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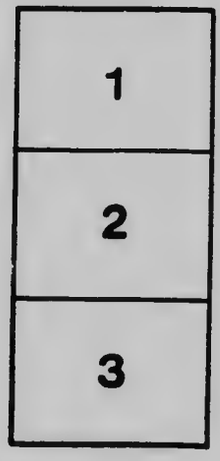


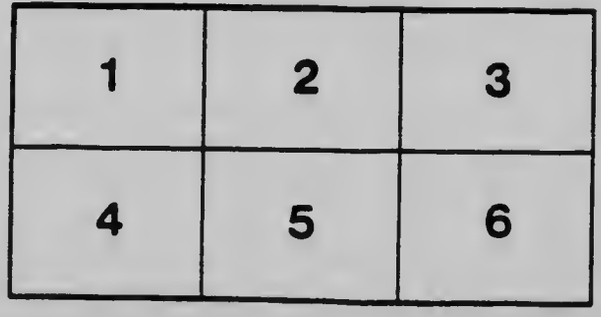

UNIVERSITY OF TORONTO STUDIES

PAPERS FROM THE PHYSICAL LABORATORIES

[illegible] ON THE EXTREME ULTRA-VIOLET SPECTRA OF MAGNESIUM AND SELENIUM BY J. C. McLENNAN, J. F. T. [illegible] AND H. J. C. IRETON

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# University of Toronto Studies

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# *On the Extreme Ultra-violet Spectra of Magnesium and Selenium*

By PROFESSOR J. C. MCLENNAN, F.R.S., MR. J. F. T. YOUNG, M.A. and Mr. H. J. C. IRETON, M.A.

(Read May Meeting, 1919.)

## INTRODUCTION

The present work is a continuation of that carried out by two of the authors with a Hilger quartz spectrograph, Type C, in the region down to 2000 A.U. The present paper deals with the spark and arc emission spectra of magnesium from 2100 A.U. to 1850 A.U. with a Hilger Type A quartz spectrograph, and the vacuum arc spectra of magnesium and selenium from 2300 A.U. to 1400 A.U. with a specially constructed fluorite spectrograph.

In the spark spectrum of magnesium, four new lines have been observed, in the arc spectrum of this metal, eleven, and in the arc spectrum of selenium, some thirty-one.

## MAGNESIUM

### *Experiments*

Three sources of radiation, the spark in air, the arc in air, and the arc in vacuo, were used in obtaining the spectra of magnesium. The spark in air was produced by the condensed discharge of a Clapp-Easthain half-kilowatt transformer, giving 10,000 volts at the secondary terminals. With this apparatus a strong thick spark was easily produced.

The arc in air was produced by using rods of magnesium metal in the carbon holders of an ordinary hand-fed arc lamp. The voltage applied was 200 volts, and the current varied from eight to twelve amperes. With such heavy currents the metal soon became hot and exposures had to be intermittent to allow for cooling of the rods.

The type of arc lamp developed for vacuum work by McLennan, Ainslie and Fuller[1] was employed with the fluorite spectrograph, magnesium metal rods being fastened to the electrodes. With good vacua it was found that a current of 4 to 5 amperes at 100 volts produced a brilliant and steady arc.

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[1] Proc. Roy. Soc. Ser. A. Vol. 95. Mar. 15, 1919, p. 316.

The spectra were recorded on Schumann plates made by the Adam Hilger Co. With the quartz spectrograph no difficulty prevented the securing of clear, sharply defined spectrograms, but with the fluorite spectrograph, the fluorescence of the prism and lenses produced a heavy general fogging of the plate. Since this did not occur with other arc sources of equal intensity in the visible region, it is possible that this may be due to the strong ultra-violet emission in the magnesium arc between 2700 A.U. and 3000 A.U.

Typical spectra are reproduced in Fig. 1. The upper spectrum is that of the magnesium spark in air, and below it is the spectrum of the magnesium arc in air, both taken with the quartz spectrograph. The lower illustration is the spectrum of the magnesium arc in vacuo taken with the fluorite spectrograph. Wave length scales are attached for reference.

It may be noted that as was observed by Saunders[1] and as mentioned in the previous work, reversal was readily obtained with the arc in air at 2852 A.U. and 2026 A.U., the frequencies of which are given by $\nu = (1 \cdot 5,S) - (2,P)$ and $\nu = (1 \cdot 5,S) - (3,P)$, while no reversals were obtained with the arc in vacuo.

The wave lengths with the quartz spectrograph were obtained from a calibration curve constructed by using the following prominent lines in the mercury arc and the zinc, cadium and aluminium sparks.

| Mercury | Zinc | Cadmium | Aluminium |
|---|---|---|---|
| 4046·78 A.U. | 3076 A.U. | 3260·1 A.U. | 1990·57 A.U. |
| 3650·31 " | 2558·2 " | 2748·68 " | 1935·90 " |
| 3341·70 " | 2502·2 " | 2573·15 " | 1862·81 " |
| 3131·66 " | 2138·7 " | 2313·88 " | 1854·80 " |
| | 2100·06 " | 2288·12 " | |
| | 2062·08 " | 2265·04 " | |
| | 2025·51 " | 2194·71 " | |
| | | 2144·44 " | |

The calibration curve for the fluorite spectrograph was obtained by measurement of the following prominent carbon, tin and lead vacuum arc lines.

