LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the eighteenth of the preceding month, for the second issue, the third of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Communications should not in general exceed 600 words in length.

Intensity of the Central Spot Produced by X-Rays Penetrating Piezoelectrically Oscillating Quartz Crystals

In an investigation of the increase in the intensity of the Laue spots when a quartz crystal oscillates piezoelectrically, Fox and Fraser[1] observed an increase both in the area and in the blackness of the central spot produced by the primary beam of x-rays when the crystal was oscillating. On the other hand, Jauncey and Deming,[2] who were investigating the effect of piezoelectric oscillations on the intensity of the diffuse scattering of x-rays from quartz, found no increase in the intensity of the primary rays penetrating the crystal. It seemed worth while to examine this matter further.

Now, Bertsch[3] finds that the increase in the intensity of the Laue spots depends upon whether or not the primary beam passes through a nodal or antinodal portion of the crystal. Hence a sideways displacement of the crystal plate may remove the effect of the oscillations on the Laue spots and may possibly have an effect on the central spot. In our experiments we passed the primary beam from a tungsten target tube operated at 42 kv peak through various portions of both X-cut (1741 kc short dimension) and Y-cut (1763 kc short dimension) crystals. We measured the intensity of the central spot by means of both an ionization chamber and a photographic film.

In a typical set of readings with the ionization chamber, the average of the "oscillating" readings differed by 0.5 percent from the average of the "not oscillating" readings with a probable error in each average of about 0.3 percent The ionization chamber method therefore shows no change in the total primary beam penetrating the crystal. Now, although the total intensity of the primary beam entering the ionization chamber window remains unchanged, the width of the beam penetrating the crystal and the area of the central spot on a photographic film may be changed when the crystal goes from "oscillating" to "not oscillating." Photographic reversal, which we obtained quite easily, may produce peculiar effects.[4] It is possible with two beams of the same true total intensity but of different areas for the broader beam to produce a blacker and bigger spot on a photographic film if the time of exposure is just right. Also with long exposure there is halation, the blackening of the film in the vicinity of the true spot by x-rays scattered from the film itself. We have found that halation combined with reversal can give a spot consisting of a black periphery with a light center. In the photographic experiments, we were careful to avoid the effects of reversal and halation by making the time of exposure short. Further, the "oscillating" and "not oscillating" spots were produced on the same strip of film. The blackness and width of each spot on the developed film were measured by means of a microphotometer. We found no certain change either in the blackness or the width from "oscillating" to "not oscillating."

The accepted explanation for the increase in the intensity of the Laue spots is that the oscillations cause a decrease in the extinction coefficient. This explanation is supported by Jauncey and Deming's result that the oscillations have no effect on the diffuse scattering. We may look upon calcite, a crystal of high perfection, as having a high extinction coefficient and upon rocksalt, a mosaic crystal, as having a low extinction coefficient. We therefore made plates of calcite and rocksalt of equivalent thicknesses with respect to absorption of x-rays and looked for a change in the width of the central spot produced by the primary rays penetrating the crystal when rocksalt was substituted for calcite. It was just possible that there might be such an effect. However, no such effect was found and so the extinction coefficient has no effect on the width of the central spot.

We conclude that the effect reported by Fox and Fraser was due to an accidental combination of photographic reversal and halation and not to a change in the primary beam penetrating the quartz.

G. E. M. Jauncey
A. T. Jaques

Wayman Crow Hall of Physics,
Washington University, St. Louis,
September 6, 1936.

---

[1] G. W. Fox and W. A. Fraser, Phys. Rev. **47**, 899 (1935).
[2] G. E. M. Jauncey and J. H. Deming, Phys. Rev. **48**, 462 (1935).
[3] C. V. Bertsch, Phys. Rev. **49**, 128 (1936).
[4] A. E. Garrett, *The Advance of Photography*, p. 358.

Electron Velocity Distribution in Gases

Specification of electron velocity distributions in ionized gases of medium conductivity is at present one of the most interesting problems of discharge physics. We wish to report briefly some results obtained by applying Druyvesteyn's method of analysis[1] to representative probe data which have been accumulated in this laboratory for arcs and glows with electron concentrations of about 10^7-10^9 cc^{-1}.

The outstanding result is the frequent existence of a wide depression in the distribution function for electron velocities rather greater than the mean, taking the Maxwellian distribution as standard. This modified form of the distribution function has been predicted by (amongst others) Morse, Allis and Lamar,[2] for electrons drifting through a gas in a uniform field and losing energy in elastic collisions with molecules. Although it is difficult to trace down the exact origin of any particular feature of a complicated discharge, it appears that conditions in our tubes have often been such as to make loss of energy in this way an important factor. Further, the ratio of random and drift currents has in many instances about the predicted value. With increase in electron concentration, the distribution function tends to the Maxwellian.

