at least 5/2. This present work indicates that the spin is 7/2.

5. Remarks on the "Lines" of Diffraction Gratings. HAROLD D. BABCOCK, *Mount Wilson Observatory.*—In most text books the elementary theory of the diffraction grating is given only for the case in which transparent or highly reflecting strips of an optical surface are separated by opaque, nonreflecting spaces of approximately the same width. Modern gratings ruled on metallic surfaces are distinctly different from this case in that the original polished surface of the metal is entirely destroyed and the burnished walls of the grooves formed by the ruling tool reflect the light largely in certain chosen directions. By means of photomicrographs and diagrams these types of gratings are illustrated. For a metal grating the effect is shown of varying the relation between the spacing of the grooves and their depth. The design of the shape of the groove to produce a desired concentration of diffracted light is described. Typical ruling diamonds are exhibited. Attention is called to Michelson's theory of the modern type of grating.

6. Measurement of the Townsend Coefficients for Ionization by Collision. FREDERICK H. SANDERS, *University of California at Berkeley. (Introduced by Leonard B. Loeb.)*—The photoelectric current between parallel plates in dry air was measured as a function of plate distance for constant field strength and pressure over plate distances ranging from 1 to 7 cm and at a pressure of 1 mm of mercury. The simple Townsend relation $i=i_0e^{\alpha d}$ was found to give excellent agreement for values of X/p from 40 to 110. The values of α/p plotted as a function of X/p lie on a smooth curve which does not fit either the equation $\alpha/p=Ce^{-CV_0p/X}$ suggested by Townsend nor the empirical relation $\alpha/p=Ae^{b(X/p)}$ found by the writer to hold for values of X/p from 20 to 36.5. Voltages and plate distances were measured to within 1/10 of 1 percent and pressures to 1/2 of 1 percent or better. For X/p's from 120 to 160 the current was found to increase with plate distance more rapidly than the simple exponential relation would indicate, as was observed by Townsend for plate distances less than 1 cm at much greater X/p's. The early appearance of this deviation may be ascribed to the greater sensitivity given by larger plate distances. Both of the relations suggested by Townsend:

$$i=i_0\frac{(\alpha-\beta)e^{(\alpha-\beta)d}}{\alpha-\beta e^{(\alpha-\beta)d}} \quad (1)$$

which was derived on the assumption that each positive ion produces β new pairs of ions by collision in 1 cm of path, and

$$i=i_0\frac{e^{\alpha d}}{1-\gamma(e^{\alpha d}-1)} \quad (2)$$

which assumes γ new electrons liberated by each positive ion which strikes the cathode, fit the experimental curves equally well. The values of β/p were found to increase steadily with X/p as found by Townsend for higher X/p's. The coefficient γ, which is approximately equal to β/α, was found to increase only very slightly over this small range of X/p's.

7. Uranium and Thorium Content of Rocks Determined from their Surface Radiation. ROBLEY D. EVANS, *National Research Fellow. University of California at Berkeley.*—Following the initial work of Graven (Akad. Wiss. Wien, 2A, **139**, 181 (1930), *ibid.* **141**, 515 (1932)), an attempt was made to measure the sum of the uranium and thorium content of rocks by means of alpha- and beta-rays emitted from the surface of the rocks. These were detected with a Workman-DeVore quartz fiber electroscope having two 75 cm² windows of 0.8μ aluminum, hence a stopping power of only *ca.* 1.3 mm of air. That *ca.* 90 percent of the ionization is due to alpha-rays, *ca.* 10 percent to beta-rays, and none to gamma-rays was demonstrated by using aluminum and lead screens with the ionization chamber, as well as by oscilloscope observations employing a sensitive linear amplifier. The technique becomes quantitative by employing smooth semi-polished surfaces of rocks, in which a definite amount of surface is exposed. Absorption measurements in both pure and poisoned gypsum were made using artificial rocks composed of gypsum poisoned with minute quantities of thorium and uranium and their decay products. These measurements confirm the experiments of Graven for the uranium series but definitely disagree with his thorium measurements. The existence of intense secondaries from gypsum under the action of feeble γ-radiation, and the dependence of the method on γ-radiation, as reported by Graven, were not confirmed. Although a slightly different absorption ratio for the Th and U series in gypsum was observed, the difference was *not sufficiently large* to provide a practical basis for evaluating both the thorium and uranium content of ordinary rocks. The unscreened radiation from rock surfaces is, however, capable of indicating the sum of the uranium and thorium content of a specimen, and if either can be measured by an independent experiment, Evans, R. S. I. **4**, 223 (1933), then the other may be obtained.

