STUDIES ON THE DECAY OF ^{120}Cs, ^{118}Cs AND ^{116}Cs

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Abstract

The neutron-deficient Cs isotopes were produced in the $^{32}S + ^{92}Mo$ reaction and separated according to their masses. The decay of these isotopes was studied by the two-parameter $\beta-\gamma$ coincidence technique using a plastic scintillation β-spectrometer and a Ge/Li/ detector. New information has been obtained on the β- and γ-radiation of Cs-120, Cs-118 and Cs-116, and on the low-energy levels of the corresponding Xe nuclei.

1. Introduction

Preliminary results are reported here of studies of the neutron-deficient even-mass Cs isotopes by nuclear-spectroscopy methods. The aim of these studies is to get information on the β-decay energies of Cs isotopes and on the low-energy levels of the daughter Xe nuclei.

2. Experimental procedure

The studies were carried out using the BEMS-2 on-line mass-separator facility[1] at the Dubna 3 m heavy-ion cyclotron. Use was made of the 190 MeV $^{32}S^{5+}$ ions to induce the

$$^{32}S + ^{92}Mo \longrightarrow ^{121-x}Cs + 3p + xn$$

reactions. The mass-separated reaction products were collected on a disk of 20 cm dia. which, rotating periodically by an angle of about 96° in less than 1 s, transported the activity to the coincidence spectrometer. The transport could be delayed with respect to the end of collection period when the decay products had to be studied. The spectrometer included a 20 cc Ge/Li/ detector and a plastic scintillator with diameter and height of 7 cm. The detectors were placed close to the source on both sides of the disk. Two-parameter $\beta-\gamma$ coincidences were measured using the Nuclear Data 4420 minicomputer-based system. Singles γ-ray spectra were recorded simultaneously.

The main measurements were performed for the 60 s Cs-120, 16.4 s Cs-118 and 3.9 s Cs-116 activities. To get an idea of the contributions from the neighbour masses /which actually occured very small for coincidence measurements/, data were recorded also for Cs-119. The γ-ray spectra of longer lived decay products were studied with the aim to identify the background γ-lines. The positon spectra of I-120 and I-118 were used for callibration and testing of the scintillation spectrometer, together with the positon spectra measured under the same conditions for the K-38, Rb-78 and Rb-80 activities, also produced in the heavy-ion reactions.

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3. Gamma-rays and energy levels

Identification of the background γ-lines was easy for A = 120, since the results of the detailed studies on Xe-120 and I-120 were available[2,3]. The Cs-120 γ-ray data corrected for the background are given in table 1. Compared to ref.[4], eight new transitions are reported here. The table contains also our new γ-ray data for Cs-118, approximately corrected for the longer lived background.

Table 1

Energies /in keV/ and relative intensities of γ-transitions

^{120}Cs		^{118}Cs	
E_γ	I_γ	E_γ	I_γ
		149.2	11
		189.4	2.7
322.6	100	337.3	100
365.4	0.9	473.9	3.5
395.7	2.4	472.8	36
452.7	1.3	494.6	17
473.5	27	496.0	16
525.5	2.4	500.8	13
553.3	18	526.9	5.8
585.7	6.4	555.5	11
601.1	9.2	586.4	26
605.0	2.2	591.2	15
702.4	1.5	630.6	5.5
832.7	2.6	643.8	3.5
875.9	7.9	676.7	2.9
949.3	8.9	760.5	5.3
1274.5	7.6	810.5	3.3
1297.8	0.9	928.7	6.2
1389.3	2.8	1022.0	3.8
1757.1	1.3	1029.4	5.3
		1192.5	7.1
		1228.9	6.0
		1766.7	4.8

Comment to the table: The estimated uncertainties of E_γ and I_γ vary accordingly from 0.5 keV and 10% for intense lines to 1 keV and 25% for weak ones.

