PROCEEDINGS

OF THE

AMERICAN PHYSICAL SOCIETY

Minutes of the Oakland Meeting, June 17, 1926

The 140th regular meeting of the American Physical Society was held in Oakland, California, at the Laboratory of Physics of Mills College, in affiliation with the Pacific Division of the American Association for the Advancement of Science. The meeting of that Association included a research conference, Wednesday, June 16, and other meetings and excursions extending through Saturday, June 19. The meeting of the American Physical Society was held Thursday, June 17, the morning session beginning at 10 o'clock. The afternoon session was a joint session with the Astronomical Society of the Pacific. The program consisted of fifteen papers of which abstracts are given in the following pages. An **Author Index** will be found at the end.

ABSTRACTS OF PAPERS

1. Polarization of x-rays. P. A. Ross, Stanford University.—Two methods were used. In the first, two films of metals occupying adjacent positions in the periodic table were so adjusted in thickness that their absorption curves coincided except between the K absorption limits. The x-rays, after scattering from paraffin at 90°, were passed through a slit system into an ionization chamber. Absorbing screens of pairs of metals (silver, cadmium, etc.) were placed in front of the chamber and readings taken through them alternately. Differences between readings then gave the intensity of the radiation lying between their K absorption limits. By rotating the x-ray tube through 90° the polarization of this band could be obtained. The results indicate an exponential increase in the amount of polarization as the short-wave limit of the *scattered* radiation is approached. Polarizations as high as 90% were obtained and the curves indicate 100% polarization at the limit. In the second method the sensitivity of the electrometer was raised from 6000 to 30,000 s.d./volt and the ordinary crystal reflection method used to obtain the distribution of energy in the radiation scattered from paraffin in directions parallel and perpendicular to the cathode stream. Again, polarization was found to increase rapidly near the short-wave limit of the scattered radiation.

2. X-ray isochromats of copper taken in different directions relative to the cathode stream. WARREN W. NICHOLAS, Stanford University.—X-ray isochromats of copper have been taken in three different directions relative to the cathode stream. It is found that an isochromat of frequency ν is linear, within experimental error, from about $(5/4)H\nu$ to $2H\nu$, where $H\nu$ is the quantum voltage for excitation of frequency ν. The linear portions of the graphs were extrapolated to find the intercept on the intensity axis at $H\nu$. This intercept was, within experimental error, independent of voltage, but it did depend on θ, the angle between the measured x-rays and the cathode stream. It is established that the intercepts for $\theta=90°$, and for the range of excitation voltages here used (15 kv. to 50 kv.), are within the limits of $+0.07I' \pm 0.03I'$, where I' is the intensity

of the isochromat ν, θ at twice the excitation voltage. For $\theta=142°$ the intercepts are nearly zero, or if anything, negative, the difference between them and the 90° intercepts being well outside limits of error; but for $\theta=38°$ the intercepts differed from those at 90° by only about $0.01I'$, being greater, and this amount is not outside the limits of error.

3. Spatial distribution of the intensity of x-rays scattered by copper. G. E. M. JAUNCEY and A. W. COVEN, Washington University, St. Louis.—The total (i.e. unmodified plus modified) mass scattering coefficient per unit solid angle in a direction ϕ for x-rays of $\lambda=0.41$A when scattered by copper has been measured for various values of ϕ. The Crowther method was used. The values obtained were: 40°, .083; 50°, .054; 60°, .034; 70°, .029; 80°, .024; 90°, .0162; 100°, .0162; 110°, .0186. The Thomson value of the mass scattering coefficient per unit solid angle for copper at an angle ϕ is $0.0109\,(1+\cos^2\phi)$. The ratio of the experimental value for the coefficient to the Thomson value at the same angle decreases from 4.8 at 40° to 1.45 at 100°. At 110° the ratio is 1.52. This however may be in error. Omitting the ratio at 110° it appears that the ratio tends to approach unity at large angles. With carbon as the scatterer and $\lambda=0.44$A, the ratio becomes unity at about 90°, while at 60° the ratio is 1.37. For copper at 60° and $\lambda=0.41$A the ratio is 2.6. The ratio for a given angle and given wave-length thus tends to increase with the atomic number of the scatterer.

