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1963

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Издательская группа
Центрального института физических исследований
Венгерской Академии Наук
Будапешт II4, п/я 49
Техн.редактор: Э.Местер Тираж: 200 экз.
I6/IX I963

Published by
the
Publishing Group of the Central Research Institute for Physics
of the
Hungarian Academy of Sciences
Budapest 114, POB 49.
Techn.Editor: E.Meszter No.of copies: 200.
16.Sept. 1963.

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Summary

The cross sections for 2,6 MeV neutron induced reactions in CsJ have been investigated. Upper limits of 0,1 mb were found for the /n,p/ reactions in both of the component nuclei and 6,3 mb and 28,3 mb for the Cs-133/n,γ /Cs-134 and I-127/n,γ /I-128 reactions, respectively. The half life of the 137 keV /8$^-$/ isomeric state of Cs-134 and that for the ground state β-activity of I-128 were measured to be 2,75 hours and 24,6 minutes, respectively.

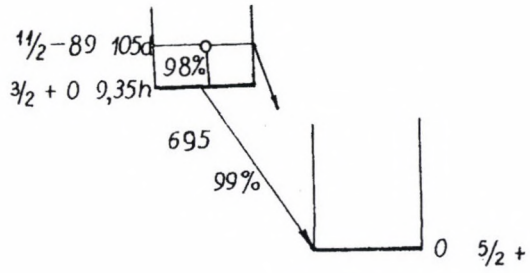
In the case of nuclei being in the neighbourhood of Cs-133 and I-127 regarding their mass number, the level density at excitations to several MeV-s above the nucleon binding energy is so high, that the applicability of the statistical theory for the nuclear reactions may be expected. Accordingly, it is possible to calculate the cross sections of the different reactions e.g. /n,p/, /n,α/, /n,2n/ etc. and the comparison of the calculated and measured values gives immediate information about the validity of the assumptions made.

We know several measurements, published in the past five years which suggest, that the validity of the statistical theory breaks down for neutron induced reactions at 14 MeV bombarding energy for the lighter nuclei of A$\approx$ 60 [1], [2]. It has been found that the reaction cross sections are much greater than expected and that the deviations are due both to the low and the high energy part of the energy spectrum. In some cases the angular distribution of the emission could be measured, and the high energy part proved to be strongly directed forwards, consequently attributed to direct processes. A direct process favours in emission the higher energy therefore even in cases when no angular distribution was measured, the peaks at the top of the evaporation spectrum usually were believed to represent direct contributions. In some papers [8], [9] certain high energy peaks were also attributed to protons produced by direct process. In a careful repetition of the experiment the peaks in question actually disappeared: Details are to be found in [4]. On the other hand the low energy discrepancies seemed to be successfully explained by Allan [3] as contributions from the /n,np/

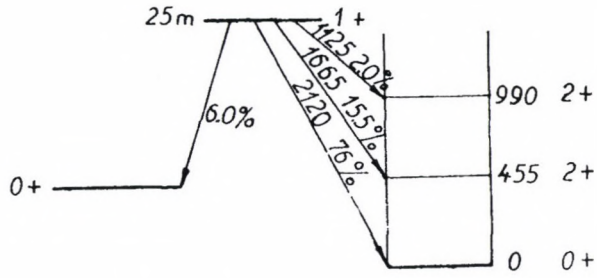
process. However there are several contradictions regarding this point among which the strongest is the measurement of Zn-64 /n,p/ Cu-64 where the bombarding energy was chosen just below the threshold of the /n,np/ process [5]. The number of similar measurements is, however, poor and very much is still to be done in this field. One may conclude that the penetrability of the Coulomb barrier is somewhat higher [6], then it was thought before. At any rate the success of the statistical model in explaining the main features of the /n,n'/ and /n,2n/ reactions where no Coulomb barrier problems arise seems to give strong support to the hypothesis of the lowered Coulomb barrier.

We were to investigate this problem. For it we used bombarding neutron energy 2,6 MeV to avoid any two-particle emission and target nuclei of about 130 mass number in order to satisfy the assumptions of the statistical theory. Since we expected very low values for the cross sections, great number of the target nuclei had to be used. A 1 $^{1}/_{2}$" x 2 " CsJ/Tl/ scintillation crystal was irradiated with 2,6 MeV neutrons of the d - d reaction at 400 keV bombarding deuteron energy. After three days of continuous activation while the variations in the neutron flux was carefully controlled, the activity of the crystall was measured by itself in a mercury shield of 5 cm and an iron box of 20 cm wall thickness. The pulses of the scintillation counter were recorded by a multichannel analyzer, so that the pulses due to a specific decay could easily be collected. The method appeared to be very useful e.g. in measuring the half life of Cs-134 m in the presence of high I-128 activity; the previous one decays with an 0,137 MeV internal conversion while the latter is β emitting with a spectrum extended to about 2 MeV. The neutron flux measurement was made with plastic scintillator and we could not achieve an error in flux measurement less than 20 %. This is the determining error in our cross section values. The background in the crystall was measured also in that box before the activation. In our previous measurement carried out through a pulse shape discrimination method the cross section σ /n, α/ was found to be completely negligible as compered to σ /n,p/[+]. Therefore the processes which can play a role in this measurement are as follows:

