Electronic Excitation of the L_{III} State of 5*d* Elements

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Experiments by Nilsson on the electronic excitation of the *K* state of 3*d* transition elements have revealed a structure in the excitation curves. Similar structure close to the excitation potential has been observed for the excitation of the L_{III} state of some 5*d* elements.

THE precision determination of h/e from the high frequency limit of the continuous x-ray spectrum has been the object of much painstaking work in several laboratories during the past decade.[1–6] It is also possible to determine h/e from a precise measurement of the electronic excitation potential of one of the x-ray levels and using the corresponding frequency as determined from absorption edge analysis.[4] Results obtained with this method have been reported by Bearden and Schwarz,[1] and recently a detailed and comprehensive report has been published by Nilsson.[7] This latter research was originally undertaken to determine h/e and to clarify the work function correction, but it has also revealed a structure in the *K* excitation curve of 3*d* elements. This structure, which in some ways is similar to the structure in the corresponding absorption edge, can be related to the density of states in the conduction band. The purpose of this note is to point out that such structure also exists in the excitation curves of 5*d* elements for which we have made some measurements.[8]

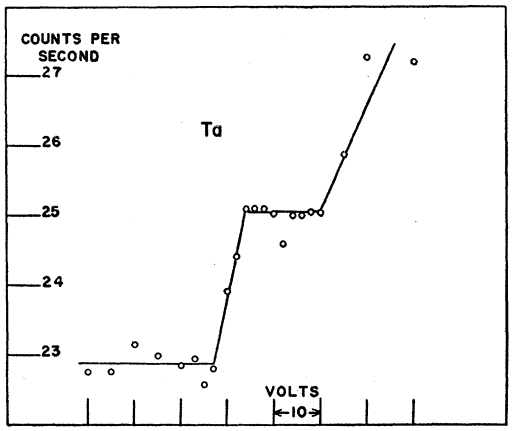

FIG. 1. L_{III} excitation curve of Ta.

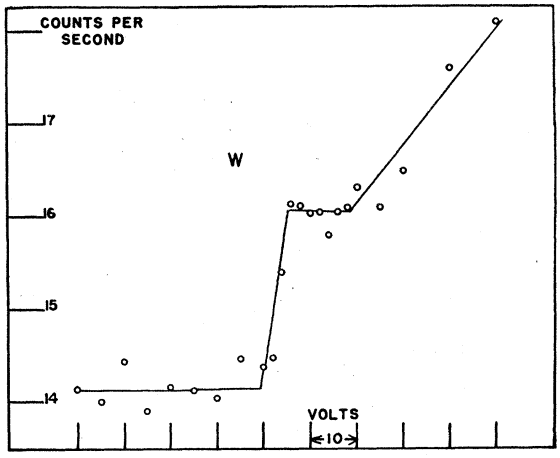

FIG. 2. L_{III} excitation curve of W.

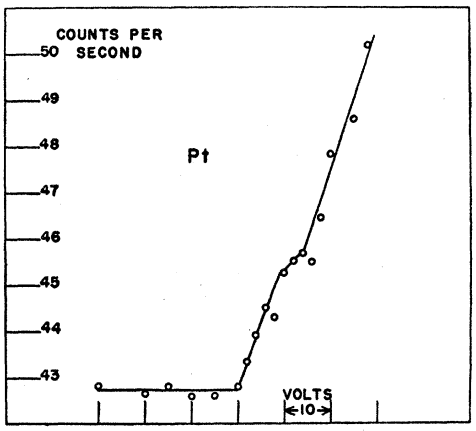

FIG. 3. L_{III} excitation curve of Pt.

The electronic excitation of the L_{III} state was measured as a function of the energy of the bombarding monoenergetic electrons coming from a unipotential oxide-coated cathode.[9] A double-crystal x-ray spectrometer was used as a monochromator, set to pass the peak of the $L\alpha_1$ line. The highly stabilized x-ray tube voltage

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[2] G. Schwarz and J. A. Bearden, Phys. Rev. **74**, 1209 (1948).
[3] G. Schwarz and J. A. Bearden, Phys. Rev. **75**, 1304 (1949).
[4] J. A. Bearden and G. Schwarz, Phys. Rev. **79**, 674 (1950).
[5] Panofsky, Green, and Dumond, Phys. Rev. **62**, 214 (1942); J. W. M. Dumond and G. Felt, (private communication).
[6] P. Ohlin, Diss. Uppsala Universitets Arsskreft 1941 (unpublished); Arkiv Mat. Astron. Fysik **A29**, No. 3 (1942); **B29**, No. 4 (1942).
[7] Ake Nilsson, Arkiv Fysik **6**, No. 49 (1953).
[8] G. L. Rogosa and G. Schwarz, Phys. Rev. **78**, 343 (1950). As pointed out in that abstract, electronic excitation curve structure was first found by one of us (G. S.) in 1941 in the laboratory of Professor J. A. Bearden at The Johns Hopkins University. The work was interrupted by the war and additional data were later obtained also at The Johns Hopkins University during 1948–1949.
[9] For details of the experimental equipment see reference 4.

