New Tantalum Isotopes Ta^{170} and Ta^{171}†

I. Rezanka, I.-M. Ladenbauer-Bellis, F. M. Bernthal,* and J. O. Rasmussen
Heavy Ion Accelerator Laboratory, Yale University, New Haven, Connecticut 06520
(Received 16 October 1970)

The tantalum isotopes Ta^{170} and Ta^{171} were produced via the following reactions: $Ho^{165}(C^{12}, 6n)Ta^{171}$, $Tb^{159}(O^{16}, 4n)Ta^{171}$, $Ho^{165}(C^{12}, 7n)Ta^{170}$, and $Tb^{159}(O^{16}, 5n)Ta^{170}$. The half-life of Ta^{171} was determined to be 25 ± 2 min and of Ta^{170}, 7 ± 2 min. About 60 γ rays were assigned to the Ta^{171} decay, while in Ta^{170} decay, only the excitations of the first- and second-excited states of Hf^{170} were observed.

In connection with the in-beam and out-of-beam investigations of neutron-deficient odd-mass hafnium isotopes at the Yale heavy-ion accelerator, the decay characteristics of the previously unknown $Ta^{170,171}$ isotopes were established.

Ta^{171} was produced via two different reactions: (1) $Ho^{165}(C^{12}, 6n)Ta^{171}$ and (2) $Tb^{159}(O^{16}, 4n)Ta^{171}$. The beam energies used were 80 MeV for carbon ions and 93 MeV for oxygen ions. The target materials were thin metallic foils of Ho and Tb with an average thickness of 3 to 4 mg/cm^2. Following the irradiations (20-30 min) the tantalum activity was isolated[1] by extraction from a 6-*N* HCl solution with 2, 4-dimethyl-3-pentanone(diisopropylketone). The γ rays of Ta^{171} were studied with 2 Ge(Li) detectors (15 and 40 cm^3) and a Si(Li) detector in connection with a model PDP-8/I computer, programmed as a 2048- or 4096-channel analyzer. Simultaneous γ-energy calibrations were carried out (Co^{57}, Na^{22}, Cs^{137}, and Co^{60}), and the γ-ray spectra were analyzed by a sophisticated least-squares peak-fitting program. The results are given in Table I. A half-life of 25 ± 2 min for Ta^{171} was found from the decay of

Table I. γ rays of Ta^{171}.

γ-ray Energies[a] in keV	Relative γ-ray[b] intensities	γ-ray Energies in keV	Relative γ-ray intensities	γ-ray Energies in keV	Relative γ-ray intensities
49.6	100	471.3	9.0	727.1	4.1
61.9	10	492.7	15	731.6	1.5
66.7	5.0	501.8	23	736.9	1.3
80.7	4.2	506.4	54	746.7	4.3
84.3	1.6	522.3	11.0	767.6	9.0
92.2	11	526.2	1.7	782.3	2.1
117.1	5.5	530.4	3.9	788.9	4.5
140.5	.8	536.0	7.7	796.7	3.3
152.4	5.8	538.0	14.9	802.3	3.3
166.3	19	554.5	6.9	836.8	1.8
175.5	16	570.9	3.2	861.4	1.7
209.2	2.9	573.4	0.4	876.8	1.7
240.8	.6	606.8	3.9	899.0	1.6
253.8	1.3	621.7	3.6	906.7	2.0
352.4	3.1	630.5	2.5	957.8	1.8
392.9	.8	665.0	2.5	987.1	8.6
406.7	4.6	678.4	2.9	997.0	3.1
423.4	3.5	702.8	1.5	1001.3	2.7
444.4	16	718.2	2.3	1007.8	3.4
454.7	4.5	723.3	2.5	1027.4	1.8

[a]Errors in given γ-ray energies are ±0.1 keV.
[b]Errors of measured relative intensities are less than 10%.

the more intense γ rays. In order to establish the correct mass assignment, Ho and Tb foils were bombarded with different beam energies. Comparison of these samples, the time dependence of the intensities of the observed γ rays, and the growth of the known daughter products[2] allowed a very reliable mass assignment.

