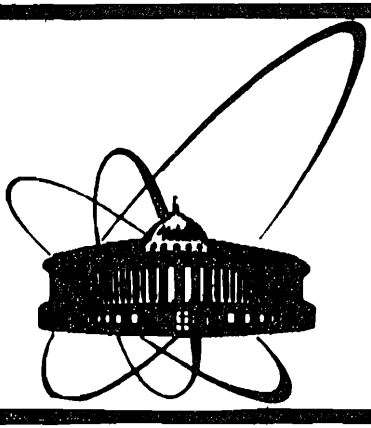

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SPECTROSCOPIC INFORMATION FROM ^{178}Hf(n,2γ)^{179}Hf REACTION

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The efficiency of the SACP method, using two Ge(Li) detectors (1,2) was demonstrated in the investigation of deformed rare-earth nuclei, in particular, of the ^{179}Hf compound nucleus. Figure shows the amplitude summation spectrum of coinciding pulses accumulated within $\approx$ 200 hours by the two Ge(Li) detectors, the efficiency of each of them being about 10% at 1332 keV.

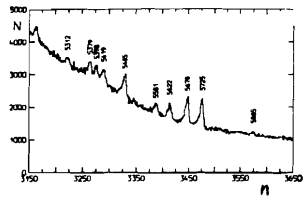

Fig. The amplitude summation spectrum of ^{179}Hf. n - is the number of the channel, N - counts per channel. The figures over peaks correspond to the total cascade energy (keV).

In the SACP spectrum there are observed 10 peaks as a result of the registration of two-quanta cascades with the fixed total energy (each of the peaks corresponds to one of 10 low-lying states). All the known low-lying levels with a spin I_f different from the compound state spin I_λ by not more than 2, were detected and only one level with the difference equal to 3. No cascade transitions from the compound-state to the low-level one with the spin difference $/I_f - I_\lambda/ > 3$ was observed as a peak.

By selection of the events in each of these 10 peaks one obtained 10 different two-quanta cascade intensity distributions, named differential spectra (DS). The peak in SACP spectrum corresponds to the registration of the full two-quanta energy, therefore one may choose from all γ-γ coincidences only the events of the full energy absorption, thus exclude the background coincidences connected with incomplete energy absorption in Ge(Li) detectors.

In the ^{179}Hf nucleus there are determined the energy of γ-transitions and their relative intensities for 236 pairs of resolved transitions (see the table in /5/). A part of these transitions are placed in the γ-decay scheme according to the algorithm, described in /3/. Data on the intermediate level energy and partial γ-decay scheme are given in the

Table.

The two-quanta cascade intensity $I_{\gamma\gamma}$ (per 10^4 decays), exciting the intermediate E_m level by the E_1 primary transition. E_f (kev) - the final level energy.

		E_f									
		214.1	374.8	420.7	476.1	518.2	614.0	679.3	700.7	720.2	788.0
E_1	E_m	$I_{\gamma\gamma}$									
4910.9	1189.2		8.8	8.6							
4617.0	1483.1			*	6.0		*			3.5*	
4527.4	1572.7		11.6*	*	9.3*	12.2	*	2.6		*	3.6
4392.6	1707.5		43.1*	7.4*		38.4*	15.4	8.9		31.0*	*
4372.7	1727.4		31.2*	12.0*		18.1	66.3*	17.1*	21.4*	28.4	17.4
4367.6	1732.5		34.7				47.6	15.2			
4342.3	1757.8	13.9	44.0*	82.7*	54.1*	34.0*	50.4*	20.8*	80.7*	15.5*	19.3
4335.9	1764.2	*	63.9*	42.9*		23.7*			25.0*	24.0	
4286.0	1814.1		7.3		17.9	5.4	25.7		17.9		
4278.7	1821.4		19.5*				*	*	5.2*		
4187.1	1913.0							11.0		21.5*	
4152.4	1947.7						15.6	12.0			
4052.2	2047.9		39.4	30.2							
4046.4	2053.7								6.3	9.3	
4028.3	2071.8		9.9	12.5			10.7			11.0	
4016.2	2083.9		12.2	25.4*	25.7*			8.1	6.0*		*
4010.6	2089.5		17.1	*				7.4			*
3952.9	2147.2						9.9		5.6		
3948.7	2151.4			14.8	16.1					6.2	
3915.9	2184.2				*			4.9		6.9	
3883.4	2216.7		10.8				9.0				
3870.8	2229.3			21.6				7.3		16.9	
3849.4	2250.7	27.9	26.4							10.1	11.5
3844.8	2255.3			11.6		11.7					
3789.8	2310.3			10.4						9.5	
3732.1	2368.0		19.7	16.0	71.6	9.6	9.2	8.7		14.1	
3704.8	2395.3			41.7				7.9			8.9
3684.1	2416.0			27.9	16.8		21.5				7.8
3673.7	2426.4						10.5		9.7		
3648.0	2452.1	7.2		29.9			19.2	7.0			
3638.7	2461.4		13.9	19.0							
3623.5	2476.6	6.2	44.6	51.2			17.9		9.0		
3589.5	2510.6		33.2	28.7				10.1			
3576.3	2523.8		30.4	17.0	23.2						
3497.8	2602.3		37.5	34.8	10.7						
3488.3	2611.8		52.5	15.3		10.4	11.2				
3460.7	2639.4		13.2							8.7	
3445.9	2654.2		8.7			8.0				6.3	8.4
3396.1	2704.0		21.2			13.0					
3356.2	2743.9			16.2			10.1		9.9		
3193.8	2906.3		17.2	15.8				7.3		8.6	
3115.7	2984.4				16.6			6.3			
3021.8	3078.3					18.4	7.7	7.0			
2949.9	3150.2						13.9		7.7		
2919.4	3180.7				10.0					8.7	
2753.8	3346.3			17.0					10.6		
2751.3	3348.8		14.1					8.2			
2689.6	3410.5		9.1					11.5			

