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 twenty-eighth of the preceding month; for the second issue, the thirteenth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Line Broadening and the Imprisonment of Resonance Radiation

Applications of existing theories of resonance radiation diffusion[1] have, in the main, employed classically predicted values of absorption coefficients, or values of this quantity predicted from measurements at low gas pressures (of the order 1 micron). Zemansky,[2] and Webb and Messenger[3] found that at larger vapour pressures, Hg resonance radiation escaped from a body of gas faster than could be accounted for on the basis of the known (low pressure) value of the atomic absorption coefficient—and indeed the more was this so the higher the vapor pressure. These authors attributed the effect to line broadening due to absorption or other causes.

Bearing on this question are some experiments of the writer, similar to experiments already reported,[4] which show that when the resonance radiations of Ne at a pressure of 1.5 mm pass a considerable distance away from a discharge and are absorbed, only a small fraction (1–3 percent) of this energy is converted into metastable atoms,[5] the remainder escaping to the walls as scattered resonance radiation.

It has been calculated from these results, assuming a mean life of the excited atoms of 10^{-7} sec. and reasonable tentative values (1–0.1 percent) for the (quenching) efficiency of gas kinetic collisions transferring excited Ne atoms to the metastable state that the mean free path (reciprocal of absorption coefficient) of the scattered resonance quanta must be of the order of 0.2–2 cm. This may be compared to the value 6.5×10^{-6} cm calculated for the cores of the resonance lines of Ne for 1 mm pressure by Found and Langmuir[6] from a formula of Ladenburg, or to the value 2×10^{-4} cm for the core of the mercury resonance line predicted for a pressure of 1 mm from the atomic absorption coefficient of Hg for this radiation as known for low pressures.[7] It is suggested that the great discrepancy here involved is caused by a broadening of the resonance lines as a result of coupling forces (Holtsmark[8] broadening), or of molecule formation.[9]

It is well known that the absorption breadths of the resonance lines of Na, Cs, etc. at pressures of the order of 1 mm are very great compared with the Doppler breadths. Hopfield[10] found a large broadening of the He resonance line in emission which was explained by Weizel[9] as due to molecule formation between excited He atoms and normal He atoms.

Abnormal broadening of the visible lines of the rare gases has not been observed: from the standpoint of the coupling theory[8] none would be expected since there are no *resonators* among the normal gas molecules which can respond to the frequencies concerned; from the standpoint of molecule formation it may be that a possible shortness of life of the upper

[1] K. T. Compton, Phys. Rev. **20**, 283 (1922); E. A. Milne, Journ. Lond. Math. Soc. Vol. 1 (1926).

[2] M. W. Zemansky, Phys. Rev. **29**, 513 (1927).

[3] Harold W. Webb and Helen A. Messenger, Phys. Rev. **33**, 319 (1929).

[4] Carl Kenty, Phys. Rev. **38**, 377 (1931).

[5] I. Langmuir and C. G. Found, Phys. Rev. **36**, 604 (1930).

[6] C. G. Found and I. Langmuir, Phys. Rev. **39**, 248 footnote (1932).

[7] See for example, M. W. Zemansky, Phys. Rev. **36**, 229 (1930).

[8] J. Frenkel, Zeits. f. Physik **59**, 198 (1930).

[9] Walter Weizel, Phys. Rev. **38**, 642 (1931).

[10] J. J. Hopfield, Astrophys. J. **72**, 133 (1930).

excited states, compared with the effective[11] life of the resonance states, renders such formation relatively unlikely.

Penning[12] calculated from Dorgelo's and Washington's measurements of the mean lives of metastable Ne atom at 7.1 mm pressure that only about 1 collision in 10^5 was of the first kind (resulting in transfer from the metastable state to the resonance state). It has frequently been suggested on the other hand, that the atoms go continually up and down between these states,[13] the efficiency of collisions of the first and second kinds being supposed to be relatively very high and the mean free path of the resonance lines being supposed to be very short (classically predicted values). Obviously, under such circumstances a calculation like that of Penning would be meaningless. But, the present results show that once a metastable Ne atom is raised to the resonance state there will be little chance of a new metastable atom being formed and hence Penning's calculation is confirmed (as are also the essentially similar calculations of a number of other observers on the lives of metastable atoms.[14]

The present results are in agreement with the direct observation of Meissner and Graffunder[15] that metastable Ne atoms are powerfully destroyed by strong Ne light (an abnormally long mean free path of the scattered resonance lines of Ne might have been inferred from this alone) and with Penning's interpretation that metastable atoms were strongly destroyed in his experiments[16] by irradiation and with the irradiation experiments of the writer.[4]

The previous results that the currents here dealt with (in the case of pure rare gases) are mainly of photoelectric origin[4,17] have been confirmed. Complete details of the experiments will be given in a paper now in preparation.

Found and Langmuir (private communication) have recently confirmed by direct means that the free paths of the scattered resonance radiations in Ne at 1 mm pressure are very great (of the order of magnitude of the tube diameter or larger) compared with the classically predicted values.

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11 Repeated reabsorptions are here taken into account.

12 F. M. Penning, Zeits. f. Physik **46**, 342–343 (1928).

13 P. D. Foote, Phys. Rev. **30**, 288 (1927); M. W. Zemansky, Phys. Rev. **34**, 226 (1929); see also C. G. Found and I. Langmuir, reference 6, pp. 250, 251.

14 See an excellent summary of data of this kind by Zemansky, Phys. Rev. **34**, 213 (1929).

15 K. W. Meissner and W. Graffunder, Ann. d. Physik **84**, 1009 (1927).

16 F. M. Penning, Phil. Mag. **11**, 961 (1931) and other papers.

17 Carl Kenty, Phys. Rev. **38**, 2079 (1931).

The New Effect Produced by the Action of X-rays on Matter

G. I. Pokrowski (Phys. Rev. **38**, 925 (1931)) has reported a series of experiments which indicate that some of the heavier elements (Pb, Bi, Hg, etc.) after irradiation with x-rays (90 and also 140 k.v.) acquire feeble radioactive properties. A sample of Pb which had been irradiated for 30 minutes was found to produce a measurable ionization current up to 90 minutes after irradiation. This experiment has been repeated by Gingrich (Phys. Rev. **39**, 748 (1932)) who used as detector a Lindemann electrometer of high sensitivity. Although Gingrich's experimental arrangement would probably have been able to detect one one-hundredth of the maximum effect reported for Pb, yet he found no difference for the ionization produced by various metals before and after irradiation with x-rays whose voltage was varied between 45 and 160 k.v. Gingrich's periods of irradiation appear to have been comparable with those of Pokrowski (30 to 40 minutes).

Pokrowski also reported an effect which was built up after continued irradiation with x-rays. This effect was detected by scintillations produced on a zinc sulphide screen. This effect was found to persist for many days after irradiation and corresponded with about one scintillation per cm^2 per second. From a knowledge of the total ionization produced he calculated that the particles from Pb which were responsible for the scintillations had an average energy of 1.1×10^6 e.v. If these were α-particles, then they should have a range in