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S.T.Boneva, V.A.Khitrov, Yu.V.Kholnov,
Le Hong Khiem, Pham Dinh Khang, Yu.P.Popov,
A.M.Sukhovoj, V.A.Bondarenko*, I.L.Kuvaga*,
P.T.Prokofiev*, G.L.Rezvaja*, L.I.Simonova*

EXPERIMENTAL ESTIMATES ON RADIATIVE STRENGTH FUNCTION OF LOW-ENERGY γ-QUANTA FOLLOWING EVEN-ODD HEAVY NUCLEI DECAY

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*Latvian Academy of Sciences, Physics Institute,
229021, Salaspils, Latvia.
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1. Introduction

Much is known about the low-lying levels ($E_{ex} \le 2$ MeV), while very little has in fact been learned till now on highly excited states of heavy nuclei below the neutron binding energy, B_n. So it is not only desirable, but it is absolutely necessary to extend our experimental knowledge to the region $E_{ex} \cong B_n$, in order to develop a model description of the properties of nuclei at excitation energies intermediate between energies of low-lying states of the simplest structure and of extremely complicated compound-states described in the frame of the statistical theory.

Accurate determination of γ-decay parameters of highly excited states is possible if one has data on :

a) radiative strength functions (RSF) of the transitions following the decay of highly excited states (e.g., of low-energy primary γ-rays following neutron capture);

b) nuclear levels densities, particularly, at excitation energies $0 < E < B_n$;

c) expected fluctuations of RSF and nuclear levels densities around their average values.

Information on radiative strength functions of E1, M1 and E2 transitions at energies below B_n as well as on level densities is extremely important for the development of reliable models of the nucleus. Their random fluctuations are not so essential because sufficient averaging occurs over a large number of levels participating in the deexcitation processes (however, they are very useful for the understanding of the nature of nuclear excitations).

A many year study of high-energy primary γ-transitions following the capture of thermal or resonance - averaged neutrons has provided a wealth of information on their radiative strength functions [1-7]. However, there is still lack of experimental information on RSF of γ-transitions of heavy nuclei at excitation energies below B_n. Here, ref.[8] is an exception since it reports on RSF of primary γ-transitions at $E_\gamma > 0.2$ MeV measured in the ^{143}Nd(n,$\gamma\alpha$) reaction. But in the (n,γ) reaction experiments it is impossible to separate and measure the intensity of the low-energy primary radiative component in a singles γ-ray spectrum, which is a continuum of transitions to densely packed intermediate states.

Measurements of two-step γ-ray cascades following thermal neutron capture, which were carried in Dubna over the last ten years, have yielded some additional information on the intensities of primary γ-transitions in a relatively wide range of excitation energies [9-22], including the region above 3 MeV [14]. By now there have been accumulated data on 15 nuclei, mainly in the region of rare-earth nuclei (i.e. the region of the 4S-maximum neutron strength function). We are now in possession of rich and reliable information about the cascade intensities at transition energies $0.5 \text{ MeV} < E_\gamma < B_n$. This work has the aim of carrying out an analysis of recently obtained data in order to demonstrate the advantages of the method applied.

2. Two - step cascades measurements and data analysis

The intensity of two - step cascades from the (n,2γ) reaction was measured using two 10% Ge(Li) or HpGe detectors. Coincidences were measured on the thermal neutron beam from the reactor of the Physics Institute of the Latvian Academy of Sciences. The beam was transmitted through a Si single crystal before reaching the target. The neutron flux on the target was $\approx 10^7$ n/cm^{2}s. The two - step cascades with a given total energy ($E_c = E_1 + E_2 = \text{const}$) were identified by the method of summed amplitudes of coinciding pulses (SACP).

It is well known for heavy nuclei also that high-energy primary transitions are mainly dipole transitions populating known low - lying level of very simple structure. With increasing excitation energy the increasing number of primary transitions is becoming hidden in the continuum due to increasing levels density . The SACP method allows the identification of not only high intensity cascades (resolved peaks) but also provides the possibility of measuring averaged intensity of all the cascades in given energy bins.

This is a principally new source of information about the radiative strength functions of low-energy primary γ-transitions.

The main problem in the analysis of such data, the determination of quanta sequences, can be considered to be solved. The reader may refer for details to refs. [9,18]. The possibility to decompose the spectrum into primary and secondary parts depends on the peak to background ratio in the summed coincidences spectrum. More efficient detectors could help to observe a larger number of peaks at better peak to background ratio and, consequently, better location of cascades to a larger number of final levels.

Combined analysis of cascade spectra (in our experiment it is from 3 to 10 spectra per nucleus) allows one to identify 100÷300 high intensity cascades and to determine their intensity. The majority of the identified cascades are placed in the decay scheme.

