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U L_1 X-RAY TRANSITION FROM SEPARATED ISOTOPES

G. L. Rogosa
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U L_I X-RAY TRANSITION FROM SEPARATED ISOTOPES

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September 26, 1955

JAN 9 1956

STABLE ISOTOPE RESEARCH AND PRODUCTION DIVISION
C. P. Keim, Director

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ABSTRACT

The $L\beta_3$ ($L_I \rightarrow M_{III}$) x-ray transition of U has been measured from separated isotopes using a double crystal x-ray spectrometer. Special target pellets were fabricated and placed inside a demountable and continuously pumped x-ray tube. No evidence for an isotope shift on the L_I x-ray level was found in the measurement of this transition from separated isotopes of U^{233}, U^{235}, and U^{238}.

U L_I X-RAY TRANSITION FROM SEPARATED ISOTOPES

INTRODUCTION

An experimental search for hyperfine structure and isotope shift in x-ray transitions has been the subject of two recent investigations. While these effects show up clearly in optical spectra, they have yet to be seen in x-ray spectra. Frilley, Gokhale, and Valadares[1] measured the widths of the $K\alpha$ lines of the elements from $_{37}Rb$ to $_{50}Sn$ with the thought of finding a hyperfine broadening for the $K\alpha$ lines of Nb and In because of their high nuclear spin and magnetic moment values. No departure in these line widths from the normal variation as a function of Z was observed, however. Rogosa and Schwarz[2] have availed themselves of separated isotopes in a search for nuclear isotopic effects on x-ray levels. The $K\alpha$ x-ray lines from Mo^{92}, Mo^{95}, and Mo^{100} and the $L\alpha_1$ and $L\beta_1$ x-ray lines from U^{235} and U^{238} were measured with no observable change in peak position or line width for the same transition from each isotope. The $L\alpha_1$ and $L\beta_1$ transitions from the U isotopes involve the L_{III} and L_{II} levels respectively. L lines originating from the L_I level were too weak to measure with their experimental arrangement since the transitions were induced by radiative excitation. Inasmuch as the nuclear isotopic effects would be greater for the L_I state as compared with the L_{II} or L_{III} state, we have now measured the $L\beta_3(L_I \rightarrow M_{III})$ x-ray line from separated isotopes of U^{233}, U^{235}, and U^{238}.

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[1] Frilley, Gokhale, and Valadares, Compt. rend. 233, 1183 (1951)

[2] G. L. Rogosa and G. Schwarz, Phys. Rev. 92, 1434 (1953)

The isotope shift observed in the optical spectra of heavy elements has been interpreted in terms of a "nuclear volume" effect.[3,4,5]

Igo and Wertheim[6], using the "volume" effect theory have calculated expected isotope shifts in the x-ray spectra of U. Comparison of our new measurements on U isotopes with their calculations for these isotopes is made.

EXPERIMENTAL

We have employed the standard techniques of x-ray spectroscopy in the measurement of the x-ray transition. Targets were prepared in the form of pellets containing separated U isotopes. The pellets were soldered individually to the copper-block target assembly of a demountable and continuously pumped x-ray tube. The pellets were fabricated such that they consisted of a base of pure copper powder, with U_3O_8 containing 10% copper powder pressed on the surface and they were sintered in a vacuum furnace at 900°C in order to give them mechanical strength. The target assembly and metal wall of the x-ray tube were water cooled. The x-ray tube was operated at 32 kv and 5 ma. Both the high voltage and the x-ray tube current were stabilized to within 0.1%.

The x-ray spectrometer is of the Ross type having a translating first crystal and rotating second crystal. Excellent calcite crystals are employed giving line widths that compare favorably with those obtained with the best crystals reported. The rotation of the second crystal is achieved by means of a precision micrometer screw and lever arrangement. Angular differences are measured to better than 1".

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[3] G. Breit, Phys. Rev. 42, 348 (1932)
[4] M. F. Crawford and A. L. Schawlow, Phys. Rev. 76, 1310 (1949)
[5] L. Wiltets, D. L. Hill, and K. W. Ford, Phys. Rev. 91, 1488 (1953)
[6] G. Igo and M. S. Wertheim, Phys. Rev. 98, 1 (1955)

Intensities were measured with a Geiger counter filled with krypton to a pressure of 70 cm. Al absorbers were used to reduce the intensity to resolvable counting rates. Data on the x-ray line were recorded by counting for a fixed time interval, one minute, point by point through the line. Numerous runs were obtained, resetting the spectrometer and counting over at the same points.

