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NEW NEUTRON DEFICIENT LUTETIUM ISOTOPES

LINP - JINR - collaboration

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Новые нейтронодефицитные изотопы лютеция

На установке ИРИС при облучении протонами 1 ГэВ мишеней из вольфрама или тантала получены новые нейтронодефицитные изотопы ^{157,158,160,161,163}Lu. Идентификация выполнена с использованием масс-сепарации и результатов исследования излучения продуктов реакции /X-, гамма-, альфа-спектроскопия/.

Работа выполнена в сотрудничестве Лаборатории ядерных проблем ОИЯИ и Ленинградского института ядерной физики.

Сообщение Объединенного института ядерных исследований. Дубна 1979

Alkhazov G.D. et al.

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New Neutron Deficient Lutetium Isotopes

On the IRIS facility the new neutron deficient ^{157,158,160,161,163}Lu isotopes have been produced in spallation induced by 1 GeV protons on a tungsten or tantalum target, and identified by mass separation and the subsequent decay spectroscopy (X-, gamma-, and alpha-ray spectroscopy).

The investigation has been performed within the collaboration of the Laboratory of Nuclear Problems, JINR and Leningred Institute of Nuclear Physics.

Communication of the Joint Institute for Nuclear Research. Dubna 1979

The facility for the investigation of nuclei far from the beta stability line has been put in operation within the collaboration of the Joint Institute for Nuclear Research, Dubna, and the Leningrad Nuclear Physics Institute, Gatchina (JINR-LINP collaboration). The facility is based on the LINP synchrocyclotron and the IRIS [1,2] mass separator working on line with 1 GeV proton beam. The system of combined target and surface ionization ion source of the mass separator has been developed at Dubna [3].

The purpose of the collaboration is to study the alpha decay, delayed charged particle emission, decay schemes and quantum characteristics of the excited states of short lived nuclei far from the beta stability line.

A part of this complex investigation, devoted to the study of alpha emission above the closed neutron shell with N=82 as well as more detailed information about the experimental technique involved has been reported earlier [4,5].

In this letter we want to report the identification of new neutron deficient lutetium isotopes.

The experimental arrangement is as follows: 1 GeV proton beam induces spallation reactions in the system of combined target and surface ionization ion source (temp. up to 3000 K), what gives relatively high yield for lutetium. Simultaneously, two mass separated ion beams with different A are extracted in two ion tracks. On the first one the ions are collected on the catcher of a rotating collector with 3 wings and transported to the surface-barrier alpha detector (resolution of 25 keV). On the second one the moving tape transports collected samples to the counting position with X- and γ-ray detectors. Transport of samples to detectors, collecting and counting time, and the record of subsequent spectra on the magnetic tape, are controlled by the small computer M-400. Data handling is performed with the help of the HP-2116C computer.

The experimental results obtained in this work are presented in Table 1. In addition to this table we have observed an alpha line with E_α =4.43 MeV and $T_{1/2}$ 23 s at the mass number A =159. This we have preliminarily assigned to the decay of new ^{159}Lu.*

*Note added in proof. Recently we have observed also K_α Roentgen line following the Lu Yb decay. It shows the decay period $T_{1/2}$ 12.5 s.

Table 1

Isotope	Type of radiation energy (keV)	Accepted half-life (s)	Remarks
^{157}Lu	α: 4995 ± 10	5.5 ± 0.3	[6,7]
^{158}Lu	α: 4665 ±10	10.4 ± 1	first ident.
^{160}Lu	X: K_αYb, K_βYb γ: 5γ lines*	34.5 ± 1.5	first ident.
^{161}Lu	X: K_αYb, K_βYb γ: 11γ lines*	72 ± 6	first ident.
^{162}Lu	X: K_αYb, K_βYb γ: 7γ lines*	86 ± 5	[8]
^{163}Lu	X: K_αYb, K_βYb γ: 37γ lines*	246 ± 12	first ident.

* See Table 2.

