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DISCLAIMER

ON ALPHA DECAY OF ^{255}No and ^{257}No*

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ABSTRACT

The alpha decay of ^{255}No and ^{257}No produced by $^{249}Cf(^{12}C,\alpha 2n)^{255}No$ and $^{248}Cm(^{13}C,4n)^{257}No$ reactions, respectively, has been studied. Five alpha-particle groups with energies and intensities 8.30(3%), 8.25(6%), 8.11(57%), 7.92(19%), and 7.76 MeV(15%) were assigned to ^{255}No and three alpha-particle groups with energies 8.32, 8.27 and 8.22 MeV to ^{257}No. The half-lives of ^{255}No and ^{257}No were measured to be 200±10 sec and 26±2 sec, respectively. The decay schemes of ^{255}No and ^{257}No are discussed.

I. INTRODUCTION

In our previous work[1] concerning alpha decay of nobelium isotopes, ^{255}No was produced by the nuclear reaction $^{246}Cm(^{13}C,4n)^{255}No$. Its alpha energy was reported to be 8.11±0.02 MeV and half-life 185±20 seconds. ^{257}No was produced by the reaction $^{248}Cm(^{13}C,4n)^{257}No$. Two alpha-particle groups of 8.23±0.02 MeV (50%) and 8.27±0.02 MeV (50%) were assigned to ^{257}No, and its half-life was found to be 23±2 sec.

Flerov et al.,[2] have produced ^{255}No using the reaction $^{238}U(^{22}Ne,5n)^{255}No$. Their values for alpha energy and half-life of ^{255}No are 8.08±0.03 MeV and 3.0±0.2 minutes. Flerov's group has not reported any results concerning ^{257}No.

In the present work ^{255}No and ^{257}No were produced in much larger amounts than earlier. While making experiments on rutherfordium (element 104) we noticed that ^{255}No is produced in greater yield by bombarding ^{249}Cf with ^{12}C ions than by bombarding ^{246}Cm with ^{13}C ions. This made it possible to investigate the fine structure in the alpha decay of ^{255}No in considerable detail.

II. EXPERIMENTAL

The ^{249}Cf target was the same as used in our rutherfordium work:[3] 60 micrograms of ^{249}Cf in an area of 0.21 cm^2, or 290 micrograms/cm^2. The 47 microgram ^{248}Cm target, used to produce ^{257}No from $^{248}Cm(^{13}C,4n)^{257}No$, was electrodeposited from an isopropyl alcohol solution in an area of 0.13 cm^2 on a substrate sandwich consisting of 0.1 mg/cm^2 Pd sputtered onto 2.2 mg/cm^2 Be. According to the mass analysis, this 350 microgram/cm^2 target contained 93.7% ^{248}Cm, less than 0.2% ^{247}Cm, 3.2% ^{246}Cm, 0.6% ^{245}Cm, and 2.4% ^{244}Cm. The targets were bombarded mainly by ^{12}C and ^{13}C ions accelerated by the Berkeley

Hilac. Currents in the range of 2 to 4 microamperes dc (as completely stripped ions) were used.

The apparatus used was the same as that used in our rutherfordium work[3] and similar to that described in our previous papers about nobelium.[1,4]