RESULTS AND DISCUSSION

The U L x-ray lines have been previously measured by Williams[7]. He found that the predominance of nuclear effects were evident from the greater widths of lines involving the elliptical orbit L_I. The half-width of $L\beta_3(L_I \rightarrow M_{III})$ a relatively weak transition was measured to be 18.8 ev. We have measured this transition from separated isotopes of U^{233}, U^{235}, and U^{238}. We have centered our attention on the location of the peak position of this transition for possible isotope shift. Accordingly we have run through the significant part of the x-ray line. Figure 1 shows five separate runs of $L\beta_3$ from U^{238}. Measurements on U^{235} were obtained before and after those on U^{238}. Figure 2 shows five runs on $L\beta_3$ from U^{235}, two of these runs were made before and after the measurements on U^{238}. Although the x-ray tube voltage and current were stabilized, intensity changes sometimes resulted from internal conditions in the x-ray tube. Some runs were rejected on this basis. We were successful, however, in obtaining five reliable runs from U^{238} and ten reliable runs from U^{235}. Unfortunately intensity changes which took place during the measurements from the U^{233} target were such that we present no reliable runs for this isotope.

Peak positions from each of the curves have been determined and there results no measurable isotope shift. The limit of an observable effect is estimated to

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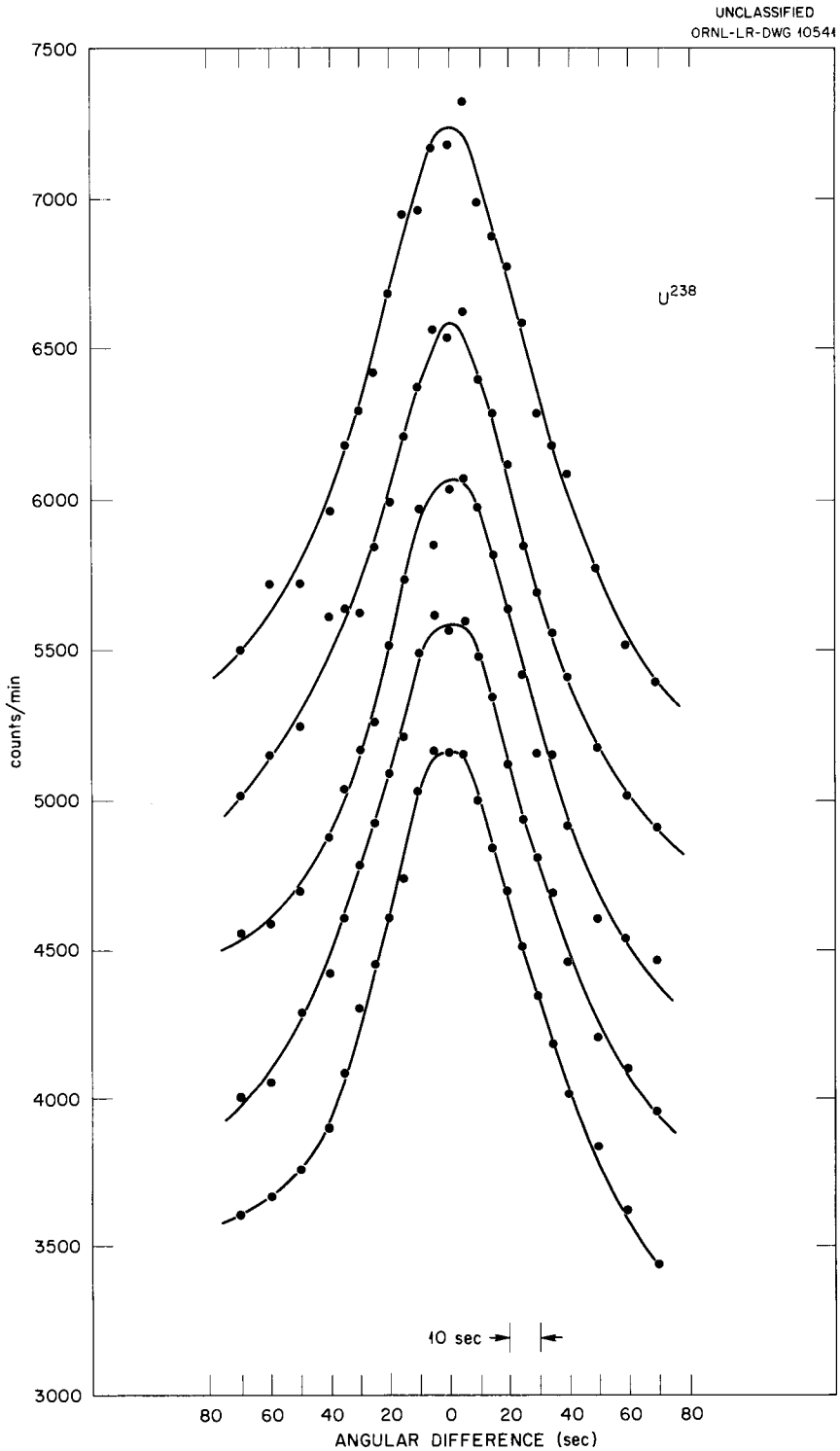
[7] J. H. Williams, Phys. Rev. 37, 1431 (1931)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ORNL-LR-DWG 10541
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
counts/min
U238
10 sec
80
60
40
20
0
20
40
60
80
ANGULAR DIFFERENCE (sec)