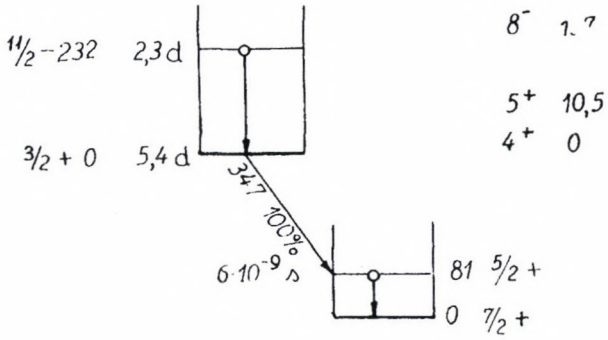
+ unpublished



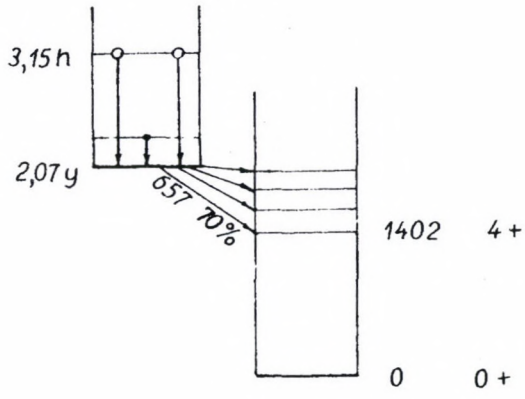
Te^{127} J^{127}



Te^{128} J^{128} Xe^{128}



Xe^{133} Cs^{133}



Cs^{134} Ba^{134}

(n,p) (n,γ)

Reaction	Threshold energy	Activity of residual nucleus	$T_{1/2}$ of residual nucleus		Cross section		
			literary data	present measurement	literary date	present measurement	calculated
Cs-133/n,p/Xe-133m	-0,35	0,233 MeV	2,3 h	-	-	$\leq$0,1 mb	4 /ub
Cs-133/n,p/Xe-133	-0,35	0,345	5,4 h	-	-		
I-127/n,p/Te-127m	-0,09	0,088	105 h	-	-	-	4 /ub
I-127/n,p/Te-127	-0,09	0,695	9,3	-	-	0,05 mb	
Cs-133/n,γ/Cs-134m	-6,73	0,137	2,895$\pm$ $\pm$0,005 h	2,75$\pm$0,1	-	6,3$\pm$1,2 mb	
I-127/n,γ/I-128	-6,59	2,12	24,99 min	24,65$\pm$0,12 min	27 mb	28,3$\pm$6 mb	

In this table we give all the decay constans and cross sections given in the literature as compared to the data we measured. It seems that while in the case of I-127 /n, γ / I-128 there is a good agreement with the cross section measured by Mescheryakov [7] and also the half lives we obtained are good, the cross section for the /n,p/ processes are below the sensitivity of our measurement. Anyway the results obtained do not seem to be in contradiction to the statistical theory and it is probable that there is no direct process of considerable amount.

References

[1] Colli, Facchini et al. Nuovo Cimento 13, 730 /1959/
[2] R.A.Peck, Phys.Rev. 123, 1738 /1961/
[3] D.L.Allan: Nucl.Phys. 24, 274 /1961/
[4] Ezel din M.Sayed, Hrehuss Gyula: KFKI Közl. 10, 203 /1962/
[5] A.Armstrong and L.Rosen: Nucl.Phys. 19, 40 /1960/
[6] K.Kikuchy, Progr.Theor.Phys. 17, 643 /1957/
[7] Hughes, Harvey: Neutron Cross Sections /1955/
[8] W.R.Dixon, Nuclear Physics 42, 27 /1963/
[9] Marcazzan-Menichella Saetta-Tonolini, Nuovo Cimento 20, 905 /1961/
[10] Blatt-Weisskopf: Theoretical Nuclear Physics
[11] Dzelepow-Peker: Decay Schemes of Radioactiv Nuclei /1958/