THE SOFT X-RAY L_{23} EMISSION SPECTRUM OF MAGNESIUM FROM SOLID AND EVAPORATED TARGETS*

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Spectroscopic studies in the soft X-ray region of 50–1000 Å have used both photographic and photomultiplier detection of the radiation diffracted in the grating spectrograph (see, for example, Tomboulian 1957). The photomultiplier method offers the advantage that it is possible to record the time variation in the intensity of radiation emitted at a particular wavelength as changes proceed in the condition of the target.

Using a 1 m grazing-incidence spectrograph with photomultiplier detector (Fisher, Crisp, and Williams 1958) a detailed study has been made of the magnesium L_{23} emission band at 250 Å.

Experimental Method and Results

The targets, which were water cooled, consisted either of a solid magnesium specimen scraped clean *in vacuo*, or a layer of magnesium evaporated onto a solid copper backing. The variation with time of the peak intensity of the band at 250 Å is illustrated in Figure 1, in which curve (*a*) is for solid magnesium and (*b*) and (*c*) are for thick and thin films of magnesium evaporated onto copper. The zero of the time scale corresponds to switching the electron beam onto the freshly prepared surface. The initial small drop in (*a*) is attributed to a rapid oxidation of the freshly cut metal surface. This effect has also been observed for solid targets of the alkali metals where there is a much greater fall to about 30 per cent. of the initial intensity in some 60 sec. The decrease is approximately exponential, in agreement with the findings of Kingston (1951) for potassium and calcium.

The initial fall is not observed in (*b*) because there is about 15 sec delay between ceasing evaporation and turning on the electron beam and presumably there is a more rapid oxidation of evaporated magnesium. The initial rise in (*c*) is attributed to homogenization of the thin film under the action of the electron beam.

The linear fall in each case is caused by the deposition of carbon from residual organic vapours when bombarded by the electron beam (Ennos 1953, 1954; Fisher, Crisp, and Williams 1958). After 35 or 40 min bombardment a brownish film is clearly visible on the target surfaces. Contamination curves of the above kind were recorded at the peak, dip, and hump at 250, 253, and 263 Å respectively

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(P, D, H in Fig. 2) and were found to be the same for any one type of target. From this it is concluded that the relative intensities of these features do not alter as contamination effects proceed. This makes possible a correction when comparing intensities observed at different wavelengths at different times.

A large number of spectra were recorded for both solid and evaporated targets, the interval after preparation of the target surface being sufficient to