Figure 1

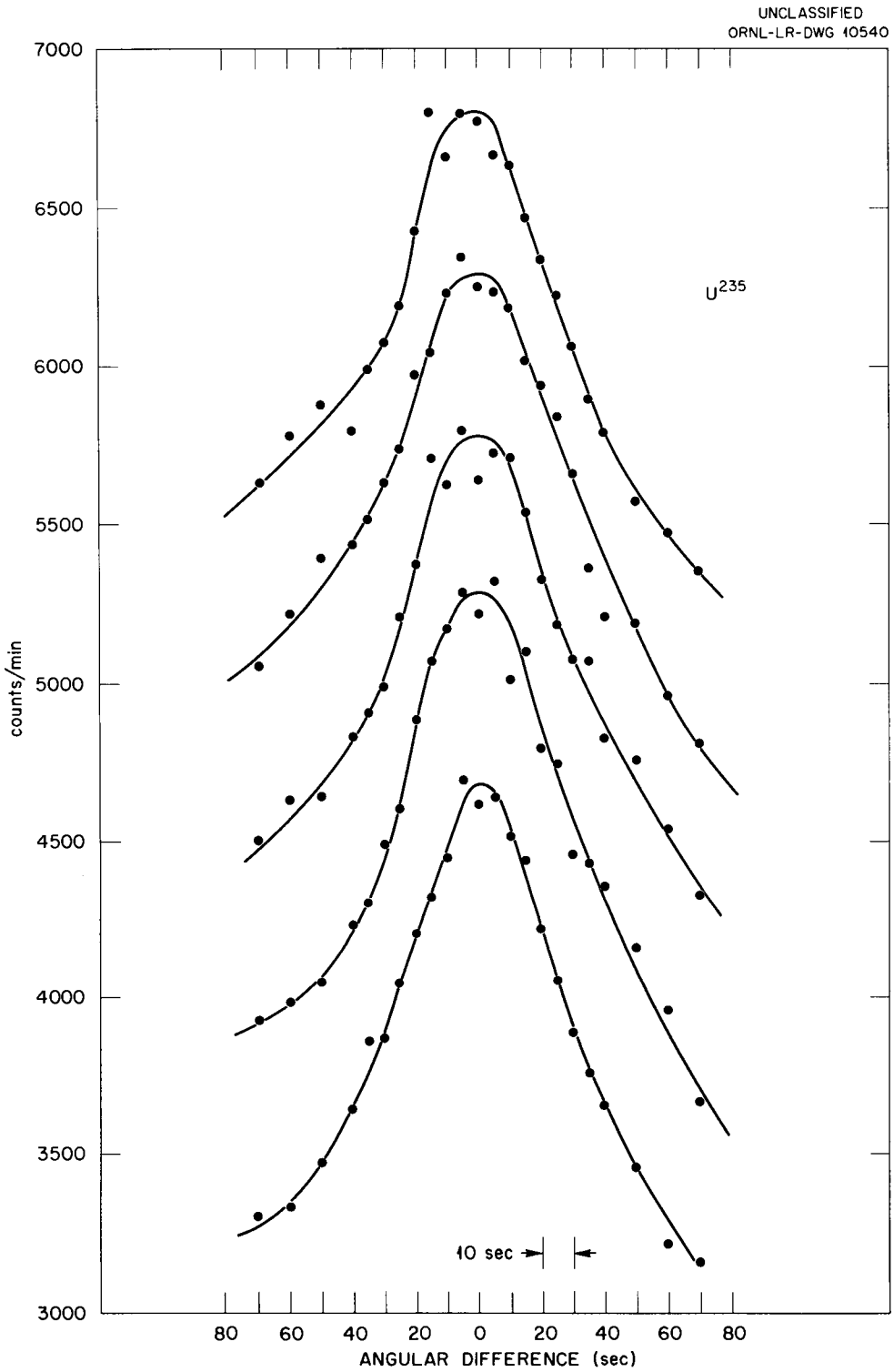
UNCLASSIFIED
ORNL-LR-DWG 10540
7000
6500
6000
5500
5000
4500
4000
3500
3000
counts/min
U235
10 sec
80
60
40
20
0
20
40
60
80
ANGULAR DIFFERENCE (sec)

Figure 2

be 1 ev. While the data from U^{233} were less satisfactory, it appears that there exists no measurable shift of the $L\beta_3$ transition from U^{233} and U^{238} with the presently employed techniques. Due to limitations of voltage and resulting low line to background ratio, half width measurements were not made.

On the "top slice" model Igo and Wertheim found that the $2s_{1/2}$ level in U has an expected shift of 0.14 ev per mass number difference. Thus for the U^{235}, U^{238} data our experiment would not have detected this calculated shift of 0.4 ev.

We have thus extended the search for nuclear isotopic influence on x-ray levels in the measurement of x-ray transitions from separated isotopes. Transitions involving all of the L levels of U have now been recorded. Present x-ray spectroscopic techniques still appear to lack the resolution to detect nuclear isotopic influence on these x-ray levels.