4. Ratio of intensities of modified and unmodified rays in the Compton effect. Y. H. WOO, University of Chicago.—Using the method already described (Phys. Rev. **27,** 119, 1926) in which small tubes of the Compton type and Soller collimators were employed, reliable measurements of the intensity ratio of modified to unmodified line in the scattered AgKα rays were obtained from fifteen radiators—chemical elements of atomic numbers ranging from 3 to 29. In each case the experiments were performed at a single scattering angle, 120°. Since the wave-length range examined was small, the relative intensity of each spectrum was obtained by integrating with a planimeter the area under the ionisation curve which represented the line. The values of the intensity ratio for various scatterers as determined are given in the following table.

Radiator	At. No.	Intensity ratio	Radiator	At. No.	Intensity ratio
Li	3	∞	S	16	1.91
Be	4	8.72	K	19	1.72
B	5	7.02	Ca	20	1.71
C	6	5.48	Cr	24	.75
Na	11	3.04	Fe	26	.51
Mg	12	2.78	Ni	28	.40
Al	13	2.61	Cu	29	.21
Si	14	2.33			

5. The disappearance of the unmodified line in the Compton effect. Y. H. WOO, University of Chicago.—Jauncey's theory of the scattering of x-rays by bound electrons (Phys. Rev. **25,** 314) demands the disappearance of the unmodified line in the Compton effect at values of the scattering angle greater than that given by vers $\varphi=242\,\lambda_0^2/\lambda_s$, where λ_0 is the wave-length of the primary x-rays and λ_s is the K critical absorption limit of the scattering substance and both λ_s and λ_0 are given in Angstroms. For the scattering of Ag Kα x-rays ($\lambda_0=.5604$A) by beryllium, boron and carbon the values of this critical scattering angle are calculated to be 64°, 98° and 137° respectively. The writer has accordingly scattered Ag x-rays by beryllium at 105° and 120°, by boron at 120° and 135° and by carbon at 140° and examined the scattered x-radiation spectroscopically by means of the ionization method already described (Phys. Rev. **27,** 119). In every case the unmodified peak shows up definitely, though it is faint in comparison

with the modified line. Thus the results of the present work are not in agreement with Jauncey's theory and are contrary to the experiments recently reported by Jauncey and his collaborators (Phys. Rev. **27**, 102; Bul. Amer. Phys. Soc. vol. 1, no. 9, p. 10, (Apr. 1926)).

6. Intensity distribution in the Kα doublet of the fluorescent x-radiation. Y. H. Woo, University of Chicago.—The characteristic fluorescent K x-rays of Zn, As (As_2O_3), Sr ($SrCl_2$), Zr (Zirkon), Mo, Ag, Sn and I were excited using a water-cooled silver target tube which was operated at about 60 kv peak and 40 to 50 m-amp. The rays from the secondary radiator were limited by a Soller collimator and reflected from a calcite crystal of a Bragg spectrometer into an ionization chamber filled with ethyl bromide. The 3rd to 4th orders were used. Assuming each component of the α doublet to be a single line of the same width, the relative intensities of α_1 and α_2 for various elements are found to be:

Element	Order	$K\alpha_1/\alpha_2$	Element	Order	$K\alpha_1/\alpha_2$
Zn	3rd	2.00	Mo	4th	2.00
As	3rd	1.98	Ag	4th	2.06
Sr	4th	1.96	Sn	4th	2.00
Zr	4th	1.96	I	4th	2.05

The results show that the ratio of the intensities of the two α components for elements of atomic numbers ranging from 30 to 53 remains constant and has the approximate value 2 to 1, in agreement with the experiments done by Siegbahn and Zacek and by Duane and his collaborators with emission spectra.

7. Proposed experiments on resonance radiation, and a derivation of the formula for the Doppler shift of scattered or of resonance radiation. ARTHUR EDWARD RUARK, Bureau of Standards.—1. When λ2536 from a mercury resonance lamp falls on a bulb containing Hg vapor heated above 275°C., it is regularly reflected; at lower vapor densities, reflection ceases to be regular. The reflected beam is only *partially coherent*. This affords a means of studying the gradual transition from instantaneous scattering-in-phase to ordinary resonance radiation. Using intermediate vapor densities, it is proposed to study the angular distribution of the reflected light, and its polarization when the incident light is polarized in various ways. 2. Schrödinger's method of deriving the Doppler shift on the hypothesis of unidirectional quanta is extended to include any scattering process, however complicated, or any series of absorptions followed by emissions after finite times. The formulae for simple scattering and for resonance radiation are identical. 3. Arguments are given in support of the assertion that, if two methods of scattering result in the same relative wave-lengths at different angles, they need not also result in the same relative intensity at different angles.

