THE TIME INTERVALS BETWEEN THE APPEARANCE OF CERTAIN SPECTRUM LINES OF HELIUM AND OF MERCURY

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Abstract

The times between the appearance of certain lines in the visible region of the spectrum of helium and of mercury have been measured by a method previously described. The results are tabulated. The time intervals were found to be independent of the conditions of excitation of the spectrum lines and are believed to be of the same order of magnitude as the differences in the total times between excitation and emission of the various lines investigated.

A METHOD for the study of the time of appearance of spectrum lines in the beginning of spark and condensed discharges has been recently developed.[1,2] It was found that the times between the appearance of the spectrum lines of the elements investigated are practically independent of the conditions of excitation,[3] and are of the same order of magnitude as the differences in the total time from excitation to emission for various spectrum lines which would be expected from the experiments of McPetrie[4] and others,[5] on the average time an atom remains in the excited state before emission. The above work has been extended and this paper gives the results for the visible region of the spectra of helium and mercury.

The experimental method is the same as that previously described in detail.[2] In the case of helium most of the observations were taken with the gas at 6 to 8 mm pressure in a very short discharge tube of the H type so constructed as to permit the capillary to be viewed end-on through ring electrodes co-axial with it. The spectrum of a spark through helium at atmospheric pressure was also studied, but under these conditions most of the parhelium lines were too faint to permit of accurate time interval measurements. However, good readings were obtained with orthohelium lines and the results agree within experimental error with those taken by means of the discharge tube.

In the case of mercury, a discharge tube similar in type to the helium tube, and containing a few globules of mercury, was strongly heated

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[1] Brown and Beams, J.O.S.A. **11**, 11 (1925).

[2] Beams, Phys. Rev. **28**, 475 (1926).

[3] Beams, Phys. Rev. **27**, 805A (1926).

[4] McPetrie Phil. Mag. **1**, 1082 (1926).

[5] See Foote and Mohler, Origin of Spectra, p. 93.

with a bunsen flame in a porcelain container, so constructed that an unobstructed end-on view of the capillary could be obtained. Under the influence of heat and a heavy discharge a rich spectrum was obtained in which a few of the spark lines were of an intensity almost equal to that of the arc lines. The fact that the tube had to be strongly heated gave opportunity for observations under different conditions of temperature, and therefore, of different vapor pressures of mercury. The intensity of the different spark lines varied considerably, being greatest at the highest temperatures, but no changes in time intervals were noted in the case of either spark or arc lines from the maximum temperature the tube could stand without burning up the electrodes, down to a temperature so low that a discharge would not take place in the tube. Furthermore, in the cases of several lines, observations were taken using a mercury spark in air in place of the discharge tube with no observed

TABLE I

Time intervals between the appearance of certain spectrum lines of helium and mercury.

Wave-length in Ångstrom units	Type of line	Integrated intensity Helium	Revised Paschen series notation	Time intervals in sec$\times 10^8$
4686	Spark	4	First member Fowler series	(not measured)
5016	Parhelium	6	$2S-3P$	1.20
4922	Parhelium	5	$2P-4D$	.07
4472	Orthohelium	10	$2p_{1,2}-4D$	2.47
5876	Orthohelium	10	$2p_{1,2}-3d$	2.27
4713	Orthohelium	4	$2p_{1,2}-3s$	5.06
6678	Parhelium	6	$2P-3D$	(doubtful)
		Mercury		
5427*	Spark	8		2.55
5679*	Spark	6		.30
5872*	Spark	4		.46
5461	Arc	10	$2p_1-2s$	1.13
4340 **	Arc	10	$2P-4d_2$	
4344			$2P-4d_3$	
4348			$2P-4D$	
4358			$2p_2-2s$	1.73
5770 **	Arc	10	$2P-3d_2$	
5790			$2P-3d_3$	
5791			$2P-3D$	2.89
6235	Arc	5	$2S-5P$	(very doubtful)

*Notation not established.
**Unresolved.

differences greater than experimental error. Table I gives the results obtained. The precision of the measurements was at least $.3\times10^{-8}$ sec.

It will be noted that in the cases of both helium and mercury the spark lines appear first. This is in accord with the results previously found with cadmium, magnesium, zinc and nitrogen,[2] and lends support to the idea that if the degree of ionization is increased the probability of an electron jump is likewise increased, and thus the time between the excitation and the emission of a spectrum line is decreased. This might be expected because of the higher electric field in the neighborhood of multiply ionized atoms as compared with atoms only excited. This, however, does not hold unless there is a large difference in the electric fields because the time of appearance of lines emitted by an atom while in the same stage of ionization is certainly not a simple function of the energy values assigned to the various upper levels or to the frequency of the line emitted.

In the case of helium, the parhelium lines $2S-3P$ and $2P-4D$ appear before the bright orthohelium lines, but the parhelium line $2P-3D$ is the last to appear. This latter observation is interesting because the lines $2P-4D$ and $2P-3D$ belong to the same series, yet are observed to appear almost 10^{-7} seconds apart. As is indicated in the table, the time of appearance of $2P-3D$ is doubtful, since the sensitivity of both the eye and of the photographic plate decreases in this region, yet the value given is probably of the right order of magnitude.

In the orthohelium spectrum the observed lines have the same $p_{1,2}$ final levels but different initial levels. The results then indicate that the electron remains on the average about 2.47×10^{-8} sec. longer in the $3d$ energy level than in the $4d$ energy level, and 2.27×10^{-8} sec. longer in the $3s$ energy level than in the $3d$ level. It is unfortunate that these close orthohelium doublets could not be resolved, for if a time existed between the appearance of the two members of the doublet, then this time should be a function of the $p_{1,2}$ levels only, and hence practically the same for each of the doublets.

In considering mercury no conclusions can as yet be drawn from the sequence of the spark lines as their spectroscopic notation has not been established. In the arc spectrum the line $2p_1-2s$ appears before $2p_2-2s$, which is in accord with the results found previously for cadmium, zinc, and nitrogen, and strengthens the emphasis placed there upon the importance of the final level in determining the time before emission. It is to be regretted that under the conditions of observation the members of the two groups which have the same $2P$ level could not be clearly separated, but it is hoped that this will be overcome in future work.

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