III. ^{255}No

In ^{12}C bombardments of ^{249}Cf target several nobelium isotopes were produced by ($^{12}C,\alpha xn$) reactions. In Fig. 1 there is a series of spectra of such a bombardment. The energy of ^{12}C ions was 70 MeV. There are four consecutive spectra, 200 seconds each, and the topmost spectrum is the sum of the four. Some of the peaks are due to a minute lead impurity in the target. The prominent alpha-particle group at 8.11 MeV is partly due to the alpha decay of ^{254}No, although at this energy it mostly belong to ^{255}No. Besides this peak there are four other alpha-particle groups with energies 7.76, 7.92, 8.25, and 8.30 MeV which decay with the same half-life, 200±10 seconds, as the 8.11-MeV alpha-particle group of ^{255}No, and in addition they have similar excitation functions to that of the 8.11-MeV peak. These two features together with some cross bombardments indicate that the four peaks are due to the alpha decay of ^{255}No, too. The energies and relative intensities of the alpha-particle groups were determined by submitting the spectra to a computer analysis[5] using the SAMPO program written for the analysis of gamma spectra by Routti and Prussin. The results are presented in Table I. For alpha-energy calibration, the 7.04-MeV peak of ^{252}Fm and the 7.43-MeV peak of ^{250}Fm were used. Excitation curves of several activities produced by bombardment of ^{249}Cf with ^{12}C ions are presented in Fig. 2.

A decay scheme for ^{255}No is proposed in Fig. 3. The decay scheme of

^{253}Fm [6] is presented for comparison. Numbers to the right of the levels are the energy of the level in keV, corresponding alpha energy in MeV, relative intensity of the alpha transition, and the alpha decay hindrance factor. Hindrance factor calculations are based on spin independent (ℓ=0) equations of Preston.[7] The radius parameter was evaluated from data on nearest two even-even alpha emitters.

Although no gamma spectroscopic studies have been done, spin and parity assignments are suggested on the basis of expected analogy with the decay of ^{253}Fm. Judging by the gross features of the level scheme and considering the hindrance factors for the alpha transitions, it seems probable that the ground state of ^{255}No is the same as that of ^{253}Fm and the ground state of ^{251}Fm is the same as that of ^{249}Cf. The 50-keV state is then the first member of the ground-state rotational band. The 190-keV state may be the same as the 145 keV $5/2^+[622\uparrow]$ hole state in ^{253}Fm decay scheme. The hindrance factor for the 7.76-MeV alpha transition is 1.6 and indicates a favored alpha transition. It seems probable that the 550-keV state is the same as the ground state of ^{255}No, or $1/2^+[620\uparrow]$ and corresponds to the 417-keV state in ^{253}Fm decay. Then according to the Nilsson diagram the 380-keV state might be the $7/2^+[624\uparrow]$ hole state or the $7/2^+[613\uparrow]$ particle state, both of which have not been observed in ^{253}Fm alpha decay. However, the hindrance factor 5.2 of the 7.92-MeV alpha transition is much too small for a L = 4 alpha transition. On the basis of the hindrance factor a possible candidate for the 380-keV state is the $3/2^+[622\uparrow]$ particle state.

IV. ^{257}No

^{257}No was produced by bombarding ^{248}Cm with ^{13}C ions. The series of spectra in Fig. 4 is the sum of four different experiments with ^{13}C ion energies ranging from 66 MeV to 74 MeV. The top spectrum is the sum of the individual 20-sec spectra from the four detectors. Again some of the labeled peaks are due to a lead impurity in the target. The three alpha groups at 8.22, 8.27, and 8.32 MeV are assigned to ^{257}No. The 8.43-MeV peak is mainly due to the alpha decay of ^{256}No, and because of the 3-sec half-life it is seen only in the first spectrum. Lighter nobelium isotopes are not seen in these spectra. Excitation curves for ^{257}No and ^{256}No are presented in Fig. 5. ^{257}No is produced by (^{13}C,4n) reaction and ^{256}No by (^{13}C,5n) reaction. The contribution of ^{214}Fr in the 8.43 MeV peak of ^{256}No can be calculated from the amount of ^{214}Ra in spectra. At the bombarding energy of 75 MeV about 2% is due to ^{214}Fr. The half-life of ^{257}No was measured to be 26±2 seconds. The energies and relative intensities of the three alpha-particle groups of ^{257}No were determined with help of the SAMPO program.[5] The 7.04-MeV peak of ^{252}Fm and the 8.43-MeV peak of ^{256}No served as energy calibration values. The results are presented in Table II together with assumed level energies and calculated hindrance factors. The value of the radius parameter of ^{256}No was used in hindrance factor calculations.