Four of the γ-transitions following the Cs-120 decay, and four of those ascribed to the Cs-118 activity have been identified with the ground-state-band transitions in Xe-120 and Xe-118 /fig. 1/ known from nuclear-reaction studies[5,6]. In both cases one finds a pair of intense γ-lines with a difference in energy equal to the energy of the $2^+ \longrightarrow 0^+$ transition. Thus the new levels can be proposed at 875.9 keV and 928.6 keV in Xe-120 and Xe-118, respectively. They may be the second 2^+ states analogous to the 2^+ levels established[7] at 879.7 keV and 846.4 keV in Xe-126 and in Xe-124, respectively. Also other levels could be proposed basing on

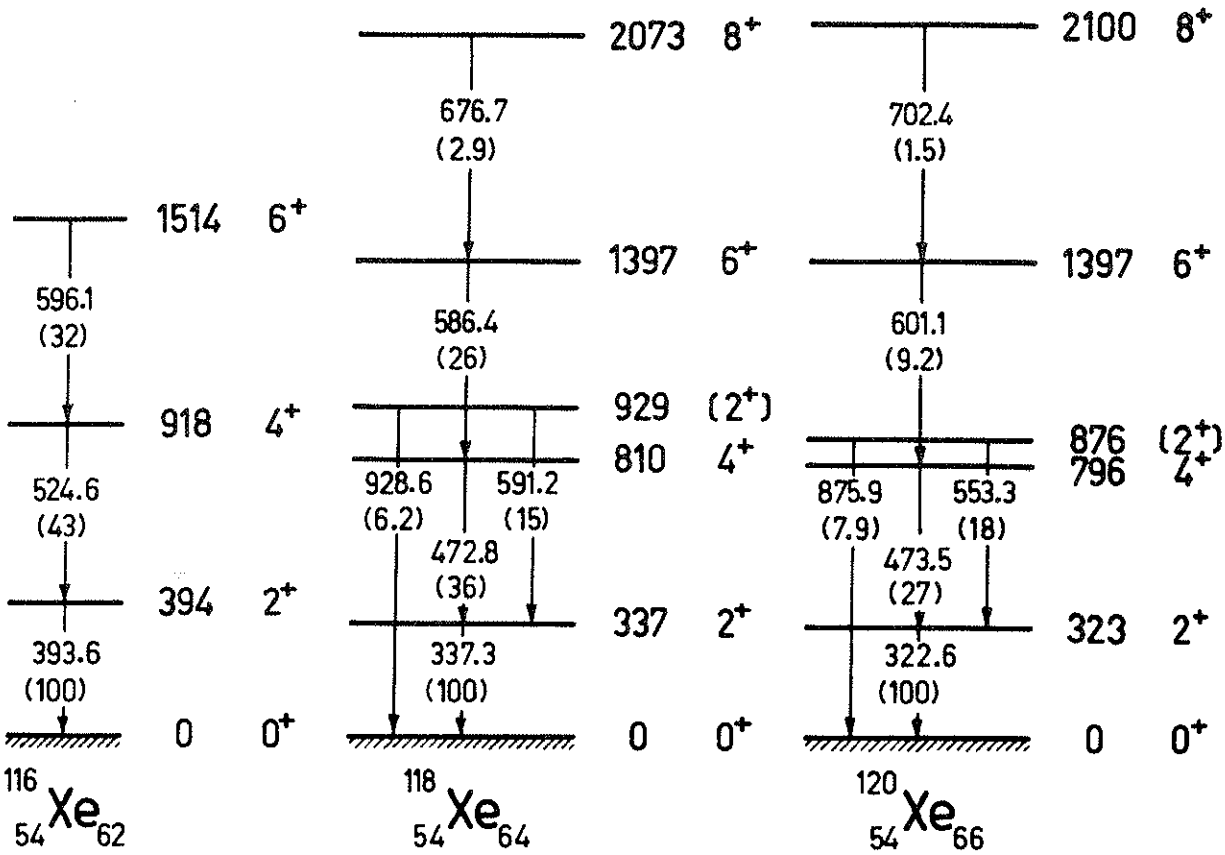

Fig. 1. The lowest energy levels of ^{116}Xe, ^{118}Xe and ^{120}Xe fed in the β-decay of ^{116}Cs, ^{118}Cs and ^{120}Cs. All energies are given in keV. The relative γ-ray intensities are given in brackets. The proposed spins and parities are shown for each level.

