Fyzikálny časopis 20 (1970), No. 3

AN INVESTIGATION OF THE SPIN CUT-OFF PARAMETER OF THE NUCLEUS OF ^{112}In FROM THE REACTION ^{113}In (n, 2n) AT 14.7 MeV

PAVEL OBLOŽINSKÝ, IGOR RIBANSKÝ, Bratislava

On the basis of a known ratio of isomeric cross-sections a dependence of the spin cut-off parameter on the multipolarity of deexciting gamma-quanta has been investigated using the method of Huizenga and Vandenbosch. It has been shown that this dependence is not significant.

INTRODUCTION

By using the method of Huizenga and Vandenbosch [1, 2] based upon the statistical theory of nuclear reactions, it is possible to determine the spin cut-off parameters if one knows the ratio of isomeric cross-sections. The parameter σ characterizes the spin distribution of the nuclear level density [3]:

$$\varrho(J) = \varrho(0)\,(2J + 1)\exp\left\{-\frac{(J + \frac{1}{2})^2}{2\sigma^2}\right\}, \tag{1}$$

where $\varrho(J)$ is the density of the levels with spin J and $\varrho(0)$ is that with spin 0, resp.

In almost all works using the mentioned method it was supposed just for the sake of simplicity of calculations that the final nucleus, in an excited state after a heavy removal of particles from the compound nucleus, was deexcited only through dipole γ-transition (the last transition was the only exception).

In the present paper the correctness of such an assumption has been investigated in the case of ^{113}In(n, 2n) ^{112}In reaction at 14·7 MeV. There have been considered both dipole and quadrupole transitions and appropriate changes in parameter σ have been observed. The experimental value of the ratio of isomeric cross-section from paper [4] has been used.

The method was first described by Huizenga and Vandenbosch [1, 2]. Some papers give its review as for example [5]. It is based upon the successive determination of the spin distribution of the compound nucleus (relative probability of the nucleus formation dependent upon the spin), spin distribution of the nucleus after the removal of the first and second neutrons and at last the spir distribution after the whole cascade of gamma quanta. It was assumed that every neutron leaving the nucleus possessed the energy