If the decay scheme of ^{257}No is analogous to that of ^{255}Fm, there should be a favored alpha transition to a level around 100 keV, while the transition to the ground state of ^{253}Fm should be strongly hindered. In ^{255}Fm alpha decay[8] 93% of the alpha transitions lead to a 107-keV state and the hindrance factor of the transition is 1.2, but only 0.09% of the transitions lead to the ground state of ^{251}Cf and the hindrance factor is 3500. Considering the hindrance factors for ^{257}No alpha transitions, it seems probable that the

8.22-MeV alpha group corresponds to the favored transition mentioned above. The 8.32-MeV alpha transition, then, should lead to the ground state of ^{253}Fm, but the hindrance factor 19 of this transition is much too small for a L=4 alpha transition. Also, the hindrance factor 9.6 for the 8.27-MeV alpha group is too small compared to the value 460 for the transition leading to a 48-keV state in ^{255}Fm alpha decay. It seems probable to us that in our ^{257}No spectra the 8.27-MeV and 8.32-MeV peaks are too intense because of summation of the signals from the conversion electrons in coincidence with the 8.22-MeV alpha group. We plan to investigate this by changing the detector geometry in the future measurements. Because of this uncertainty, the intensity values and hence the hindrance factors in Table II are in parentheses.

V. ACKNOWLEDGMENTS

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Table I. Alpha groups of ^{255}No

Alpha-particle energy [MeV]	Excited-state energy [keV]	Intensity [%]	Hindrance factor
8.30 ± 0.02	0	3 ± 1	620
8.25 ± 0.02	50	6 ± 1	210
8.11 ± 0.01	190	57 ± 3	7.8
7.92 ± 0.01	380	19 ± 2	5.2
7.76 ± 0.01	550	15 ± 2	1.6

Table II. Alpha groups of ^{257}No

Alpha-particle energy [MeV]	Excited-state energy [keV]	Intensity [%]	Hindrance factor
8.32 ± 0.02	0	(19 ± 2)	(19)
8.27 ± 0.02	50	(26 ± 2)	(9.6)
8.22 ± 0.02	100	(55 ± 3)	(3.1)