The details of the construction of the decay scheme are given in ref.[9]. Note that this decay scheme [21,22] is extended to the 3 MeV energy region. Though being not complete (involves high intensity primary dipole transitions only), it is very reliable. This shows the success of the analysis by the summed coincidences method. Comparison [21,22] with the reported in refs.[23,24] known decay schemes (usually to ≅ 2 MeV) confirms the reliability of the constructed decay scheme. Some of new levels at a relatively high excitation energy of 3 - 4 MeV have been tentatively placed in the scheme. Therefore, one can estimate the probability of appearing of at least one false level in the decay scheme below the given excitation energy. This probability has been estimated [18] for two investigated by us nuclei, ^{178}Hf [16] and ^{179}Hf [17], and was found to be less than 10% at excitation energies below 3.5 MeV in the schemes developed using the SACP method.

Most complicate and complete decay schemes can be developed by combined analysis of singles γ-ray spectrum, the (n,γ) reaction, and summed coincidences spectra of two step cascades (the (n,2γ) reaction) as it has been done in the case of the ^{187}W nucleus. The sensitivity of our spectrometers for resolving cascades is unfortunately not high enough, about (3-5) x10^{-4} photons per decay. The schemes reliability should increase with the use of more efficient detectors. It is worth mentioning that in our experiments we have observed a number of highly intensive transitions at relatively high excitation energies , near to half neutron binding energy. This fact had already been discussed in refs.[19,20] and a reasonable description based on single particle state fragmentation had been presented [20].

3. Energy dependence of the cascade intensity

This section is devoted to the spectrum of primary dipole transitions. We had no possibility so far to distinguish the E1 and M1 components in the spectrum. As the intensity of γ-transitions of higher multipolarities in heavy nuclei is negligibly low, we may speak here about the whole primary transitions spectrum. From the statistical theory point of view, the shape of this spectrum depends on the level density and the energy scaling of radiative widths and their fluctuations.

Table 1 summarizes total primary γ-transition intensities for four deformed nuclei : ^{165}Dy, ^{175}Yb, ^{179}Hf, ^{181}Hf, and the spherical nucleus, ^{137}Ba. The data on total cascade intensities were collected at Dubna and Salaspils Institutes and the data on high-energy primary transitions were taken from ref.[25]. On the basis of this information we were able to determine the average partial widths of primary transitions in a wide energy range. The values obtained for the ^{137}Ba and ^{181}Hf nuclei are given below. Sum intensities measured for other isotopes $\sum(i_\gamma+i_{\gamma\gamma})$ show that analogous data can be obtained for many other nuclei.

The relative intensity of a high-energy primary transition is $i_\gamma = \Gamma_{\lambda f}/\Gamma_\lambda$, where $\Gamma_{\lambda f}$ is the partial width of the γ-transition from compound-state λ to final level f, Γ_λ is the total radiative width of the capture compound-state. By analogy, the two - step cascade intensity, $i_{\gamma\gamma}$, can be expressed through gamma-widths of two decaying states, λ and g, in the cascade λ ⇒ g ⇒ f as follows :

$$i_{\gamma\gamma} = (\Gamma_{\lambda g} / \Gamma_{\lambda})(\Gamma_{gf} / \Gamma_{g}). \qquad (1)$$

The sum intensity was measured in a given energy interval ΔE_g for a limited number of excited states, $n = <\rho_g>\Delta E_g$. Here ρ_g is the level density in the energy interval ΔE_g in the vicinity of the level g.

The measured intensity of primary γ-transitions, $I_\gamma = \sum i_{\gamma\gamma} + \sum i_\gamma$, amounts to about 80% of the total intensity of primary γ-transitions for many compound - nuclei (see table 1) including the ^{137}Ba and ^{181}Hf nuclei. The large error in determination of $i_{\gamma\gamma}$ in the ^{137}Ba experiment comes from uncertainty in determination of the thermal neutron capture cross section [26]. The integral intensity of primary γ-transitions is :

$$I_{\gamma\gamma} = \sum i_{\gamma\gamma} + \sum i_{\gamma} = <\Gamma_{\lambda g}> / \Gamma_{\lambda} \; \kappa \; <\rho_g> \Delta E_g \; , \qquad (2)$$

where $\kappa = \sum <\Gamma_{gf}>/\Gamma_g \le 1$. This coefficient is nearly unity at large enough number of accessible final levels, n_f, and decreases with increasing excitation energy, where it is impossible to identify two - step cascades for the highly excited states. The accessible spin window of states (g) populated via dipole transitions is determined by the condition $|I_g - I_\lambda| \le 1$.