$$E_n = 2T, \quad (2)$$

where T is the temperature of the residual nucleus given by the relation

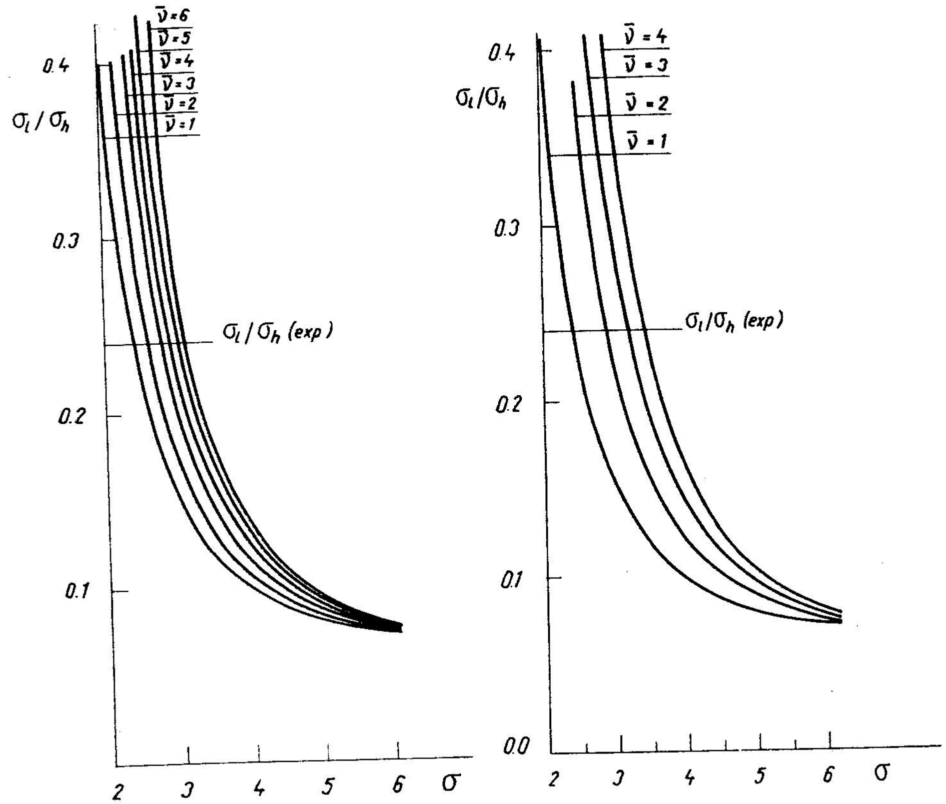

Fig. 1. Theoretical curves plotted in terms of the spin cutoff parameter σ and the multiplicity $\bar{\nu}$. a) dipole emission; b) quadrupole emission.

$$aT^2 - 4T = U. \quad (3)$$

U is the energy of the nuclear excitation corrected for the pairing energy. The values of the pairing energy were taken from paper [6]. The single-particle level density parameter was calculated using relation [7]

$$a = 0{\cdot}095(\bar{J}_N + \bar{J}_P + 1)\,A^{2/3}, \quad (4)$$

where $\bar{J}_N$ and $\bar{J}_P$ are the main values of quantum numbers of the single-particle levels angular momenta above the shell close to the Fermi level, A is the nucleus mass number. The transmission coefficients were taken from paper [8] assuming the parameter of the muclear radius $r_0 = 1{\cdot}5$ fm.

Both dipole and quadrupole transitions and also their combinations have been considered for the final nucleus gamma deexcitations. In the last step