8. The Heat of Dissociation of Bi_2 Determined by the Method of Molecular Beams. CHENG CHUAN KO, *University of California at Berkeley. (Introduced by Leonard B. Loeb.)*—With the velocity analyzer of Zartman with improved technique the combined velocity spectrum of Bi atoms and Bi_2 molecules was obtained at 827°, 851°, 875°, 899°, 922°, 947°C. From the spectral distribution curves the relative abundance of Bi atoms and Bi_2 molecules in the beams at the above temperatures could be determined to 1 percent. The vapor pressure curve of Bi was obtained experimentally by the method of effusion and the values so obtained were combined with the degree of dissociation of the vapor as computed from the beams to give the heat of dissociation. The heat of dissociation was computed from the data, assuming the pressure to be

given by the temperature of the crucible T_c. In calculating the heat of dissociation, the equilibrium temperature was taken as that of the slit chamber T_s which was 24° above T_c. The results of these calculations plotted with $\log_{10} K_p$ as ordinates against $1/T_s$ give a straight line whose slope yields the value of the heat of dissociation as $77{,}100 \pm 1200$ calories. The curves for the distribution of velocities observed and computed on the assumption of a given ratio of Bi atoms to Bi_2 molecules in the beam were compared to test the law of distribution of velocities. On the high velocity side agreement was obtained within the limits of experimental accuracy. On the low velocity side deviations were noted of such a sort that the observed curves below a velocity of $\alpha/2$ (i.e., $\frac{1}{2}$ the most probable) gave *more* molecules than the theory demanded. Other deviations were observed on some of the runs taken with a fourth slit in which a *deficiency* of molecules was observed between velocities of 0.75α and $\alpha/2$. This deviation was probably due to a warping of the image slit carriage due to heat. The nature of the variation at velocities less than $\alpha/2$ indicated the presence of molecules of greater mass than Bi_2 in the beam and at the lower temperatures a distinct peak corresponding to Bi_3 molecules was observed which were present to less than 2 percent.

9. Charging Devices for Portable Ionization Electroscopes. E. J. WORKMAN,* *Reed College.*—The increasing use of portable ionization electroscopes for radiation measurement has created a demand for lighter and more compact sources of potential for charging than is obtainable by the use of commercial dry batteries. One method of meeting this need depends upon the use of a small variable air condenser and a dry battery of a few volts. A well-insulated (hard rubber or better) variable radio condenser of approximately 900 cm capacity is charged to a potential of 22 volts by a small C-battery. A turn of the dial toward smaller capacity disconnects the battery and connects the condenser to the deflecting element of the electroscope when the potential has been raised the desired amount. All switching is controlled by a mechanism on the dial shaft and with a given arrangement of connections the electroscope can repeatedly and accurately be charged to the desired potential. In cases where pocket size equipment is desirable a 1.4 volt flash light battery may be used with a small, say 4 cm in diameter, parallel plate condenser. A thin sheet of mica serves for the dielectric at the position of maximum capacity and the separation of the plates and switching action is accomplished by pressing the charging "button" of the electroscope into contact with the charging device. Crude apparatus of this type has been found satisfactory for charging a small deflecting element to potentials around 300 volts, but is less reliable because of the "creeping" action on the dielectric.

10. The Study of a Powerful Source of Positive Alkali Ions. PAUL KECK and LEONARD B. LOEB, *University of California at Berkeley.*—A positive alkali ion source was developed in which an atomic beam of alkali atoms was projected against a platinum strip filament at 1000°C in a high vacuum. By accelerating the resulting positive ions in an electrical field positive ion currents of the order of 2×10^{-4} amperes/cm² could be obtained with the source of potassium at 330°C and a potential of 340 volts. Over 60 percent of the atoms in this beam had an energy distribution of less than 25 volts. This device can be further developed and could be used for the study of light emission by positive ion impact at low voltages, for an effective separation of the Li isotopes when coupled with a positive-ray analyzer at the rate of 0.13 mg Li per day, and as a 3 electrode tube for the production of electrical oscillations.

11. Azimuthal Investigation of Cosmic Radiation. S. A. KORFF, *National Research Fellow, Mt. Wilson Observatory.*—A study is being made of the distribution of cosmic radiation east and west of the magnetic meridian, employing Gieger-Müller counters connected to record coincidental discharges. Preliminary results indicate that at the Mt. Wilson laboratories, Pasadena (elev. 885 ft.), counting rates at equal altitude angles east and west are equal within the experimental errors of about 4 percent. This result is in agreement with the observations of Millikan and Neher, and with the calculations of Lemaitre and Epstein. The experiments are being continued at higher elevations.

12. The *K* Absorption Discontinuities of the Elements Zirconium to Iodine. P. A. ROSS, *Stanford University.*—A study of the K discontinuity has been made with a double crystal spectrometer. All of the elements studied except cadmium show faint fine structure on the high frequency side of the discontinuity, the fine structure appearing as narrow bands of slightly decreased absorption lying within a range of from 20 volts to 120 volts of the main absorption edge. The width of the discontinuity in volts has been measured and shows a somewhat erratic increase with increasing atomic number. Defining the wave-length of the discontinuity as that corresponding to the point of inflection of the main absorption curve, values of the wave-length have been obtained to an estimated accuracy of ±0.02 x.u.