Sign * marks cascades placed in the /4/ decay scheme.

Table. The scheme contains 157 two-quanta cascades and the energies of 48 levels. The ^{179}Hf γ-decay scheme presented in the Table is not complete because:

i) the detection threshold equal to 520 kev was used in the experiment;

ii) mainly the cascades of dipole type to a limited number of low-lying levels were observed;

iii) the algorithm /3/ alows one to place in the scheme only cascades starting with sufficiently intensive primary transitions and their intermediate level decay is followed at least by two γ-transitions.

A comparison of the obtained scheme (the Table) with the known one /4/ gives an idea that on the whole they are in good agreement. The difference is only in levels at 1732,5, 1814,1, 1947,7, 2071,8 2151,4 keV revealed by us, and absent in /4/. A part of known secondary transitions is not present in the scheme either because of their low energy (< 520 keV) or the low intensity. Additional decay modes for known levels are established in our scheme mainly in the energy range $E_M > 1{,}9$ MeV. Above $E_M = 2{,}2$ MeV the ^{179}Hf decay scheme was obtained for the first time.

An analysis of the method of placing the cascades in the γ-decay scheme /6/ showed that false levels due to random coincidences of transition energies may be expected at $E_M > 3{,}4$ MeV. Therefore, the data given in the Table should be used as a basis for the construction of a full γ-decay scheme in a wide range of excitation energies of ^{179}Hf making use of all available spectroscopic information on this nucleus.

The total intensity over all possible two-quanta cascades that determine the area under the peaks in the SACP (Figure) spectrum is 67.4% a decay of a compound state. The yield of the most intensive cascades is 40,5%. The two-quanta cascades to ten low-lying states of ^{179}Hf are the main way of the compound state decay excited by a thermal neutron capture.

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Бонева С.Т. и др.
Е3-87-538

Спектроскопическая информация в реакции (n,2γ) на примере ядра ^{179}Hf

Приводится схема γ-распада ^{179}Hf, полученная с помощью метода суммирования амплитуд совпадающих импульсов Ge(Li)-детекторов. Промежуточные уровни, возбуждаемые наиболее интенсивными каскадами, установлены до энергии возбуждения 3,4 МэВ. В предлагаемой схеме γ-распада размещено более 150 двухквантовых каскадов из 236 наблюдаемых с помощью метода суммирования амплитуд совпадающих импульсов двух Ge(Li)-детекторов.

Работа выполнена в Лаборатории нейтронной физики ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1987

Boneva S.T. et al.
E3-87-538

Spectroscopic Information from ^{178}Hf(n, 2γ)^{179}Hf Reaction

The ^{179}Hf γ-decay scheme, obtained by the method of summation amplitude of coinciding pulses (SACP) is given. The intermediate levels, excited by the most strong cascades are established up to 3.4 MeV excitation energy.

The investigation has been performed at the Laboratory of Neutron Physics, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna 1987