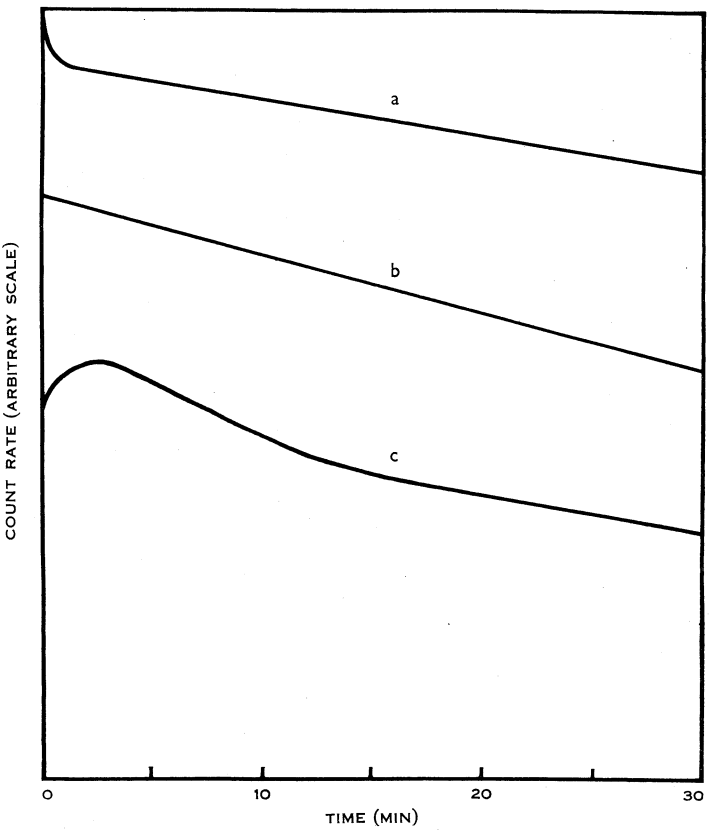

Fig. 1.—Typical curves illustrating the variation of the intensity of radiation emitted at a particular wavelength with time for a freshly prepared target surface at 8×10^{-6} mm Hg. (*a*) Solid magnesium, scraped surface; (*b*) thick evaporated magnesium film, evaporating furnace run for about 15 sec; (*c*) thin evaporated magnesium film, evaporating furnace run for about 5 sec.

ensure that the contamination rate was linear. Scanning speeds were selected with due consideration of the response time of the recording devices (Fisher, Crisp, and Williams 1958). Counting losses were negligible for the counting rates and the resolving time used.

A typical record for a solid target is shown in Figure 2. R indicates the reversal of the direction of traverse. Although the speed of traverse has also

changed at R the abscissae still correspond to a linear time scale and therefore the correction $\pm\delta$ to be applied to the peak intensity P when comparing it with the hump intensity H is valid. A similar correction was applied to the dip intensity D and values were calculated for the ratios $(P-B)/(H-B)$ and $(D-B)/(H-B)$, where B is the background. The mean values of these ratios agreed for spectra from both types of target to within the probable error of 3 per cent. It is therefore concluded that the band shapes are constant, at least in so far as they are represented by these ratios.

Measurements were also made of the edge breadth and wavelength as defined by Skinner (1940). The edge breadths for solid and evaporated targets are constant to within 0·02 eV and the edge wavelengths to within 0·09 Å. Because of the different thermal conductivities of the solid magnesium and copper targets

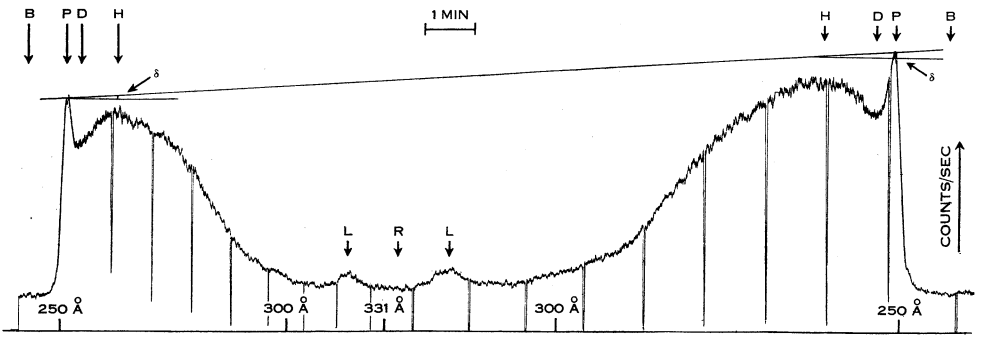

Fig. 2.—Reproduction of chart record for the L_{23} band emitted from a solid magnesium target. Target voltage 4 kV. Target current 4 mA. Maximum counting rate 4000 counts/sec. For explanation of lettering see text. L indicates the $(L_3—L_1)$ line identified by Tomboulian and Cady (1941).

an estimate was made of the difference in surface temperature resulting from the electron beam. This came to about 60 °C and allowed a small correction to be made to the observed edge breadths. No density of states curve has been deduced from the present data, since the optical resolution of 0·9 Å causes considerable loss in the observed height of the sharp peak. It is of interest to notice, however, that in the present instrument, where the plane of the analyser slit lies along a radius of the Rowland circle, the experimental " window " $d\lambda$ Å wide is constant for all wavelengths and the intensities recorded are certainly proportional to the number of photons in the wavelength range $d\lambda$ Å (Fisher 1954). There is thus no doubt what power of the frequency of radiation to use when translating from observed spectra to density of states curves (Tomboulian 1957), in contrast to the photographic case.

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