FOOTNOTES AND REFERENCES

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FIGURE CAPTIONS

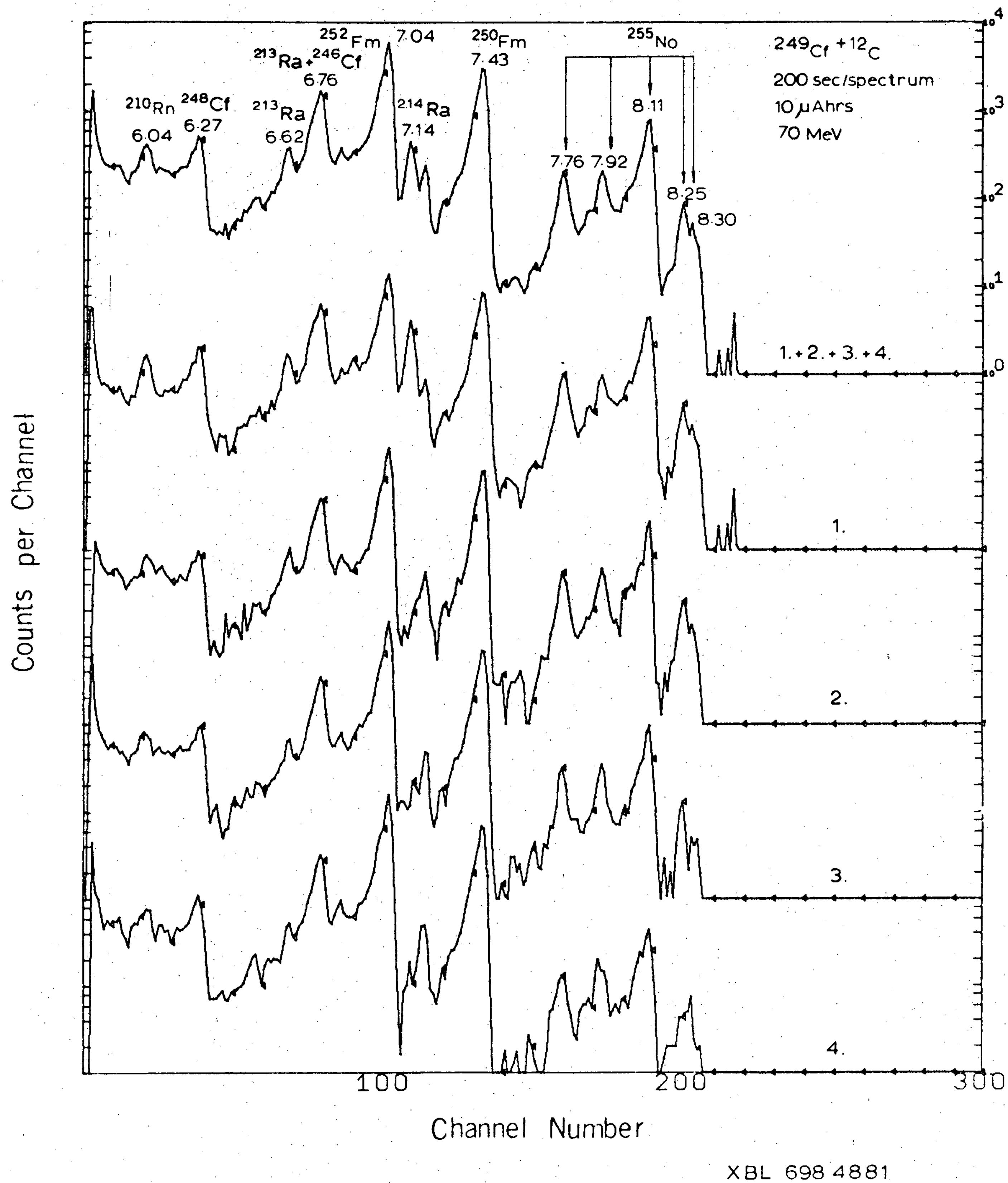
Fig. 1. A series of alpha spectra of the activities produced by bombardment of ^{249}Cf with 70-MeV ^{12}C ions. The top spectrum is the sum of the individual spectra from the four detectors.

Fig. 2. Excitation curves of several activities produced by bombardment of ^{249}Cf with ^{12}C ions.

Fig. 3. Decay schemes of ^{253}Fm and ^{255}No. Numbers to the right of the levels give their energies in keV. Alpha energy E_α is in MeV.