Preliminary coincidence experiments (4096 $\times$4096 channels) favor the existence of energy levels at 49.5 ($\frac{5}{2}^-$), 141.8 ($\frac{7}{2}^-$), 258.9 ($\frac{9}{2}^-$), 494.1, 506.4, and 1008 keV. Further coincidence studies are in progress in order to establish a more complete level scheme of Hf^{171}.

In addition to Ta^{171}, Ta^{170} was observed in the same experiment, produced via the reactions $Ho^{165}(C^{12}, 7n)Ta^{170}$ and $Tb^{159}(O^{16}, 5n)Ta^{170}$. The 2^+-0^+ and 4^+-2^+ ground rotational band transitions in Hf^{170} were known from earlier in-beam conversion electron studies.[3] Here, the energies of these transitions were determined as 100.9 $\pm$ 0.1 and 221.3 $\pm$ 0.2 keV, respectively. The observation of these γ rays decaying with 7 $\pm$ 2 min half-life adds strong weight to the assignment of the activity to Ta^{170}.

†Work supported by the U. S. Atomic Energy Commission under Contract No. At(30-1)3909.

*Present address: Chemistry Department, Michigan State University, East Lansing, Mich. 48823.

[1]F. F. Felber, Jr., thesis, UCRL Report No. UCRL-3618, 1957 (unpublished).

[2]C. M. Lederer, J. M. Hollander, and I. Perlman, *Table of Isotopes* (Wiley, New York, 1967), 6th ed.

[3]F. S. Stephens, N. L. Lark, and R. M. Diamond, Nucl. Phys. 63, 82 (1965).

π-Carbon Elastic Scattering Near the 33 Resonance

Morton M. Sternheim*
University of Massachusetts, Amherst, Massachusetts 01002

and

Elliot H. Auerbach†
Brookhaven National Laboratory, Upton, New York 11973

(Received 7 October 1970)

Elastic π^--C scattering is calculated with the Kisslinger optical model from 120 to 280 MeV. With parameters obtained from π^--N phase shifts, general qualitative agreement is obtained with the recent Binon *et al.* data. Modifying the parameters further improves the fit.

We have calculated π^--carbon elastic-scattering differential cross sections at energies near the 33 π-nucleon resonance using the Kisslinger optical model.[1,2] Our results for optical parameters derived from two-body phase shifts agree well qualitatively with the recent experiments of Binon et al.[3] at seven energies from 120 to 280 MeV. This contrasts to the large differences between theory and experiment recently found in pion double-charge-exchange reactions,[4] in the production of C^{11} by $\pi^\pm$ bombardment[5] of C^{12}, etc.

Table I. Kisslinger model parameters. Units are F^3. "Free parameters" are those derived directly from π-N phase shifts, while "Fermi averaged parameters" are corrected for nucleon motion. "Best fit" curves in Figs. 1 and 2 are computed with Fermi averaged b_0 values.

Energy	Free parameters				Fermi averaged parameters				Fitted parameters	
(MeV)	Reb_0	Imb_0	Reb_1	Imb_1	Reb_0	Imb_0	Reb_1	Imb_1	Reb_1	Imb_1
120	−0.95	0.40	8.13	5.59	−0.87	0.42	7.34	7.15	9.24	3.14
150	−0.81	0.36	5.63	8.52	−0.73	0.38	3.84	8.27	−0.09	13.75
180	−0.72	0.33	1.71	8.81	−0.61	0.35	0.64	7.48	0.87	9.48
200	−0.67	0.31	−1.21	7.45	−0.54	0.33	−0.83	6.40	−0.39	8.61
230	−0.60	0.30	−2.46	4.99	−0.44	0.32	−1.98	4.66	−0.39	7.10
260	−0.51	0.28	−2.67	3.22	−0.34	0.31	−2.27	3.24	−1.55	5.33
280	−0.48	0.27	−2.62	2.42	−0.27	0.31	−2.18	2.53	−1.69	4.48