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V.G.Nikolenko, G.S.Samosvat

CONTRIBUTIONS OF SPIN CHANNELS IN NEUTRON p-RESONANCES OF YTTRIUM

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1. INTRODUCTION

Study of the angular distribution of intensities of scattered neutrons in isolated p-resonances with spin $I \pm 1/2$ (I is the spin of the target nucleus) allows one to establish the proportion in which the two input reaction channels differing by a spin value mix in the formation of these resonances, i.e., to determine the neutron width components $\Gamma_n = \Gamma_- + \Gamma_+$, the first one corresponds to the channel with spin $I-1/2$, and the second, $I+1/2$. References [1,2] contain necessary formulas, references and information about the methods as well as the first results of similar measurements.

The principal question here is whether the reduced widths Γ_-^1 and Γ_+^1 experience independent or correlated fluctuations from resonance to resonance. In the former case the relative contribution from one of the channels, say $\beta = \Gamma_-/\Gamma_n$, will be distributed in a certain way between 0 and 1 [1], while in the latter case its value will vary in a narrower interval. The now available data are yet not sufficient to clarify this question though contain a certain indication to correlated fluctuations: the measured β values for ^{19}F and ^{89}Y are near 0.33 and 0.8, respectively, but the number of investigated resonances is too small - two for the former nucleus and three for the latter. The present paper reports an improvement of the method that has allowed us to determine the channel mixtures for 10 resonances of ^{89}Y.

2. EXPERIMENT. DATA PROCESSION

The measurements were performed at the 1000 m flight path of the pulsed reactor IBR-30, time resolution being 5 ns/m. Figure 1 presents the experimental arrangement with the use of the "ring" geometry. Sets of ^3He counters 1 and 2 registered the neutrons scattered on the sample 3 (~7 kg Y_2O_3) at angles of about 90° and 150°, respectively. The coil neutron beam was formed with a collimator 4 and went through the polyethylene "bag" 5 filled with argon. The shielding materials 6, 7 and 8 were parafine with B_4C, B_4C and concrete, respectively.

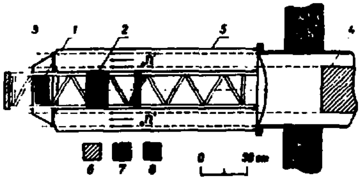

Fig.1. Experimental arrangement.

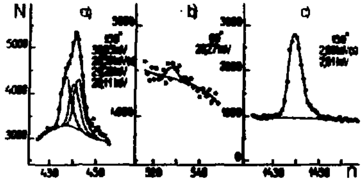

Fig.2. Examples of fitting of the peaks.

The neutron scattering spectra were processed by extracting the areas of the resonances which are noticeably higher than the background (from 28 resonances according to refs.[3,4] we "see" 20 in the range from 2.6 to 30 keV). This was done with the UPEAK[5] program by fitting the best peak shape and backing to experimental points by the least squares method. It is possible to describe all the peaks with one numerical model obtained from the peak at ~2.6 keV, since the resolution function width is by a factor of 10-50 broader than the p-resonance width. Figure 2 presents the extremal cases of resonance extracting for a given value of the scattering angle θ and resonance energy E_0: a) four unresolved resonances; b) the weakest peak; c) the strongest peak (among p-resonances).

Since the p-resonance area is proportional to $1+\omega_1 P_1(\cos\theta) + \omega_2 P_2(\cos\theta)$, where ω_1 is the constant determined by E_0 and potential scattering cross section[2], then one may find ω_2 using the area values for two scattering angles.

3. RESULTS AND DISCUSSION

Experimental results on ω_2 for 12 p-resonances are given in the Table. Using ω_2-values there were assigned spins to the investigated resonances (third column in the Table) on the basis of the following[1,2]: resonances with spin $I=0$ have $\omega_2=0$, if $I=2$, then $\omega_2=7/10$, if $I=1$, then ω_2-value is in the interval 0-2 depending on spin channel mixing parameter β. The spin values we arrived at are in good agreement with those from refs.[3,4] and are even more complete.

The fourth column contains main results of the present work. The β-values were found using the connection[1,2] between ω_2 and β for the targets with spin $I=1/2$:

$$\beta = \begin{cases} (1 \pm \sqrt{2\omega_2})/3 & \text{for } 0 \le \omega_2 \le 0.5 \\ (1 + \sqrt{2\omega_2})/3 & \text{for } 0.5 < \omega_2 \le 2. \end{cases}$$

Table

E_0, keV	ω_g	J	β
2.61	1.63±0.15	1	0.94±0.03
3.38	1.43±0.18	1	0.90±0.04
9.41	0.36±0.12	1	0.62/0.05±0.05
12.99	0.38±0.11	1	0.62/0.04±0.04
14.21	1.12±0.24	(1)	0.83±0.06
20.27	1.20±0.50	(1)	0.85±0.11
23.00	0.43±0.10	1	0.64/0.03±0.04
24.12	0.06±0.20	0,1	
24.56	0.26±0.13	1	0.58/0.09±0.06
28.11	0.82±0.56	1,2	
29.26	1.75±0.27	1	0.96±0.05
30.05	0.95±0.13	(1)	0.79±0.03

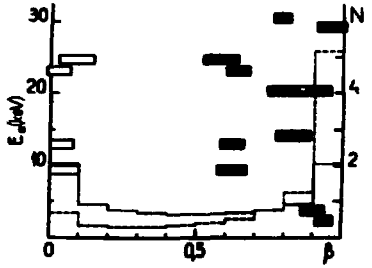

Fig.3. β-distribution. N - relates to histograms and indicates the number of resonances (from 10 resonances) corresponding to the interval of width 0.1.

One may judge about the β-distribution looking at Fig.3, where the lengths of rectangles are equal to double errors in determination of β. Unfortunately, four of ten resonances with assigned spin 1 have $\omega_g < 0.5$, i.e., their β may take any of the two possible values indicated for each resonance. Thus it is impossible to make a definite conclusion about the character of channel mixing distribution. Really, if all the four resonances have the smallest β-values, i.e., in Fig.3 there are clear rectangles and no hatched ones, then the obtained results are in agreement with the symmetrical β-distribution (solid line) which means no correlation between Γ_-^1 and Γ_+^1 distributed according to the Porter-Thomas law and having equal averages. On the other side, if there are only hatched rectangles, then they together with black ones are gathered in a narrower interval $0.5<\beta<1$, that is hardly probable (~0.2%) for the considered β-distribution. To achieve a noticeable probability for the latter, one should assume either large difference between the average widths (dashed line in fig.3 corresponds to $\overline{\Gamma_{-}^{I}} = 10\overline{\Gamma_{+}^{I}}$) or some correlation between the widths. Other versions for the four resonances having the largest or the smallest β-values lead naturally to less definite conclusions.

Note, that the unambiguous determination of β is possible in the measurement of the angular distribution of γ-yield in the (n,γ) reaction [6].

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Николенко В.Г., Самосват Г.С. Е3-82-336
Вклады спиновых каналов в нейтронных p-резонансах иттрия

По угловой зависимости рассеяния определены вклады спиновых каналов в десяти p-резонансах ^{89}Y, имеющих спин 1 и расположенных в области нейтронных энергий от 2,6 до 30 кэВ.

Работа выполнена в Лаборатории нейтронной физики ОИЯИ.

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Nikolenko V.G., Samosvat G.S. E3-82-336
Contributions of Spin Channels in Neutron p-Resonances of Yttrium

The contributions of spin channels in 10 p-resonances of ^{89}Y with spin 1 in the neutron energy range 2.6-30 keV were determined using the angular dependence of scattered neutrons.

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

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