8. Series spectra of beryllium Be_I and Be_{II}. I. S. BOWEN and R. A. MILLIKAN, California Institute of Technology.—We published in Nature in 1924 a preliminary report on the term values of Be_{II} series lines. By the methods there outlined and especially because we have recently obtained from Hugh Cooper, of the Kemet Laboratories Inc., Cleveland, electrodes of metallic beryllium, we have completed the location of all the important term values of Be_I and Be_{II} as follows:

	Be_I				Be_{II}		
$3s$	23110.22	$3d$	13137.50	$2s$	146880.5	$4p$	28120.2
$4s$	10685.0	$4d$	7249.2	$3s$	58649.3	$5p$	17910.2
$5s$	6186.9	$5d$	4589.7	$4s$	31424.8	$3d$	48827.4
$6s$	4033.0	$6d$	3165.7	$5s$	19546.3	$4d$	27460.4
$2p_2$	53212.86	$7d$	2315.5	$2p_2$	114951.7	$5d$	17574.6
$2p_2$	53212.18	$8d$	1760.1	$2p_1$	114945.1	$4f$	27435.0
$2p_1$	53209.83			$3p$	50384.7	$5f$	17558.0

9. Intensities in the hydrogen fine structure. WILLIAM V. HOUSTON, National Research Fellow, California Institute of Technology.—Sommerfeld and Unsöld have recently treated the intensities of the hydrogen fine structure components by analogy with the known intensities in the alkalies. This treatment gives a doublet separation which does not agree with the precise experimental value. They also require for the explanation of intensity variations that the $2s$ state shall be metastable. This scarcely seems valid in view of the fact that it coincides with the $2p_1$ level, and that jumps between these levels give very strong lines in the alkalies. The observed facts can be explained by plausible assumptions as to the intensity of the forbidden components $3p_1-2p_1$, $3p_2-2p_2$, and $3s-2s$ in the order of decreasing intensity. The work of many observers shows that these components are to be expected in this order, and that the current in a discharge tube is likely to produce them in hydrogen. These components will increase with an increase in current and thus explain the effect of current density on the observed structure. They also show a resultant polarization which explains the polarization observed in Hα.

10. On the luminosity of comets. H. ZANSTRA, National Research Fellow, California Institute of Technology.—Treating the sun as a black body of temperature $T=6000°$, the strength of a resonance line in the head of a comet has been calculated under the assumption that a spectral line of relative width $w=\Delta\nu/\nu$ is completely absorbed from the sunlight. Taking for the temperature of the comet's head a value of the order 300° Abs. and for w the half width corresponding to this temperature, the following formula is derived for the magnitude $m_{a\text{com}}$ of the comet's head in the light of one spectral line of frequency ν:

$$m_{a\text{com}} = -6.4-5 \log D_1-2.5 \log w+1.086\, x_a-7.5 \log x_a-\log \mu,$$

where D_1=apparent diameter of comet's head, in minutes, $x_a=h\nu/kT$, and μ the multiplicity of the line, the comet being one astronomical unit away from sun and earth. The formula applies to the D-line of sodium and may tentatively be used for certain bands in the spectrum. Disregarding, for a rough comparison, the continuous spectrum, the formula leads to a total luminosity of the comet's head of the same order as observed (Holotschek).

11. The mobility of acetylene ions in air. HENRY A. ERIKSON, University of Minnesota.—The mobilities in air of the positive and negative ions produced in acetylene by means of the alpha rays from polonium have been measured by means of a blast method. It is found that in acetylene as in air, carbon dioxide, hydrogen and argon only one negative ion is formed. This ion has the same mobility in air as have the negative ions formed in the other gases referred to. It is also found that in acetylene, at least up to an age of one second, only one positive ion is formed whereas in air, carbon dioxide, hydrogen and argon an initial positive ion is formed which in a fraction of a second changes over into a final positive ion. The initial positive ions in air carbon dioxide and argon all have the same mobility in air as have the negative ions formed in these gases. In hydrogen however, the initial positive ion has a mobility slightly less than the above. It is found that the positive ion formed in acetylene also has a mobility slightly less. Acetylene therefore resembles hydrogen in this respect. It is also found that a neutral acetylene molecule is able to take up the charge of the final positive ion formed in air and in nitrogen. The resulting positive ion has the same mobility in air as the normal positive acetylene ion. This indicates that the process is of the nature of an electron interchange rather than a chemical oxygen effect.

