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Calculation of half-life for ^{79}Se decay

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Abstract The half-life for ^{79}Se decay is calculated by using the Log $f^{1u}t$ systematics method. Based on the data analysis and comparison with experimental data the ^{79}Se half-life is recommended. The scheme for ^{79}Se decay is also shown and the radiation data are calculated in the text.

Key words ^{79}Se, Nuclear decay, Systematics, Data calculation
CLC number O571.3

1 Introduction

The ^{79}Se is one of the fission products with long half-life. It is an important nuclide of radioisotope applications and radioactive waste-treatments, and is also used as the fission monitor. The measurement of its half-life is very difficult, because the differences of half-lives in different experiments are very large. Therefore, it is highly important and interesting to calculate its half-life with Log $f^{1u}t$ systematics. The calculated half-life has also been compared with reliable experimental data.

2 Calculation codes and flow chart

The calculation codes and their functions are listed in Table 1. They are all ENSDF (Evaluated Nuclear Structure Data File) physics analysis codes[1] for the International Network of Nuclear Structure and Decay Data Evaluation, which can be obtained from the National Nuclear Data Center (NNDC) at Brookhaven National Laboratory, USA. In Table 1, a simple description about the codes that was used is given.

As seen in Fig. 1, the main steps of ^{79}Se half-life calculation are as follows: (1) Prepare the ENSDF format data file for ^{79}Se half-life calculation. ENSDF format of input data is adopted by the calculation code. The ENSDF format check must be done before the calculation, so that ^{79}Se half-life calculation will be reliable. (2) Run LOGFT code to calculate the Log $f^{1u}t$ values. The Log $f^{1u}t$ values for different half-lives will

Table 1 Calculation codes[1] and their functions of half-life and radiation data for ^{79}Se decay

Code name	Main function
FMTCHK	ENSDF formatted data check
LOGFT	Calculation of electron capture probabilities and Log$f^{1u}t$
RADLST	Energy and intensity calculation for Auger electron and X-ray
ENSDAT	Calculation data output shown in tables and drawings

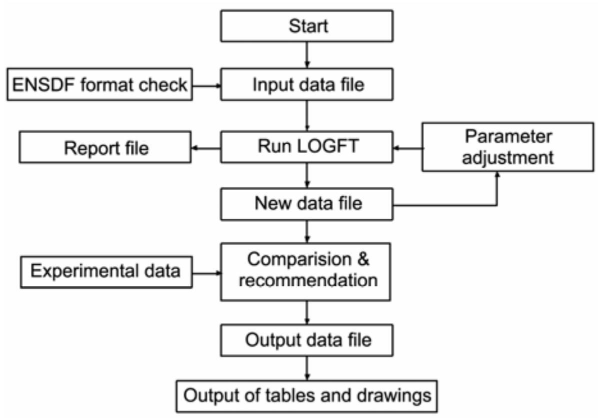

Fig. 1 Calculation flow chart of half-life and radiation data for ^{79}Se decay.

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be calculated when the electron capture branching ratio to the j^{th}-level of daughter nuclide is known and the calculation results will be put into the ENSDF format decay data file that is prepared. (3) Based on the $\text{Log} f^{1u}t$ systematics, the correct $\text{Log} f^{1u}t$ value of ^{79}Se decay can be selected and then the half-life of ^{79}Se can be calculated. (4) Compare the half-life calculated with experimental half-lives and recommend the new half-life of ^{79}Se decay. (5) Run RADLST code to calculate the radiation data. (6) Run ENSDAT code to output the calculation data in tables and to draw the decay scheme.

3 $\text{Log} f^{1u}t$ systematics calculation

The spin and parity of the ground-state (GS) are $J^{\pi}=7/2^{+}$ for ^{79}Se and $J^{\pi}=3/2^{-}$ for ^{79}Br, and the change of spin and parity is $\Delta J^{\pi}=2^{-}$ in ^{79}Se β^{-} decay. Obviously, this is a first-forbidden unique β^{-} decay and its $\text{Log} f^{1u}t$ should be marked as $\text{Log} f^{1u}t$. The ground-state of ^{79}Se does not decay to the ground-state of ^{79}As through $(\varepsilon+\beta^{+})$ decay directly and the experimentally determined β^{-} branching ratio from ground-state of ^{79}Se to ground-state of ^{79}Br is $I_{\beta^-}=100$ %。

In ^{81}Kr ε decay, the spin and parity is $J^{\pi}=7/2^{+}$ for ^{81}Kr and is $J^{\pi}=3/2^{-}$ for ^{81}Br and the change of spin and parity is $\Delta J^{\pi}=2^{-}$. Obviously, this is also a first-forbidden unique ε decay.