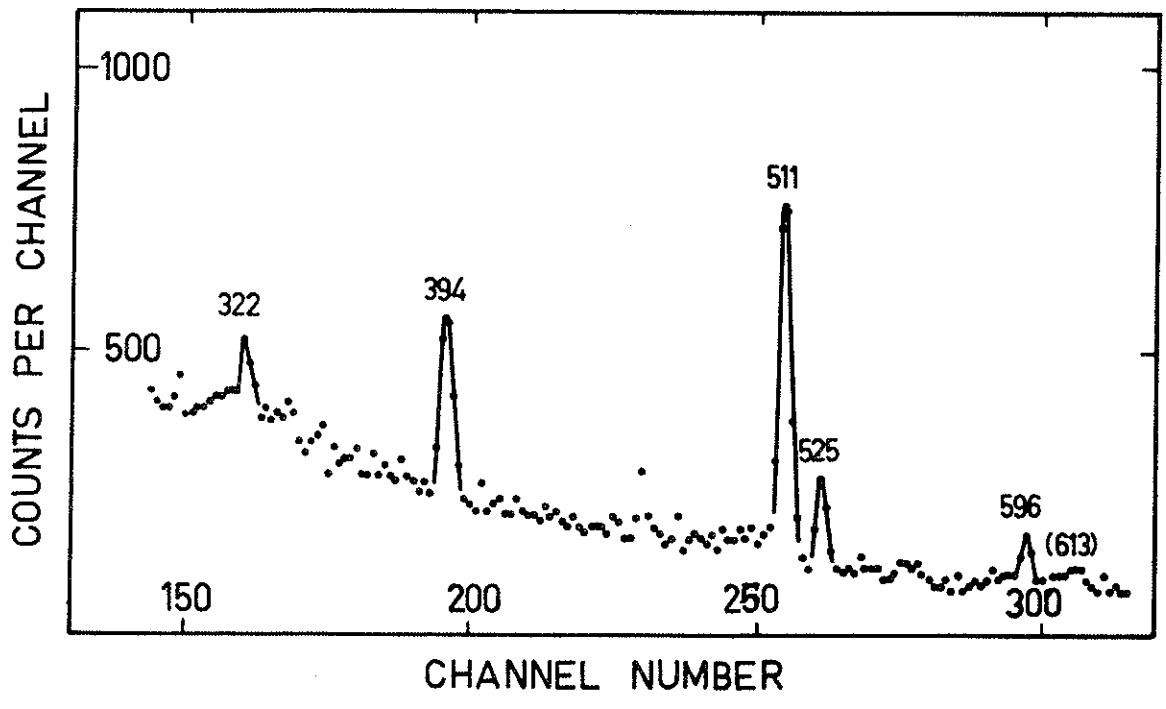

Fig. 2. A section of the ^{116}Cs γ-ray spectrum measured for $\approx$10 h. The time of measurement for one source was 10 s.

the transition-energy fits, but γ-γ coincidence studies are necessary for their confirmation.

The strength of the Cs-116 samples was rather low and only a few lines were observed in the γ-ray spectrum of this isotope, fig. 2. Analogously to the Cs-118 decay scheme, the three most intense transitions are suggested to connect the lowest levels of the Xe-116 ground-state band, fig. 1. This interpretation is supported by that the level-energy ratios change smoothly with the mass number /e.g. for the 4^+ and 2^+ levels these ratios are 2.47, 2.40 and 2.33 for Xe-120, Xe-118 and Xe-116, respectively/. The γ-transitions of 337, 469...keV, reported earlier[8] for the Xe-116 ground-state band on the basis of the "in-beam" spectroscopy experiment, are not observed in the Cs-116 spectrum.