[1] Saunders. Astro.-Phys. Jl. Vol. 43, No. 3. April, 1916.

| Carbon | Tin | Lead |
|---|---|---|
| 2307·5 A.U. | 1756·6 A.U. | 2204·4 A.U. |
| 1930·5 " | | 1821·7 " |
| 1656·9 " | | 1796·5 " |
| 1562·0 " | | 26·5 " |
| 61·2 " | | 1682·5 " |
| 60·5 " | | 71·6 " |
| 1464·5 " | | 1555 8 " |
| | | 1434·0 " |

The wave lengths of the lines and their relative intensities are given in Table 1, together with lines recorded by other observers in the region below $\lambda = 2026$ A.U. In reaching these values, a great many plates were taken and the best measured with a Hilger comparator.

## Series Relations

In the present investigation the series of single lines given by the formula $\nu = (1\cdot5,S) - (m,P)$.

| m = | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| $\lambda$ = | 2853·22 | 2025·08 | 1828·1 | 1748·09 | 1707·3 | 1683·64 |

has been verified for the values m = 3, 4, 5, 6.

Lorenser[1] has calculated the wavelengths of the different members of the series $\nu = (1\cdot5,S) - (m,p_2)$ to be

[1] Lorenser, Mang. Diss. Tübingen, 1913.

TABLE I

| HANDKE | | LYMAN | | SAUNDERS | | THE AUTHOR'S | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spark in Air | Int. | Spark in Hydrogen | Int. | Vacuum Arc | Int. | Spark in Air | Int. | Arc in Air | Int. | Vacuum Arc | Int. |
| .. | | .. | | 2026 A.U. | 10 | 2026 A.U. | 10 | 2026 A.U. | 10 | 2026 A.U. | 10 |
| .. | | .. | | .. | | .. | | 2004 | 1 | .. | |
| .. | | .. | | .. | | 2000 | 1 | 2000 | 1 | .. | |
| .. | | .. | | .. | | .. | | 1996 | 1 | .. | |
| .. | | .. | | .. | | 1990 | 1 | .. | | .. | |
| .. | | .. | | .. | | 1978 | 1 | .. | | .. | |
| .. | | .. | | .. | | .. | | 1973 | 1 | .. | |
| 1930.9 A.U. | 6 | .. | | .. | | 1931 | 10 | .. | | .. | |
| .. | | .. | | .. | | 1909 | 2 | .. | | .. | |
| 1886·8 | 5 | .. | | .. | | .. | | .. | | .. | |
| 1864·1 | 4 | .. | | .. | | 1887 | 4 | .. | | .. | |
| 55.9 | 5 | .. | | .. | | 1864 | 2 | .. | | .. | |
| 39·6 | 3 | .. | | .. | | 1856 | 2 | .. | | .. | |
| .. | | 1828·1 A.U. | 1 | 1828·0 A.U. | 6 | .. | | .. | | 1828 | 5 |
| 1753·0 | 3 | 1753·6 | 6 | .. | | .. | | .. | | 1753 | 3 |
| 1750·7 | 2 | 50·9 | 5 | .. | | .. | | .. | | 51 | 1 |
| 50.0 | 1 | .. | | .. | | .. | | .. | | .. | |
| .. | | .. | | .. | | .. | | .. | | 1748 | 3 |
| 1746.7 | 1 | .. | | .. | | .. | | .. | | .. | |
| 44·1 | 5 | .. | | .. | | .. | | .. | | .. | |
| .. | | .. | | .. | | .. | | .. | | 1743 | 1 |
| 1741·4 | 5 | .. | | .. | | .. | | .. | | .. | |
| .. | | 1737.8 | 7 | .. | | .. | | .. | | 1738 | 4 |
| 1736·3 | 2 | .. | | .. | | .. | | .. | | .. | |
| .. | | 1735·0 | 6 | .. | | .. | | .. | | 1735 | 1 |
| 1734·0 | 1 | .. | | .. | | .. | | .. | | .. | |
| . | | .. | | .. | | .. | | .. | | 1707 | 1 |

| m = | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| λ = | 4571·27 | 2090·08 | 1843·08 | 1757·1 | 1711·6 | 1621·00 |

Although the existence of a line at $\lambda = 2091$ A.U. was verified in the present work in both arc and spark spectra in air, no indication was obtained of the existence of members of the series with higher frequencies.

## Summary

1. The spectra of magnesium for spark in air and arc in air has been investigated in the region between $\lambda = 2026$ A.U. and $\lambda = 1850$ A.U. and some seven new lines recorded.

2. The spectrum of the magnesium arc in vacuo has been investigated in the region between $\lambda = 2300$ A.U. and $\lambda = 1400$ A.U. and seven new arc lines measured. Several of these agree with lines found by Saunders with the spark in hydrogen and with lines found by Handke with the spark in air.