At high excitation energies not all levels are identified and the experimental level density is too low, but at low enough excitation energies the decay schee may be complete. Therefore, at low excitation energies ($E_{ex} \simeq 1 \div 2$ MeV) one can use experimental values for the level density to calculate the cascade intensity by equation (2), but at higher excitation energies ($E_{ex} \ge 2$ MeV), one may use the level density determined by parametrization in the frame of the different models reported in refs.[27-33]. A simple and often used approach to the problem presented by some authors [31,32] has got, by analogy, the name of the Back - shift Fermi Gas (BSFG) model. We have applied this two free parameters approarch, as well as the Ignatyuk's thermo-dynamical approach [33] with fixed parameters, to our experimental data treatment. Level densities calculated in the frame of different models for ^{181}Hf are shown in fig.1 in comparison with the experimental data.

This comparison shows that the BSFG model with parameters from ref.[32] gives the result in relatively good agreement with the experimental data, provided one takes into account that:

a) at the excitation energy $E_{ex} \le 1.4$ MeV in the observed scheme there may be present any levels with $I^\pi = 1/2^+$ and $3/2^+$ excited by primary M1-transitions. As one may see in fig.1 there are probably not more than 4÷5 such levels in the scheme [22] at the excitation energy $E_{ex} < 1.4$ MeV.

b) at the excitation energy $E_{ex} > 1.8 \div 2$ MeV the main part of the ^{181}Hf levels are not placed in the decay scheme.

c) some fluctuation of level density at low excitation energy must be present for any investigated nuclei.

On the basis of the data illustrated in fig.1 and comparison between results obtained in different models of excited state density [27-33] we made the conclusion about the possibility of correct enough model extrapolation of the level density to the excitation interval 2 MeV ≤ $E_{ex} \le B_n$.

The grounds for this conclusion were:

a) well established level density at low excitation energies and at the neutron binding energy;

b) reliably calculated by advanced combinatorial methods [28,29] variation of level density at different excitation energy, spin and parity.

Combinatorial calculations [29] show that:

a) in deformed nuclei the density of levels with given J^π at the excitation energy $E_{ex} \ge 2$ MeV changes monotonously and it can be approximated in a rather accurate way to dependences of the type reported in [27,32];

b) the same is true and for the spin and parity dependence of level density,

c) in spherical nuclei variations of density of states are maximum. But even in near-magic nuclei (for example, the calculation of density of states with $J^{\pi}=1/2^{+}$ and $1/2^{-}$ in ^{143}Nd [29]) the averaging of the level density over the excitation energy interval E_{ex}=500 keV limits its divergence from a smooth dependence of the type [27,32] by a coefficient 0.5 ÷ 1.7;

d) with the increasing of the state density (i.e., the excitation energy) these fluctuations decrease fast [29]. These combinatorial calculations show that in an absolutely unstudied excitation region E_{ex} > 3 MeV unaccounted in simple models [27,32] variations of density of states (excited by cascade transitions in ^{137}Ba and ^{181}Hf) must not exceed some tens percent. Moreover, the direct combinatorial calculation of the level density in ^{137}Ba [28] well reproduces the observed density of low-lying levels and, consequently, allows good extrapolation of this value within the model [32].

The above analysis allows the conclusion that approximation of the level density to the dependence [32] at 2 MeV $<E_{ex}<B_n$ at least would provide a correct qualitative representation of the RSF of low-energy primary transitions. Then the level density value to be estimated below would be sufficient, to the first approach, to choose a model most suitable for making predictions on RSF's.

One cannot keep from emphasizing that as it follows from data in fig.1 supported by our experience the investigation of cascade transitions on higher resolution spectrometers (including their investigation in isolated or averaged resonances) could permit observation of all the states with J=1/2 and 3/2 even in such complicate deformed nuclei as ^{181}Hf up to the excitation energy of no less than 3 MeV.

Up-to-date the RSF's have been determined experimentally practically for all target-nuclei though in a very narrow interval of energies of primary transitions to low-lying excited states of the nucleus. The analysis [4] of the dependence of this γ-decay parameter on the atomic weight of the nucleus showed that:

a) the averaged dependence of RSF on atomic weight is monotonous;

b) there is the possibility to describe the experimental data in the frame of essentially different models;

c) dispersion of the RSF values relative to the averaged dependence is strong enough and cannot be attributed to statistical or systematical experimental errors. Comparison of level density variations at $E_{ex}\geq 3$ MeV predicted in terms of different models [27-33] of the nucleus with RSF variation values determined experimentally for different nuclei [4] permits the conclusion that level density fluctuation values at these excitations could bring into RSF values obtained by us an error not larger in value than that of measured fluctuations [4] of RSF's for high-energy primary transitions in nuclei with different A. Observed deviation of cascade intensities from calculated values in the first turn must be connected with the dependence of partial widths of primary and secondary transitions on the structure of levels connected by them. This dependence was observed, for example, in [19,20,34].