Isotopes ^{158,160,161,163}Lu have been identified for the first time. Conflicting results on ^{157}Lu have been reported earlier [6,7] (see details in ref. [11]); for ^{162}Lu we unambiguously confirmed the results from [8]. Gamma lines assigned to ^{160,161,162,163}Lu decays, for the energy range from 30 keV up to 900 keV (for ^{161}Lu 30-300 keV) are listed in Table 2. Some gamma lines observed here for ^{160,162,163}Lu have the same energies as found in the in-beam excitations of ^{160,162,163}Yb [9,10]. This supports additionally our assignments.

The identification of the new isotopes is based on the analysis of the characteristic K_α and K_β lines in the X-ray spectra, and the genetic relationship to the decay of the daughter well known nuclei, in addition to the unambiguous mass determination after mass separations. For each mass a possible contamination of neighbouring masses was carefully checked up. The details will be published elsewhere.

As an example of identification, Fig. 1 shows both the part of the alpha spectrum for the mass A=158 and the decay curve for new alpha line E_α=4.665 MeV, as well as

Table 2

$E_\gamma \pm \Delta E_\gamma$ (keV)	$I_\gamma \pm \Delta I_\gamma$	$E_\gamma \pm \Delta E_\gamma$ (keV)	$I_\gamma \pm \Delta I_\gamma$
^{163}Lu		^{162}Lu	
54.00±0.10	85.0± 8.0	67.00±0.15	1.0±0.3
79.19±0.05	3.5± 0.7	166.80±0.10	100.0±5.0
93.33±0.10	5.4± 1.0	320.86±0.10	20.0±2.0
94.17±0.05	12.0± 2.0	631.40±0.10	28.0±3.0
96.49±0.05	9.5± 1.8	656.40±0.20	6.7±1.5
98.11±0.05	5.4± 1.0	825.30±0.20	18.0±2.0
102.50±0.10	7.4± 1.5	839.80±0.30	7.7±1.5
150.74±0.05	45.0± 5.0		
163.03±0.05	100.0±10.0	^{161}Lu	
167.26±0.06	22.0± 3.0	67.13±0.20	48 ± 5
206.69±0.15	6.2± 2.0	86.79±0.15	17 ± 4
220.93±0.10	16.0± 4.0	100.32±0.10	95 ± 9
221.62± 0.15	12.0± 3.0	105.20±0.10	28 ± 5
243.91±0.15	6.2± 1.5	110.78±0.10	100 ± 9
253.00±0.10	7.1± 1.5	156.24±0.10	49 ± 5
302.90±0.15	28.0± 4.0	170.09±0.20	14 ± 4
313.83±0.15	24.0± 3.0	177.13±0.20	14 ± 4
317.00±0.20	11.0± 3.0	204.57±0.20	30 ± 6
318.00±0.30	6.0± 2.0	221.76±0.20	20 ± 4
343.30±0.50	6.0± 2.0	256.24±0.25	49 ± 8
371.73±0.10	62.0±10.0		
391.10±0.20	20.0± 3.0	^{160}Lu	
396.34±0.10	63.0± 7.0		
400.30±0.20	16.0± 2.0	243.43±0.10	100.0±5.0
448.80±0.20	30.0± 5.0	395.74±0.15	30.0±2.0
453.50±0.30	17.0± 3.0	577.33±0.20	13.0±1.5
456.60±0.40	11.0± 3.0	820.12±0.30	9.0±1.5
460.70±0.40	16.0± 3.0	870.67±0.40	8.6±1.5
483.50±0.20	32.0± 6.0		
498.90±0.30	24.0± 5.0		
537.00±0.50	10.0± 3.0		
553.00±0.30	32.0± 5.0		
562.50±0.40	16.0± 3.0		
566.40±0.50	11.0± 2.0		
634.10±0.50	14.0± 4.0		
644.40±0.40	16.0± 3.0		
871.50±0.40	23.0± 4.0		