3. The series $\nu = (1 \cdot 5,S) - (m,P)$ has now been verified for values of $m$ from two to six, but the experiments have failed to detect any further lines of the series $\nu = (1 \cdot 5,S) - (m,p_2)$ beyond, possibly, the second member.

## Selenium

These experiments were also a continuation of previous work.[1] To secure an arc in vacuo emitting selenium radiation, solid commercial carbons were bored to a depth of one and a half inches and filled with compressed selenium metal powder. These were placed in the vacuum arc lamp previously mentioned, and a steady bright arc was obtained with a current of 4 to 6 amperes at 100 volts.

In the illustration, Fig. II, the upper spectrum is that of the carbon arc in vacuo, and the lower that of selenium in the carbon arc. The following table contains the wavelengths of all the lines measured with relative intensities. As before, several of the best of a large number of plates were measured.

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[1] McLennan and Young, Phil, Mag., Vol. XXXVI, p. 450, Dec. 1918.

TABLE II

| Wave-length | Int. | Element | Wave-length | Int. | Element |
|---|---|---|---|---|---|
| 2307·5 A.U. | 8 | Carbon | 1619 A.U. | 1 | Selenium |
| 2165 | 10 | Selenium | 1615 | 2 | " |
| 38 | 2 | " | 09 | 1 | " |
| 2073 | 10 | " | 04 | 3 | " |
| 51 | 10 | " | 1591 | 1 | " |
| 38 | 10 | " | 85 | 2 | " |
| 1993 | 2 | " | 78 | 2 | " |
| 60 | 8 | " | 61 | 10 | Carbon |
| 30 | 8 | Carbon | 48 | 1 | Carbon |
| 17 | 4 | Selenium | 33 | 1 | Selenium |
| 14 | 4 | " | 31 | 1 | " |
| 1898 | 6 | " | 30 | 1 | " |
| 59 | 8 | " | 03 | 1 | " |
| 55 | 8 | " | 1474 | 1 | " |
| 1761 | 2 | " | 68 | 1 | " |
| 52 | 1 | " | 65 | 3 | Carbon |
| 1691 | 2 | " | 58 | 1 | Selenium |
| 75 | 3 | " | 51 | 1 | " |
| 71 | 3 | " | 48 | 1 | " |
| 56 | 10 | Carbon | 46 | 3 | " |
| 25 | 1 | Selenium | 37 | 3 | " |
| 21 | 1 | " | 30 | 1 | " |

Owing to the difficulty of securing sufficient vapour density around arcs in vacuo it was found impossible to obtain any reversals in the arc spectrum so that no conclusions can be made from the point of view of absorption about the series of selenium in this region of the ultra-violet.

## SUMMARY

1. Thirty new lines have been recorded in the selenium arc spectrum between $\lambda = 2300$ A.U. and $\lambda = 1400$ A.U.

Admiralty Physical Laboratory,
South Kensington.

*14th April, 1919.*

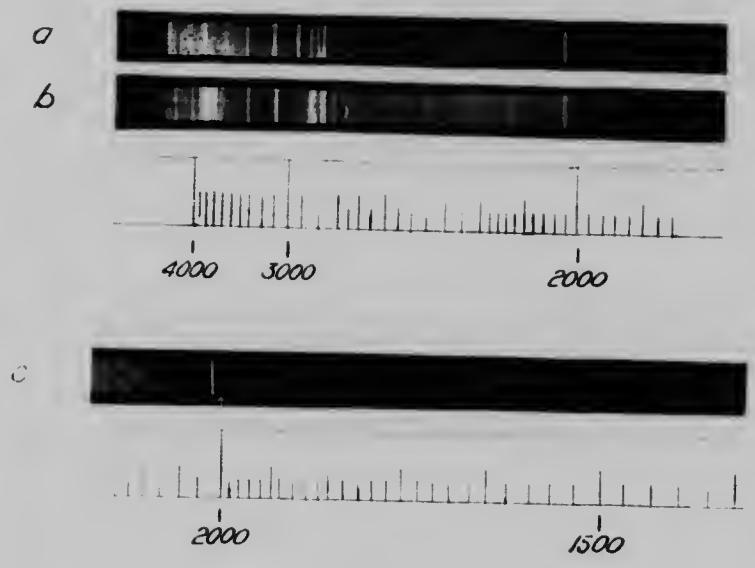


Figure 1

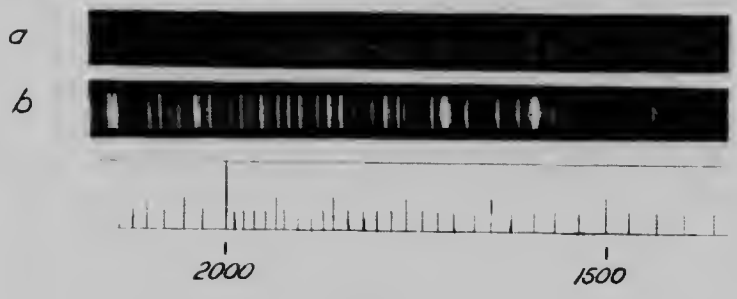


Figure 2

# UNIVERSITY OF TORONTO STUDIES

## Papers from the Physical Laboratories

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