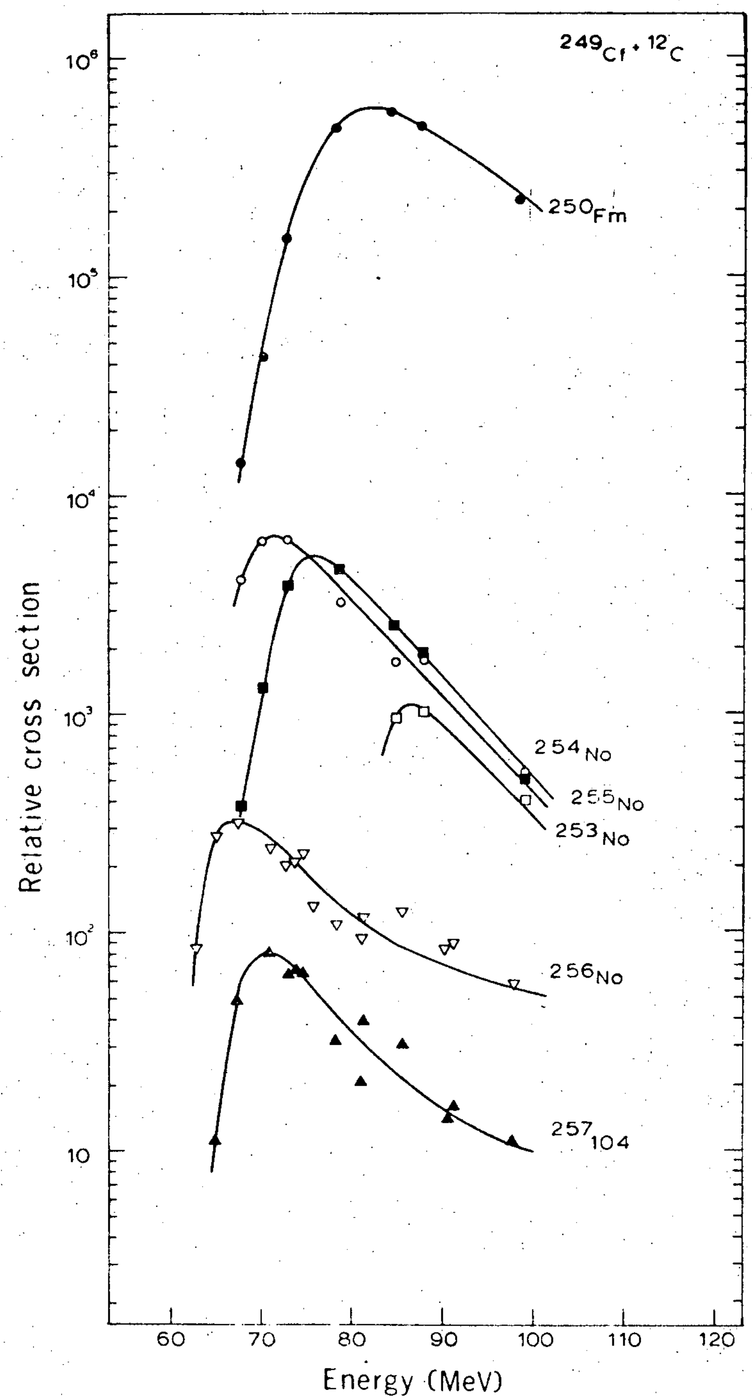
Fig. 4. A series of alpha spectra of the activities produced by bombardment of ^{248}Cm with ^{13}C ions. The series of spectra is a sum of four different experiments with energies ranging from 66 MeV to 74 MeV.

Fig. 5. Excitation curves of ^{256}No and ^{257}No produced by bombardment of ^{248}Cm with ^{13}C ions.



210Rn 6.04
248Cf 6.27
213Ra 6.62
213Ra+246Cf 6.76
252Fm 7.04
214Ra 7.14
250Fm 7.43
255No
7.76
7.92
8.11
8.25
8.30
249Cf + 12C
200 sec/spectrum
10 μAhrs
70 MeV
1.+2.+3.+4.
1.
2.
3.
4.
Counts per Channel
Channel Number
100
200
300
XBL 698 4881