12. The Characteristics of a Spark. W. P. BOYNTON AND W. H. BRATTAIN, University of Oregon.

The *external* behavior of an electric circuit containing a spark gap is described by assuming the conductance continuously decreasing to zero in a finite time. Assuming this decrease uniform one of us (Phys. Rev. (2) 5, p. 511, 1915) has given equations for the discharge of a single oscillating circuit and of two tuned circuits with quenched primary spark. The treatment is now extended to the opening of a switch and to the partial discharge of a condenser.

By a cathode ray oscillograph an oscillatory spark of period .0269 sec. has been studied *in detail*. In each half-cycle the potential starts at the break-down value, falls quickly to a low level, describing a curve convex to the axis, then reverses to break-down value of opposite sign, each low level "cup" being further from the axis than its predecessor. Potential and current curves were coordinated to secure a potential-current characteristic, agreeing with that obtained by direct experiment. This shows entirely distinct branches for successive half cycles of the same sign, and does not retrace for increasing and decreasing currents. The behavior is explained on the basis of ionization followed by saturation currents.

13. An analysis of the periodic fluctuations in a high voltage direct current system. LEONARD P. DICKINSON, Stanford University.—The paper gives results of tests upon the high voltage set used in the x-ray laboratory of the Department of Physics of Stanford University. Curves taken with a Braun-Ryan oscillograph, show that the charging currents supplied to the condensers of the set by the rectifying kenetrons, contain a second harmonic of 37½%, with other harmonics of lesser magnitude. The result is that these condensers are charged during approximately one-third of a cycle, and are discharged during the remaining two-thirds of the cycle. As would be expected, the discharge current is equal to that supplied to the x-ray tube. The analysis of the condenser current agrees so closely with theory that it is felt that theoretical predictions as to voltage fluctuations at the x-ray tube are essentially correct. These predictions indicate that the maximum fluctuation at the terminals of the load will not exceed 7.0 volts, with a current in the x-ray tube of 10 mil-amperes. It is concluded that the variation in load voltage is negligible under the usual conditions of service.

14. Velocity distribution of high-speed secondary cathode rays. S. CHYLINSKI, University of Chicago.—Electrons from a Coolidge cathode of a specially constructed metal x-ray tube strike a silver target at 45° located in a space free from electrostatic fields. A beam of secondary electrons emerging from the target at 90° with the primary is bent by means of a magnetic field into a semi-circle of 6 cm radius, and enters a Faraday cylinder. Appropriate slits are interposed in the path of the beam, and the walls of the tube are smoked to reduce stray radiations to a minimum. The velocity distribution of the outgoing electrons for primary velocities ranging from 5000 to 20,000 volts have been investigated. The curves show that the greater number of the outgoing electrons have speeds comparable to those of the primary rays. After reaching a maximum at a velocity of about 0.8 of the initial velocity the number of secondary electrons falls sharply to zero for velocities more than about 0.9 that of the incident electrons. It seems probable that energy relations exist between the primary rays and the outgoing electron similar to those in the case of photo-electrons excited by x-rays. In order to obtain a more definite test of this point an investigation of the velocity distribution up to voltages beyond the critical potential for the K series of silver is now in progress.

15. Some electrostatic disturbances upon the earth which seem to be caused by disturbances upon the sun. FERNANDO SANFORD, Stanford University.—In an apparatus which has been used for the past five years for measuring a daily variation of the surface potential of the earth at Palo Alto, there are at certain times very great deviations from the ordinary daily range of variation. These deviations have some of

the characteristics of magnetic storms, but they seem to occur most frequently during the forenoon hours, while magnetic disturbances occur at the same time all over the earth. Since very great earth potential disturbances have accompanied some of the great sun spot disturbances, an attempt has been made to find whether the disturbances of earth potential regularly accompany the passage of sun spots across the sun's central meridian. The data given in the paper indicate the probability, but not the certainty, of a physicial relation between the two phenomena.

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