The second, less definite result, is the common occurrence of a fairly distinct group of electrons with a mean energy of the order of 5–10 electron volts, under conditions when much ionization was certainly due to fast primary electrons. If we suppose this group consists of electrons ejected from molecules by the primary electrons, its roughly constant energy receives an explanation on the quantum theory of ionization, which predicts that many of the ejected electrons should have an energy of this order, whatever the primary energy.[3]

It has been assumed in this investigation that the ideal conditions postulated in the usual theory of probes have been satisfied sufficiently well for the results to have meaning in relation to the undisturbed plasma. It would be very difficult to go into this theoretically for the complex discharges which have been studied, although the lines on which such calculations could be made have been laid down.[4] It is however at least certain that the main features of the results are independent of probe size over a wide range of this.[1, 5]

K. G. Emeleus
R. J. Ballantine

Queen's University,
Belfast, Ireland,
August 21, 1936.

---

[1] Sloane and Emeleus, Phys. Rev. **44**, 333 (1933).
[2] Morse, Allis and Lamar, Phys. Rev. **48**, 412 (1935).
[3] Mott and Massey, *The Theory of Atomic Collisions* (Oxford 1933), p. 171.
[4] Tonks and Langmuir, Phys. Rev. **34**, 876 (1929).
[5] Greeves and Johnston, Phil. Mag. **21**, 659 (1936).

Attempt to Observe the Spectrum of Doubly Excited Helium

According to the calculations of Massey and Mohr,[1] the excitation cross sections of the doubly excited states of helium by electron impact are very small for low electron energy and reach their maximum values for electron energy of the order 500–600 volts. Hence an attempt is made to excite the spectrum of doubly excited helium by electrons of these energies. Electrons emitted by a hot cathode consisting of an oxide coated spiral tungsten filament are accelerated through a glass tube to a hollow nickel anode at a distance of 2 cm from the cathode. The pressure of helium in the tube is kept within 0.07 and 0.12 mm of mercury so that the electron mean free path is of the order of 1 cm. The accelerating voltage is varied between 1100 and 1800 volts so that the electron energy on impact with the helium atoms would be of the order of 500–700 volts. A tube of 3 mm bore extends from the hollow anode and confines the excitation process within it in order to increase the intensity of the radiation which is observed end-on in the direction of accelerating field. The strongest lines of the spectrum $2s^2\,{}^1S-2s2p\,{}^1P$, $2s2p\,{}^1P-2s3s\,{}^1S$ and $2s2p\,{}^3P-2s3s\,{}^3S$, whose positions are calculated from the energy states obtained by the variational method[2] to be at 6320A, 5840A, and 2670A, respectively, are looked for. But prolonged exposures fail to reveal any faint lines at the expected positions.

In a way, this failure to observe the spectrum is understandable when one considers the widths of the levels of doubly excited helium. The lifetime of a doubly excited state is mainly determined by the process of autoionization, i.e., a radiationless transition in which one electron goes to $1s$ state while the other is ejected with the proper energy. The transition probabilities between a doubly excited state and the singly excited states and those between doubly excited states are small compared with that due to autoionization and hence can be neglected in estimating the lifetime of the doubly excited state. Calculation of the probability of autoionization has been carried out for $2s3s\,{}^3S$ by Kreisler[3] using for the ejected electron the continuous wave function of hydrogen. To ascertain the order of magnitude of Kreisler's result, we calculate the probability of autoionization using our variational wave function for $2s3s\,{}^3S$ and Wentzel's spherical wave[4] for the ejected electron and obtain a result agreeing with Kreisler's in the order of magnitude, namely, $P\sim10^{14}$ sec.$^{-1}$. The lifetime is then $\sim10^{-14}$ sec. and the width of the level is ~3000 cm^{-1}. The widths of other doubly excited levels would certainly be of the same order of magnitude. Thus transitions between two doubly excited states would give rise to a continuous band extending over hundreds of angstroms, if they are observed at all. This seems to show that the suggestion that the corona spectrum may be due to doubly excited helium is untenable.[5]

The lines observed by Compton and Boyce[6] and Kruger[7] in the region of 300A, if they arise from transitions between doubly and singly excited states, would according to these calculations have a width of 3A, or 1 mm at the dispersion employed by Kruger. This does not agree with the observation of Compton, Boyce and Kruger; for although the width of the line 320.4A is not explicitly mentioned, it appears to be quite sharp in the reproduction in their papers. Thus we may regard the question as to the origin of the lines at 320.4 and 357.5A still unsettled.

We are grateful to Mr. K. T. Chao for his help during the experiment.

A. T. Kiang
S. T. Ma
Ta-You Wu

Physics Department,
National University of Peking,
August 8, 1936.

---

[1] Massey and Mohr, Proc. Camb. Phil. Soc. **31**, 604 (1935).
[2] T. Y. Wu, Phys. Rev. **46**, 293 (1934). The corrected energies and eigenfunctions are given in T. Y. Wu and S. T. Ma, J. Chinese Chem. Soc. **4**, 344 (1936).
[3] Kreisler, Phys. Acta Polonica 4, 1–2, 151 (1935).
[4] G. Wentzel, Zeits. f. Physik **40**, 574 (1926); **43**, 524 (1927).
[5] Rosenthal, Zeits. f. Astrophys. **1**, 115 (1930); Goudsmit and Wu, Astrophys. J. **80**, 154 (1934).
[6] K. T. Compton and Boyce, J. Frank. Inst. **205**, 497 (1928).
[7] P. G. Kruger, Phys. Rev. **36**, 855 (1930).