Fig. 1



XBL 694 4815

Fig. 2

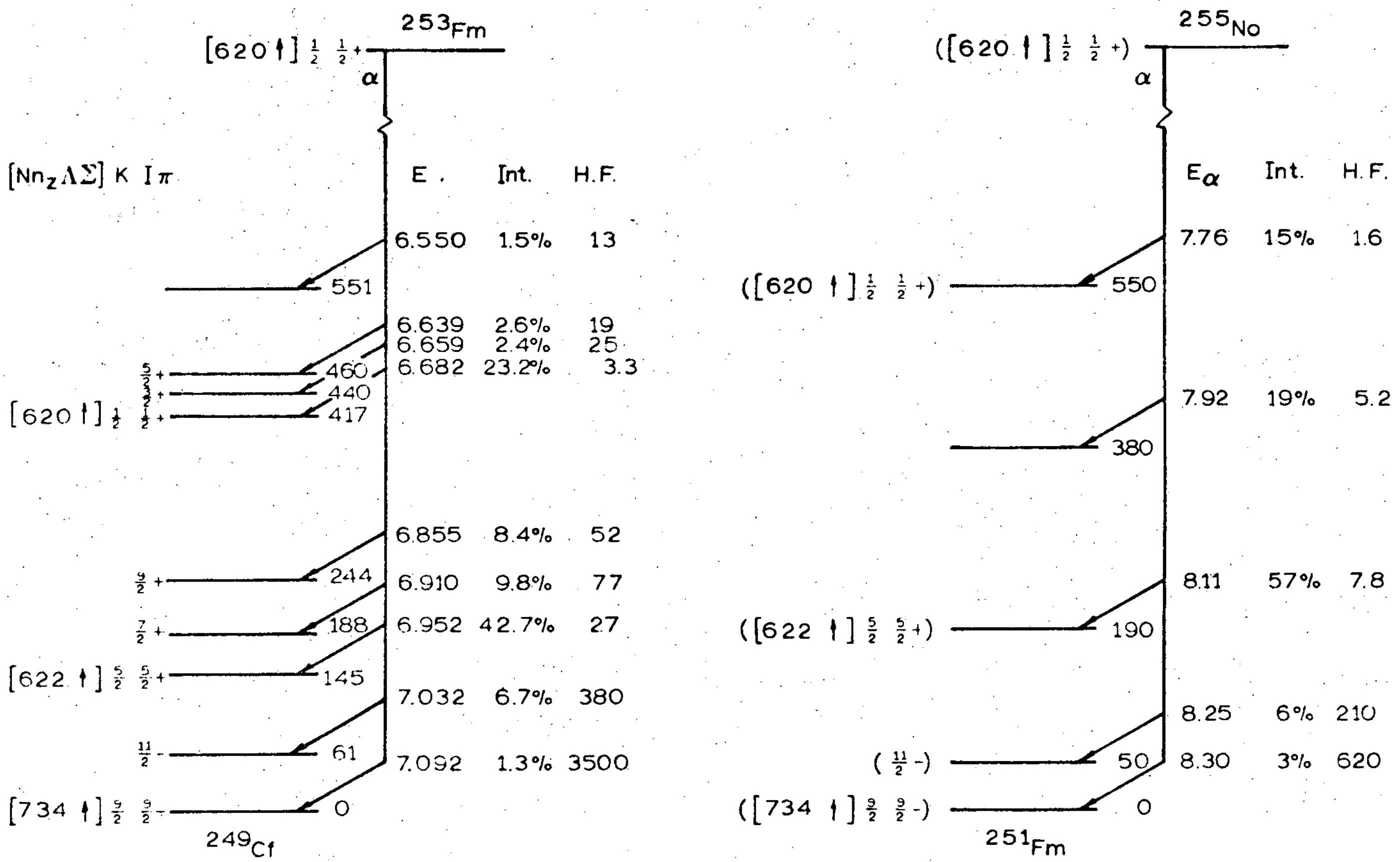


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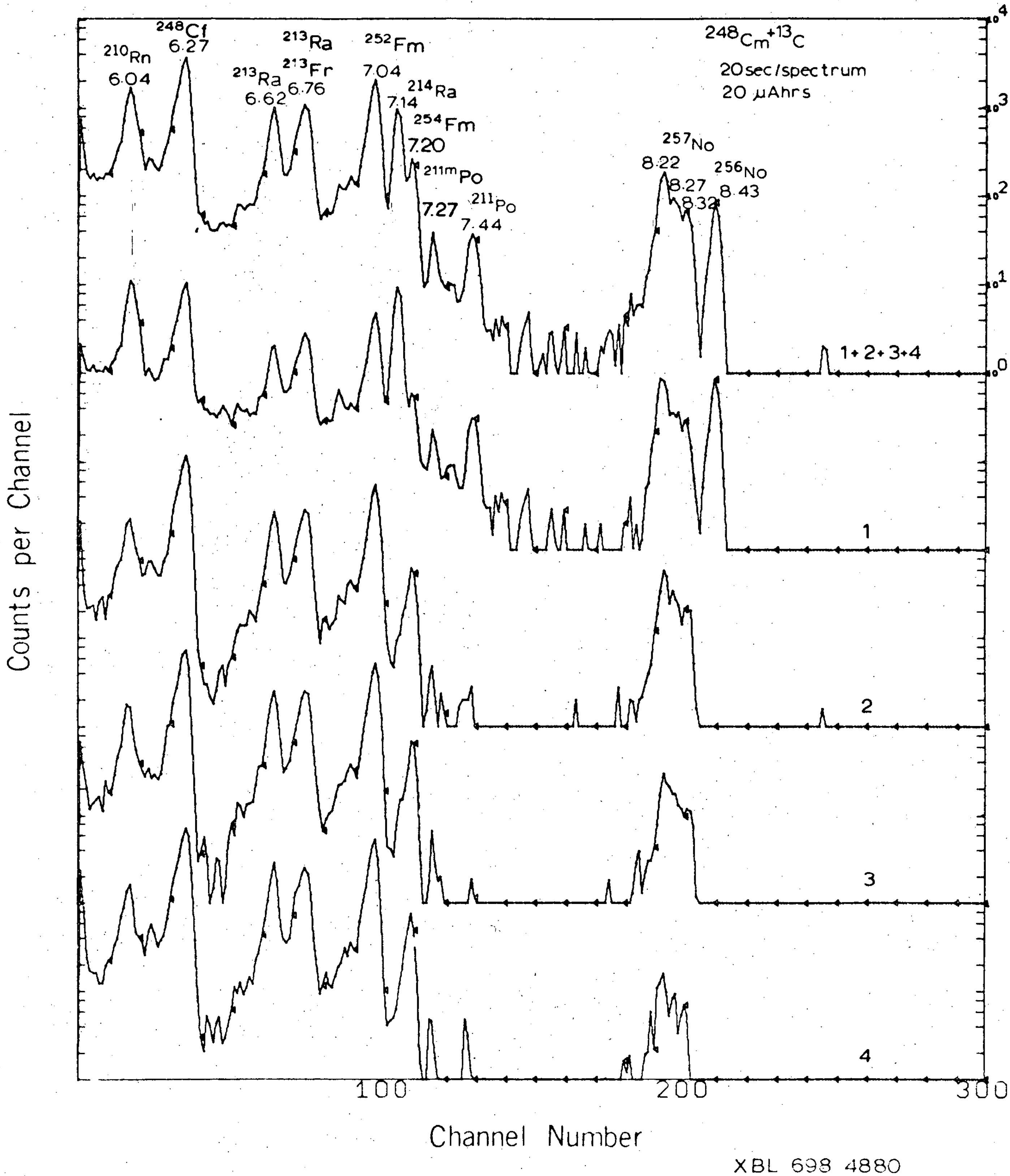
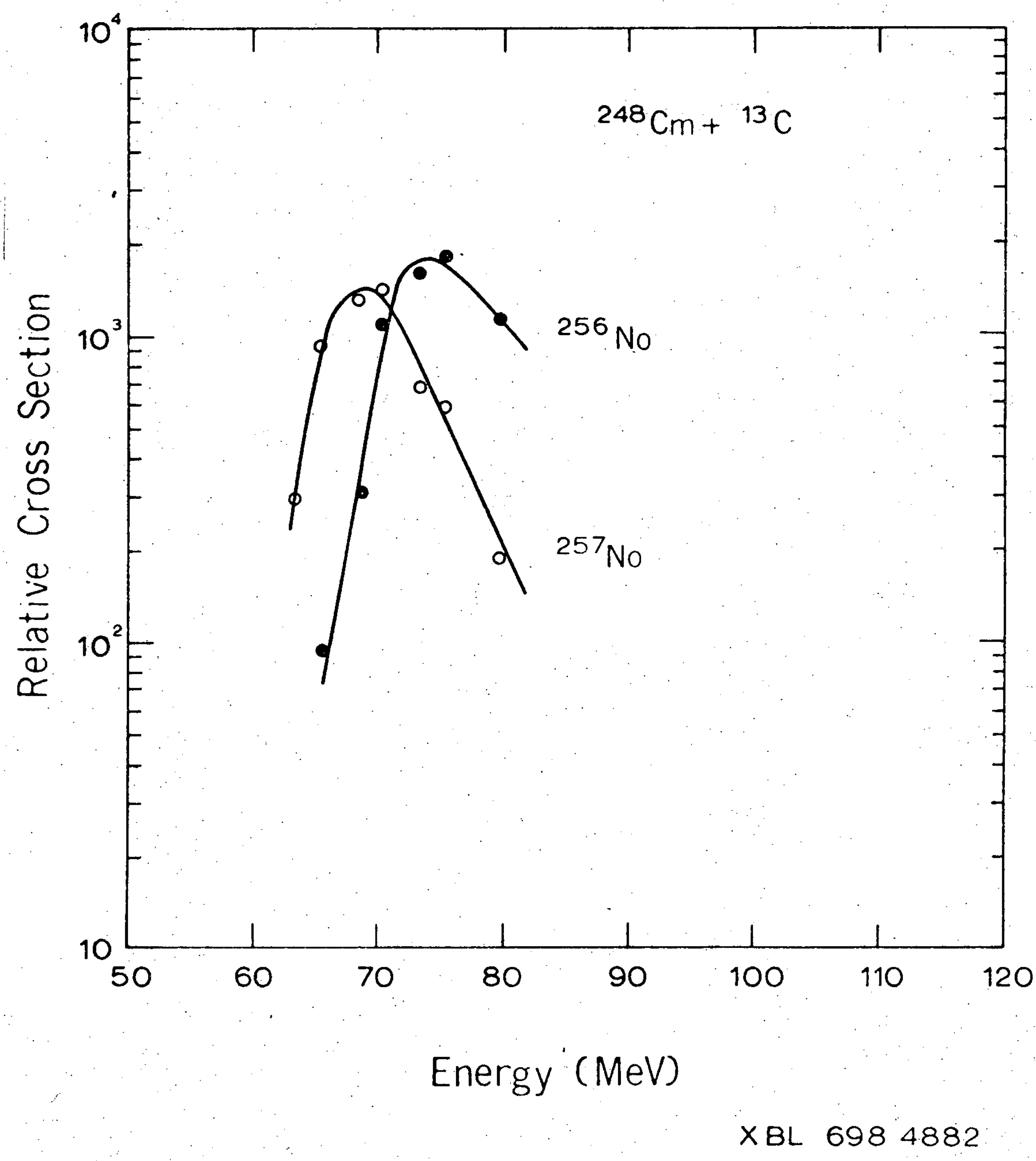
Fig. 3



210Rn 6.04
248Cf 6.27
213Ra 6.62
213Ra 213Fr 6.76
252Fm 7.04
214Ra 7.14
254Fm 7.20
211mPo 7.27
211Po 7.44
257No 8.22
8.27
8.32
256No 8.43
248Cm+13C
20sec/spectrum
20 μAhrs
1+2+3+4
1
2
3
4
Counts per Channel
Channel Number
100
200
300
XBL 698 4880

Fig. 4.



^{248}Cm + ^{13}C
^{256}No
^{257}No
Relative Cross Section
10^4
10^3
10^2
10
50
60
70
80
90
100
110
120
Energy (MeV)
XBL 698 4882

Fig. 5

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