Table 3 shows that the general decay characters of the ^{79}Se β^{-} decay and the ^{81}Kr ε decay are basically the same. Therefore, the $\text{Log} f^{1u}t$ systematics method for ^{81}Kr ε decay is also suitable for calculating the half-life of ^{79}Se. The $\text{Log} f^{1u}t$ systematics value of ^{81}Kr ε decay can also be adopted to calculate the half-life of ^{79}Se decay. From Table 2, we can see that the $\text{Log} f^{1u}t$ values are increased with its half-life $T_{1/2}$ when $I_{\beta^-}=100$ % is fixed. The $\text{Log} f^{1u}t$ systematics results were published by Singh, et al.[2] in 1998. From the results the $\text{Log} f^{1u}t=11.01$ for the ground-state of ^{81}Kr to the ground-state of ^{81}Br through ε decay is known when its $I_{\varepsilon}=99.7$ % is fixed. The half-life of ^{79}Se, $T_{1/2}=5.60\times10^{5}$ a, can be obtained from this $\text{Log} f^{1u}t$ systematics calculation when its $I_{\beta^-}=100$ % is fixed .

Table 2 $\text{Log} f^{1u}t$ values of β^{-} decay from GS of ^{79}Se to GS of ^{79}Br calculated by LOGFT code.

$\text{Log} f^{1u}t$	$T_{1/2}$ /a	I_{β^-}/ %
6.26	1.00×10^{1}	100
7.26	1.00×10^{2}	100
8.26	1.00×10^{3}	100
9.26	1.00×10^{4}	100
10.26	1.00×10^{5}	100
10.73*	2.95×10^{5}*	100*
11.01	5.60×10^{5}	100
11.26	1.00×10^{6}	100
12.26	1.00×10^{7}	100
13.26	1.00×10^{8}	100

* Recommended values of this work.

Table 3 Decay character comparison between ^{81}Kr to ^{81}Br and ^{79}Se to ^{79}Br

Parent nuclides				Daughter nuclides			$\text{Log} f^{1u}t$	$T_{1/2}$ /a	I_{β^-}, I_{ε} / %
Nuclide	Level / keV	J^{π}	Decay mode	Nuclide	Level / keV	J^{π}			
^{79}Se	0.0	$7/2^{+}$	β^{-}	^{79}Br	0.0	$3/2^{-}$	11.01	5.60×10^{5}	100
^{81}Kr	0.0	$7/2^{+}$	ε	^{81}Br	0.0	$3/2^{-}$	11.01	2.29×10^{5}	99.7

4 Comparison with experimental data

In Table 4, the experimental and calculated data of the half-life of ^{79}Se decay are listed. The differences of half-lives among different experimenters are very large and only the latest measured value, $T_{1/2}=(2.95\pm0.38)\times10^{5}$ a[7], obtained by using mass spectrometry method with projectile X-ray detection, is near the calculated one. Here, $T_{1/2}=(2.95\pm0.38)\times10^{5}$ a is recommended as the half-life of ^{79}Se decay.

Table 4 Measured and calculated half-life of ^{79}Se decay

$T_{1/2}$ / a (measured)	$T_{1/2}$/a (calculated)	Published year	Reference
$<6.5\times10^{4}$		1978	[3]
$(4.8\pm0.4)\times10^{5}$		1995	[4]
$(1.1\pm0.2)\times10^{6}$		1996	[5]
$<6.5\times10^{5}$		1997	[6]
$(2.95\pm0.38)\times10^{5}$		2001	[7]
	5.60×10^{5}	2004	This work

5 Decay scheme and radiation data

On the basis of the half-life of ^{79}Se decay recommended above, the scheme of ^{79}Se β^- decay is shown in Fig.2, where the decay characters are also given. In Table 5, the radiation data of ^{79}Se β^- decay are listed, which are calculated by using the RADLST code.

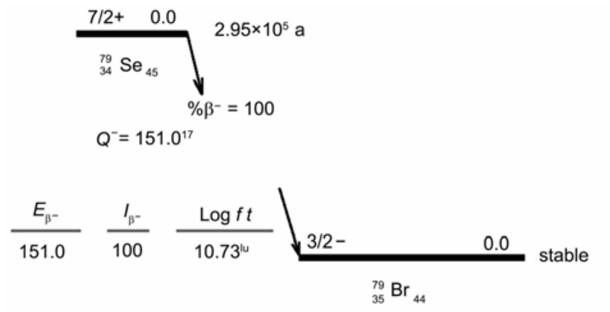

Fig. 2 Decay scheme of ^{79}Se β^- decay.

Table 5 Radiation data of ^{79}Se β^- decay

Radiation type	Energy / keV	Absolute intensity / %
β^-	151.0 ± 1.7 (Max) 52.92 ± 0.62 (Avg)	100

6 Discussion

It is a test for us to calculate the half-life of ^{79}Se decay by using the Log$f^{1u}t$ systematics method. The result is very interesting. This method can be adopted for the experimenters to measure the half-life of some nuclides. The method is also used for data evaluators to select the correct data from different and dispersive data of the half-life.

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