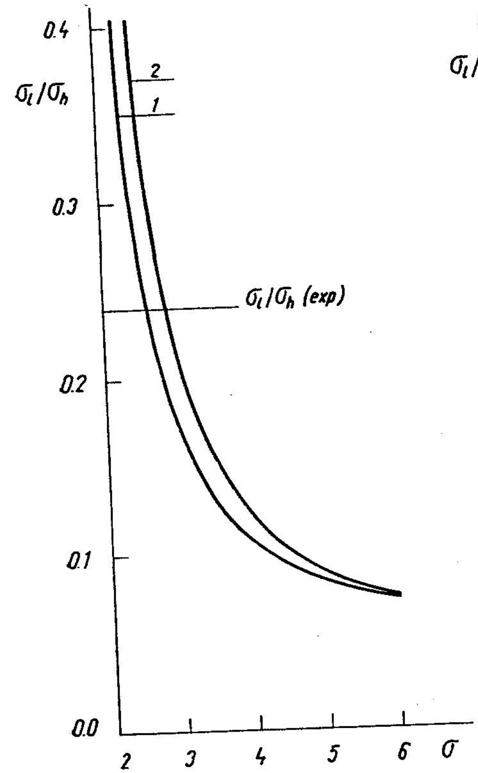

Fig. 2a

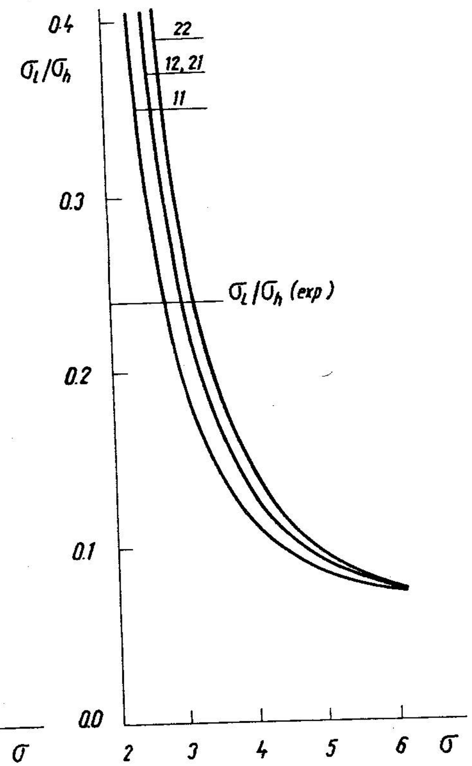

Fig. 2b

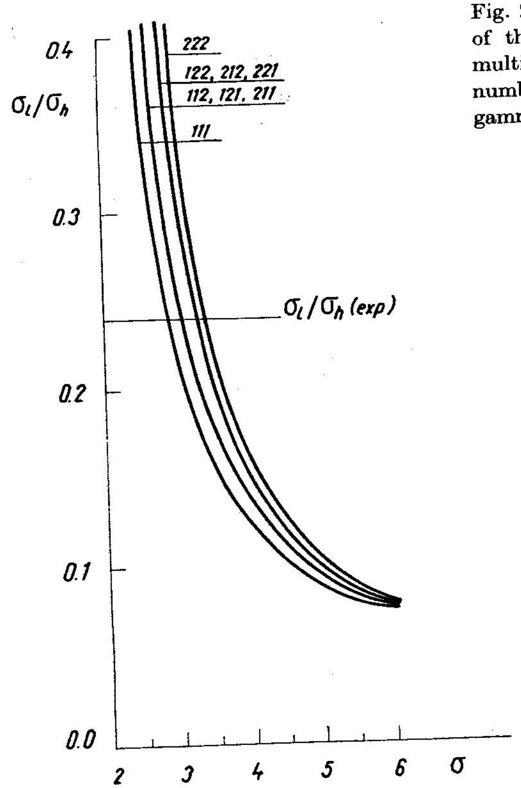

Fig. 2. Theoretical curves plotted in terms of the spin cutoff parameter σ and the multiplicity $\bar{\nu}$. Combined transitions. The numbers represent the multipolarity of gammas with respect to their order. a) $\bar{\nu} = 2$; b) $\bar{\nu} = 3$; c) $\bar{\nu} = 4$.

Fig. 2c

of decay leading to either the metastable or stable state a transition with a smaller change of spin was considered to be usual. The main number of gamma quanta in the cascade has been calculated according to relation [9]

$$\bar{\nu} = \frac{1}{l+1}\sqrt{aU}\,, \tag{5}$$

where l is the multipolarity and U the excitation energy.

RESULTS AND CONCLUSION

The calculations were carried out by CDC-3300 computer using the adopted program [10] in FORTRAN IV. The ratio of the isomeric cross-section was calculated from several values of σ and $\bar{\nu}$ for all dipole and quadrupole transition combinations. The respective curves for these cascades are in Fig. 1; in Fig. 2

there are the curves belonging to different types of cascades with the same number of gamma quanta emitted.

Comparing these curves with the experimental values of the ratio of isomeric cross-sections, the parameter σ was determined. With regard to the values $\bar{\nu} = 3$ resulting from relation [5] for the dipole cascade and $\bar{\nu} = 2$ for the quadrupole cascade the values of the parameter σ were in both casses equal to one another within the limit of errors $\sigma = 2{\cdot}7 \pm 0{\cdot}2$, $\sigma = 2{\cdot}8 \pm 0{\cdot}3$. The other cases, as seen in Fig. 2., lead basically to the same values of σ. The curves related to cascades with the same number of quadrupole transitions at the same value $\bar{\nu}$ are practically identical.

The results obtained give the right to conclude that in the observed reaction the assumption of dipole transitions is correct, at least from the point of view of the value of spin cut-off parameters.

The authors wish thank Mr. Žiak for his assistance in calculations.

REFERENCES

[1] Huizenga J. R., Vandenbosch R., Phys. Rev. *120* (1960), 1305.
[2] Vandenbosch R., Huizenga J. R., Phys. Rev. *120* (1960), 1313.
[3] Bloch C., Phys. Rev. *93* (1954), 1094.
[4] Minetti B., Pasquarelli A., Zeit. Phys. *217* (1968), 83.
[5] Károlyi J., Csikai J., Petö G., Nucl. Phys. *A 122* (1968), 234.
[6] Nemirowski P. E., Adamchuk Yu. W., Nucl. Phys. *39* (1962), 551.
[7] Abdelmalek N. N., Stavinsky W. S., Nucl. Phys. *58* (1964), 601.
[8] Minetti B., Pasquarelli A., Report PTIN 44, Torino 1967.
[9] Groshev L. V. et al., Proc. Conf. on the Peaceful Uses of Atomic Energy, Geneva 1958, 138.
[10] Hafner W. L., Huizenga J. R., Vandenbosch R., Report ANL 6662, Illinois 1962.

Received February 2d, 1970

Fyzikálny ústav SAV,
Bratislava