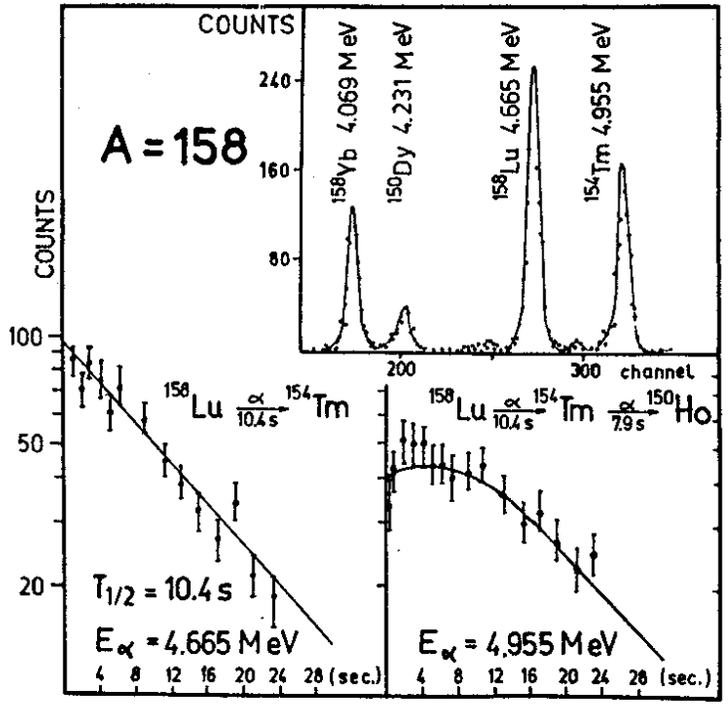

Fig.1. Decay curves and alpha spectrum for A=158.

a known line E_α =4.955 MeV belonging to the ^{154}Tm decay. On the basis of the parent-daughter relationship the E_α = =4.665 MeV line $T_{1/2}$ =10.4 ± 1.0 s has been assigned to the new ^{158}Lu. The ^{157}Lu isotope has been identified in a similar way. The second example (Fig. 2) shows the K_α and K_β transitions following the Lu → Yb decay, and their half-life determination, recorded for the mass A =161. Gamma lines having the same $T_{1/2}$ 1.2 min have been assigned also to ^{161}Lu decay. A similar picture was observed for ^{160,162,163}Lu, too.

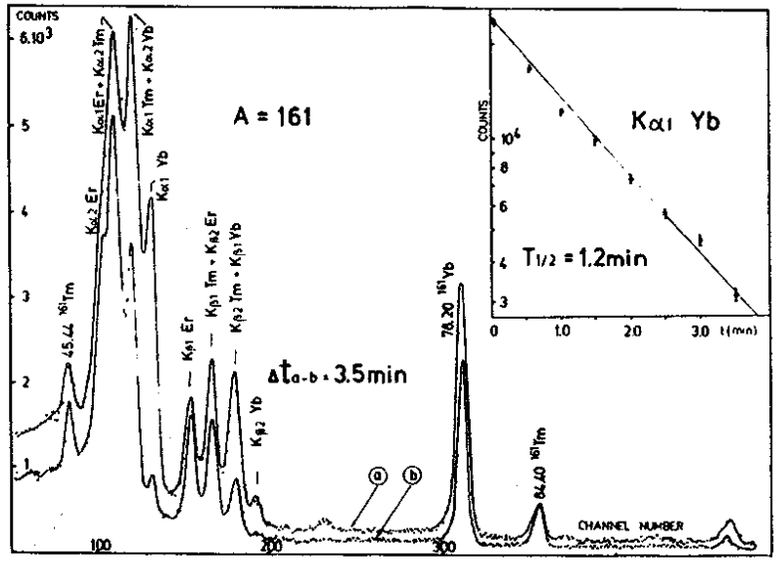

Fig.2. X -ray spectrum and decay curve for A =161.

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