Element	$\theta \pm 0.5''$ (calcite at 18°)	$\lambda \pm 0.02$ (x.u.)	Width (volts)
Zr	6° 30′ 56.5″	687.43	12.9
Cb	6° 10′ 32.6″	651.71	18.0
Mo	5° 51′ 35.7″	618.51	15.2
Ru	5° 17′ 51.8″	559.35	19.3
Rh	5° 2′ 44.7″	532.82	20.0
Pd	4° 48′ 38.7″	508.06	22.4
Ag	4° 35′ 26.7″	484.88	25.0
Cd	4° 23′ 6.3″	463.07	25.1
Sn	4° 0′ 40.2″	423.76	30.2
Sb	3° 50′ 27.2″	405.81	30.0
Te	3° 40′ 51.2″	388.93	34.9
I	3° 31′ 49.2″	373.04	38.2

13. Probabilities of *L* Ionizations of Au by Cathode Rays. D. L. WEBSTER, L. T. POCKMAN AND PAUL KIRKPATRICK, *Stanford University.*—Probabilities of ionization of L_{22} and L_{21} electrons were measured in arbitrary units as functions

* Read by title.

of cathode-ray energy by intensities of the $L\alpha$ and β_1 lines from gold leaf. Corrections for cathode-ray diffusion are unreliable below 80 or 90 kv. From there to 180 the probabilities follow Bethe's formula of proportionality to $U^{-1} \ln (4U/B)$, where $U = V/$(minimum ionizing potential V_0), but with $B = 4.4$ and 6.5 respectively, values probably too high for his theory. These values were found after deducting effects of L ionization by $K\alpha$ transitions, estimated by assuming an ionization probability $V_0^{-2} f(U)$ with $f(U)$ the same for all electrons. This deduction is only 1.5 percent at 180 kv for $L\alpha$ and 1.9 percent for $L\beta$; and empirically, the change of slope of the L intensity graphs at V_K is too small to detect with present technique.

14. Failure to Detect Radioactivity in Beryllium. ROBLEY D. EVANS, *National Research Fellow*, AND M. C. HENDERSON, *University of California, Berkeley.*—We have attempted to confirm the presence of radioactivity in beryllium, as observed in the ionization-chamber-electrometer measurements of Langer and Raitt (Phys. Rev. **43**, 585 (1933)), by using a linear amplifier that will detect individual alpha-particles; but we have obtained negative results. In the present experiments an ionization chamber was used resembling that used by Wynn-Williams and others, 20 mm in diameter and 4.5 mm deep, with only a coarse wire-grid as first electrode. The output of the amplifier operated a loudspeaker, an oscilloscope, and a Thyratron counter. The apparatus was standardized against polonium alpha-particles. A flat boss 20 mm in diameter was ground on a face of a lenticular block of beryllium, and this fresh beryllium surface was mounted 1 mm from the entrance to the ionization chamber. Based on the beryllium decay constant and alpha-particle range given by Raitt and Langer, we expected about 2.9 alpha-particles per minute. Within a probable uncertainty of 0.1 counts per minute, no alpha-particles were observed. The present experiments are therefore interpreted as suggesting that beryllium is stable.

15. Analysis of the Action of Hydrogen Peroxide on Photographic Emulsions. MERTON W. JONES AND JULIAN M. BLAIR.*—Data published by Sheppard and Wightman for the production of the latent photographic image by hydrogen peroxide are analyzed in terms of the Blair-Leighton equation. It is found that this equation fits the experimental data well, except for fluctuations observed by Sheppard and Wightman at high densities. Experimental data are presented which follow values indicated by the equation, but do not confirm the existence of such variations at high density. Neither do they confirm the previously reported evidence of solarization under certain conditions of treatment with hydrogen peroxide. There is apparently no correlation between the sensitivity of an emulsion to light and its sensitivity to hydrogen peroxide. Two different emulsions of the same brand of plates were found to be practically identical with regards to their sensitivity to light but differed more in their sensitivity to hydrogen peroxide than did a slow process emulsion and a fast process emulsion.

16. The Intermittency Effect in Photographic Exposure. JULIAN M. BLAIR AND MALCOLM C. HYLAN,* *University of Colorado. (Introduced by L. B. Loeb.)*—It has long been known that intermittent exposures produce different effects upon a photographic emulsion from equal amounts of light in a continuous exposure. Earlier investigators have not agreed as to the cause of this effect. The results of these investigators are discussed. An explanation of the varied aspects of this phenomenon is offered on the basis of the Blair-Leighton equation, combined with a theory of photochemical lag. Certain predictions are made concerning the effects of intermittency upon exposures to radiations of different wave-lengths. Conditions under which abnormal intermittency effects can be obtained are also described. Experiments verifying these predictions are described.

17. Photographic Studies of the Planets in Light of Different Wave-Lengths. W. H. WRIGHT.

18. Spectra of Mars, Venus, and Jupiter under High Dispersion. T. DUNHAM.

19. Molecular Spectra in the Photographic Infrared. D. M. DENNISON AND A. ADEL.

20. Radioactivity and the Age of Meteorites. R. D. EVANS.

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