4. Beta transitions

Determination of the β-decay energies and testing the mass formulae in the region far from stability was originally the main goal of the present work. Therefore, the β-spectra gated by selected γ-transitions were analysed: /i/ in Kurie coordinates, and /ii/ in the way proposed by O.B. Nielsen[9]. Examples of the β-spectra, uncorrected for the finite resolution of the β-spectrometer but with the background subtracted, are shown in fig. 3. For the Rb-80 activity, which was used as one of the callibration standards, the end-point energy[10] is 4061 ± 21 keV for the β^+-spectrum gated by the 617 keV transition. The Cs-120 and Cs-116 spectra were gated by the 323 and 394 keV transitions, respectively. The total number of β-particles recorded in these coincidence spectra was $\sim 10^4$ for Cs-120 and $\sim 10^3$ for Cs-116. In both cases the spectrum can be roughly divided into two components. The same has been observed for Cs-118.

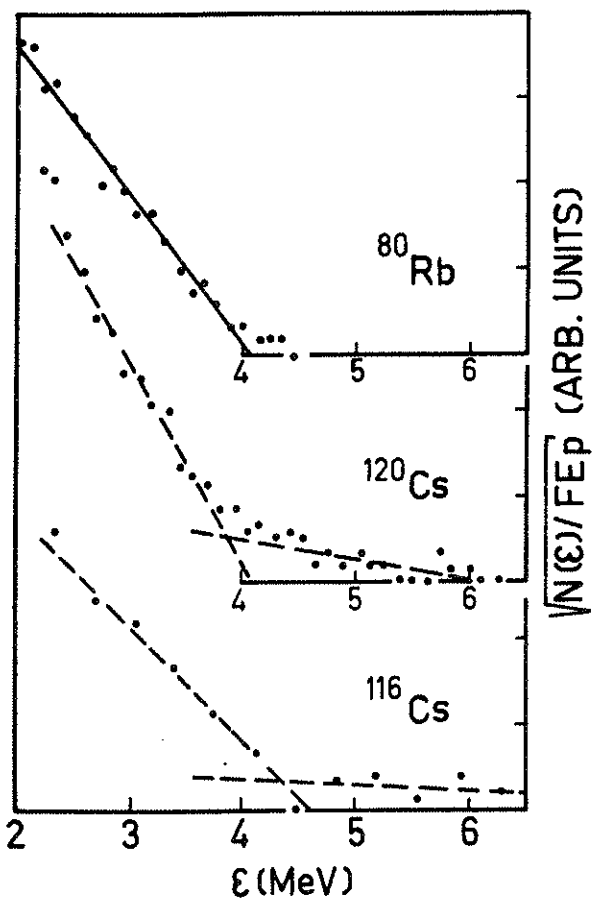

Fig. 3. Examples of positon spectra gated by the $2^+ \longrightarrow 0^+$ γ-transitions.

Table 2

End-point energies of the β-spectra /MeV/

Decaying nucleus	Low-energy component	High-energy component
^{120}Cs	4.1 ± 0.3	6.0 ± 0.5
^{118}Cs	5.8 ± 0.4	8.5 ± 1.0
^{116}Cs	4.5 ± 0.5	≈8

The accuracy of the end-point energy values is higher for the low-energy components. However, to make use of this information for the determination of the decay energies, an improved knowledge of the decay schemes is required. Further studies on the decay schemes are in fact anticipated. The poor accuracy obtained for the end-point energies of the high-energy components results from the insufficient statistics /limited by the time available for the measurements/ and difficulties of energy callibration above 6 MeV /our efforts to produce e.g. Na-20 using the BEMS-2 facility have not been succesful as yet/. Nevertheless, it is worthwhile to estimate the decay energy at least for Cs-120. Under the assumption that the high-energy component feeds the 322.6 keV level in Xe-120 we get Q_{EC} = 7.3 ± 0.5 MeV. The mass formulae advanced by different authors predict somewhat larger values /e.g. ref.[11] 8.3 MeV, ref.[12] 8.1 MeV and ref.[13] 8.1 MeV/.

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