was changed in steps of a few volts and the $L\alpha_1$ x-ray intensity, recorded by a Geiger counter, was measured as a function of the voltage. This intensity is a measure of the electronic excitation of the L_{III} state. Figures 1–3 show the L_{III} excitation curves of the $5d$ elements Ta, W, and Pt, revealing a structure very similar to that recorded by Nilsson for the $3d$ elements.

One of the major difficulties in obtaining the excitation curve is the contamination of the target. This factor limited the number of runs which could be averaged. Figure 1 is the average of four runs with 4096 counts per point. Figure 2 is the average of five runs with 5120 counts per point, and Fig. 3 is the average of five runs with 10 240 counts per point. The structure shown in the excitation curves is reproducible under "clean" target conditions. We have chosen to draw the curves with straight line segments in that future careful work will probably reveal more detailed structure for the $5d$ elements similar to that found by Nilsson in some of the $3d$ elements.

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Energy Levels in F^{18} from Alpha-Particle Reactions in Nitrogen*

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We have examined both the elastic scattering of alpha particles in nitrogen as a function of the energy between 1.5 and 3.5 Mev at 90°, 125°16′, 137°43′ and 156°20′ (center of mass), and the cross section for the $N^{14}(\alpha,p)O^{17}$ reaction at 90° (lab) in the same energy region. Two new resonances at $E_\alpha=2.935$ Mev and $E_\alpha=3.140$ Mev correspond to levels in F^{18} at excitation energies of 6.69 Mev and 6.85 Mev, respectively. These same levels were found to emit protons as well, leading to the ground state of O^{17}. The (α,p) reaction has a relative probability of about 5 percent for the upper level and 0.3 percent for the lower level, compared to the elastic scattering.

1. INTRODUCTION

THE availability of high currents of singly charged helium ions from our pressurized Van de Graaff generator using a radio-frequency ion source makes it possible to re-examine most of the alpha-particle reactions which were carried out with natural alpha emitters in the past. Since we had a gas scattering system available from our alpha-helium scattering experiments,[1] we decided to investigate the historically important nitrogen nucleus, first disintegrated by Rutherford in 1919.[2] The elastic scattering of alpha particles on nitrogen had previously been studied at higher energies by Devons[3] and Brubaker,[4] yielding broad resonances in F^{18} at 8.0-Mev and 8.5-Mev excitation ($E_\alpha=4.6$ Mev and 5.2 Mev, respectively). Champion and Roy,[5] using cloud-chamber technique, and Roy,[6] employing nuclear emulsions, have studied the $N^{14}(\alpha,p)O^{17}$ reaction. They reported resonances distinct from those giving rise to elastic scattering anomalies at about 5.6-, 7.1-, and 7.6-Mev excitation in F^{18} corresponding to alpha energies of 1.7, 3.5, and 4.2 Mev, respectively. Angular distributions of the proton groups leading to the ground state and the 0.875-Mev excited state of O^{17} were obtained by Roy[6] for the two highest levels.

2. EXPERIMENTAL

(a) $N^{14}(\alpha,\alpha)N^{14}$

A beam of singly charged helium ions collimated to a circular area of 1 mm diameter entered our scattering chamber through a differential pumping system. The scattering gas pressure was kept around 3 mm Hg. A movable proportional counter filled with nitrogen to 7 cm Hg subtended an angle of about two degrees at the scattering volume and could be set accurately at angles up to 147.5° in the laboratory. A very thin window of Formvar some 6–8 $\mu g/cm^2$ thick allowed us to efficiently detect alpha particles down to about 40 kev.

A Faraday cup separated from the scattering chamber by a 0.00002-inch nickel foil was used to integrate the beam current. The normalization of the entire system was achieved by scattering from argon gas, for which pure Rutherford scattering behavior in both angular and energy dependence was ascertained over the ranges of interest.

* A preliminary account of this work was given at the 1953 Washington Meeting of the American Physical Society [Bull. Am. Phys. Soc., 28, No. 3, 15 (1953)].

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