

A Note on the Hyperfine Structure of Beryllium Lines

The identification of the neutron by Chadwick¹ has developed a keen interest in the value of the nuclear moment of beryllium. For this reason the beryllium lines given in Table I have been examined for structure with the aid of a Fabry-Perot interferometer. The interferometer plates were spaced 2, 3, 5, 8 and 10 mm apart. The spectrum was excited in a metal liquid air-cooled Schüller lamp so that the Doppler effect should be small.

The only line showing a definite structure was the Be II line $\lambda 4673\text{A}$. $3\ ^2D-4\ ^2F$ transition. The wave-length separation here corresponds to a $\Delta\nu$ difference of 0.480 cm^{-1} , which is the $3\ ^2D_{3/2}-3\ ^2D_{5/2}$ separation.

TABLE I.

line	λ	classification	structure
Be I	8254	$2\ ^1P-3\ ^1S$	sharp
Be II	4673	$3\ ^2D-4\ ^2F$	one component at -0.105A
Be I	4572	$2\ ^1P-3\ ^1D$	sharp
Be II	3130	$2\ ^2S-2\ ^2P_{1/2,3/2}$	sharp
Be I	2348	$2\ ^1S-2\ ^1P$	line width about 0.030A

The term "sharp" in Table I means that no structure was found. In the case of $\lambda 3130$ the two lines $2\ ^2S_{1/2}-2\ ^2P_{1/2}$ and $2\ ^2S_{1/2}-2\ ^2P_{3/2}$ are 0.648A apart and were unresolved by the prism instrument used. It was, therefore, necessary to make one line fall on the first chief maximum of the other line in the interferometer pattern so that the intervening space would be free to show any components. Even so, no components were found.

The only indication of possible structure lies in the fact that $\lambda 2348\text{A}$ has a line width of about 0.030A .

This negative result does not necessarily mean that $i=0$ for Be and it is hoped that an examination of the Be III and IV lines with the 21 ft. grazing incidence vacuum spectrograph which is now being set up in this laboratory will show a beryllium structure comparable with that of lithium.

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¹ T. Chadwick, Nature **129**, 312 (1932).

Newton's Rings in Transparent Metallic Films

In attempting to produce a film of manganese on glass by cathodic sputtering from a piece of pure manganese only $2.5 \times 1.5\text{ cm}$ in area, a series of colored fringes were observed in the film by reflected light. These fringes are undoubtedly similar to those observed by Bockstahler and Overbeck¹ who reported some observations on sputtered tin. In order to make a closer study of these fringes, a mica screen having a circular opening of 1.5 cm diameter, was placed about one mm in front of the manganese cathode. Due to the intense heating, a Pyrex glass plate was used to receive the film. Manganese sputters very slowly. With a current of about 10 milliamperes, hydrogen being the residual gas, some ten hours were required to produce a film in which was visible, by reflected light, a series of brilliant Newton's rings. During the period of sputtering these rings gradually increased in size, other rings forming within, until the outermost ring had a diameter of almost 5 cm . The order of colors appearing was as follows: yellow, light brown, reddish brown, purple, blue, green, and back to yellow. This

seems to be about the same as that reported by Edwards² who made some observations on films of copper deposited on aluminum and nickel.

The glass directly underneath the center of the circular opening in the mica, was found to be free of any metallic deposit, due doubtless to the intense heating of the glass plate produced by the cathode rays. The film was thus of variable thickness, being a maximum just under the edge of the circular opening in the mica screen, and diminishing to zero both towards the center and the edges of the glass plate. Hence a cross section of the film taken across the center of the glass plate would be like a vertical cross section of a volcanic mountain, the center of the film corresponding to the crater of the volcano.

It seems quite likely that the colored fringes are due to the interference of light between the front and rear surfaces of the transparent manganese film, confirming the

¹ L. I. Bockstahler and C. J. Overbeck, Phys. Rev. **37**, 465 (1931).

view taken by Edwards.² These rings enable one to test this assumption, for whatever phase differences in light that might be introduced as the result of reflection and refraction at the front and rear surfaces of the film, it must be true that adjacent rings of identical color are located at points in the film differing in thickness by one half of a wave-length as measured in the metal. This serves as a step by step method for evaluating the thickness of the film at various points. Accordingly the film was illuminated normally by monochromatic light, and the positions of the various black interference rings measured by means of a short focus cathetometer. Reflection from the rear of the glass plate was eliminated by attaching a glass prism to the rear of the plate by means of cedar oil.

There is some question as to the thickness of the film at the first or outermost black ring. Allowing for the phase differences due to reflection and refraction at the surfaces of the film, the thickness of the film at this point was estimated to be not over one tenth of a wave-length. By plotting two cross sections of the film taken at right angles to each other, the mean thickness of the film was evaluated graphically. The maximum thickness of the film was found to be 8.1×10^{-5} cm.

Total Secondary Electron Emission from Metal Faces

It is well known that in experiments relating to the emission of secondary electrons from metal faces due to an incident beam of primary electrons, the ratio R of the total secondary to the primary current increases almost linearly with the potential from about 30 volts, attains a broad maximum (almost similar to a saturation effect) at some potential and then decreases slowly and linearly as the applied potential is increased. The energy at which the maximum occurs depends on the nature of the target and also for any particular metal, on the nature of the crystal face bombarded.^{1,2} The reason why the secondary electron curve bends round and decreases at higher potentials has so far been obscure.

Copeland³ has recently made the interesting suggestion that if the rate of fall of R with potential be divided by the actual value of R in the region, the ratio for various metals gives a fairly linear graph when plotted against the densities of the targets. The aim of this note is to draw attention to the further interesting observation that this ratio for any

Assuming the film as having a circular area of 2.5 cm in diameter, the weight of the film was computed by means of the expression $\pi r^2 d N \lambda / 2n$, where r is the radius of the film; d , the density of manganese; n , the refractive index of manganese as obtained previously³ for this sample forming the cathode; λ , the wave-length in air; and N the number of black fringes which serves as a measure of the mean thickness of the film. The weight of the manganese film so computed was 0.0045 gr from measurements made on the black rings as viewed in mercury green light, and 0.0042 gr as viewed in yellow sodium light. By actual weight of the glass plate before and after sputtering, the weight of the manganese film was found to be 0.0040 gr. The results are sufficiently in agreement to justify the conclusion that the phenomenon observed is one of interference.

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² H. W. Edwards, *Phys. Rev.* **38**, 166 (1931).

³ J. B. Nathanson, *J. O. S. A.* **20**, 593 (1930).

particular metal probably depends also on the grating constant of the crystal face presented for bombardment. Experiments on polycrystalline nickel targets¹ and on the 100² and 110 faces of large nickel single crystals, conducted by the writer in Prof. O. W. Richardson's laboratories in King's College, London, show that the ratio dR/RdV varies almost linearly with the grating constants of the faces.

These observations suggest that the decrease of R at higher potentials is probably due to the absorption of the primary electrons and to a much larger extent of the secondary electrons. As the potential is increased, the depth of penetration of the primary electrons within the metal increases and as a result, there is much greater absorption of the slower

¹ S. R. Rao, *Proc. Roy. Soc.* **A128**, 41 (1930).

² S. R. Rao, *Proc. Roy. Soc.* **A128**, 57 (1930).

³ P. L. Copeland, *Phys. Rev.* **40**, 122 (1932).