For the same purpose of comparing with the experimental data we have calculated the cascade intensity in the frame of the statistical theory of γ-decay under the following assumptions :

1) Radiative partial widths of E1 transitions are calculated in the frame of the Giant Dipole Electric Resonance (GDER) in addition to the model [35] within the Brink hypothesis, while the M1 and E2 transitions are calculated in the frame of the Weisskopf single particle approach;

2) Experimental data on the ratios of widths of different multipolarity γ-transitions are taken from ref.[4]. Other details of the calculation are analogous to those described earlier in ref.[34].

The results of the calculations under these assumptions for the two models of level density [32,33] are shown in figs.2 and 3. The cascade intensity summed over 500 keV energy bins is shown in the form of histograms as a function of the energy of primary transitions.

One can see that the experimentally measured cascade intensities behave much differently and are strongly structured in comparison with the smooth energy distribution predicted by models. Better agreement between the experimental and calculated values for cascade intensities is observed in the case of the ^{181}Hf in some energy intervals, provided one uses the Ignatyuk's model, which takes into account the Strutinsky's correction for shell inhomogeneities [36]. In the case of the ^{137}Ba cascade decay the results of level density calculation by either model [32] or [33] are virtually the same.

The calculated cascade intensity distributions are presented in figs.2,3 only for the verification of the predictions of the statistical theory. They are not used below for the determination of the RSF.

4. Radiative strength functions of dipole transitions

The transition strength function is usually defined as:

$$K(E1) = \langle\Gamma_{\lambda g}\rangle / E_{\gamma}^{3} D_{\lambda} A^{2/3}. \qquad (3)$$

According to eq.(2) partial widths are related to the measured intensities as :

$$\langle\Gamma_{\lambda g}\rangle = I_{\gamma}\Gamma_{\lambda} \,/\, (\kappa\langle\rho_{g}\rangle\Delta E_{g}). \qquad (4)$$

Total radiative widths of neutron resonances Γ_{λ} were determined for all the nuclei of the Periodic Table by the method of time - of - flight neutron spectrometry [37]. We have calculated the strength functions using level density values from ref.[32] and a value of $\kappa = 1$. Comparison of the level density values predicted by these two models [32,33] for a majority of even - odd nuclei belonging to this mass region has shown that they usually differ by less than a factor of 1.5 at excitation energies $E_{ex} \geq 2$ MeV.

As the coefficient κ is usually unknown, we, by taking $\kappa = 1$, obtain the lower estimate on $\langle\Gamma_{\lambda g}\rangle$ which is acceptable, for example, when more than 80% of the primary transitions intensity has been observed in our spectra and in the primary

transition spectrum to cascade final levels.

In the limit of the above stated assumptions and making use of the measured primary γ-transition intensities we have calculated, by eq.(3), the radiative strength functions averaged over 0.5 MeV bins for the ^{181}Hf (fig.4) and ^{137}Ba (fig.5) nuclei. The bars indicate statistical errors and expected Porter - Thomas fluctuations.

E1 strengths, according to refs.[1-7], satisfy the assumption that the capture state has the statistical nature and is described in the frame of the GDER model. A recently developed model [38] modifies the simple shape of the Lorentzian dependence under the assumption that the spreading width Γ depends on the temperature of the nucleus and the energy of γ-quanta. This model was applied to the spherical nucleus ^{144}Nd and model parameters were determined. We have calculated K(E1) in the frame of both models [35,38]. The results are illustrated in figs. 4 and 5. It should be noted that in the case of the deformed nucleus ^{181}Hf the GDER splitting is taken into account and thus model [38] is applied independently to each of the two resonance components. The experimental values include both E1+M1 transition intensities as it is impossible to separate the M1 contribution yet.

If the ratio $\Gamma_{\lambda g}(E1)/\Gamma_{\lambda g}(M1)$ for low-energy primary transitions differs little from that for high-energy ones [5], the difference between experimental K(E1+M1) and model calculated K(E1) values will be less than a few tens percent.

For the two nuclei under investigation we have detected about 80% of the total radiative width. The remaining 20% of the total intensity in the case of the ^{181}Hf nucleus can be divided between three energy bins : 1 - 1.5; 1.5 - 2; 2 - 2.5 MeV, and added to the detected intensity in these bins (points in fig.4) to have approximate estimate of the behaviour of the total dipole strength function. Such addition is justified by the fact that the value for $\langle\Gamma_{\lambda g}\rangle\langle\rho_{g}\rangle$, calculated with two models [32,33] for two level densities and two predicted values of $\Gamma_{\lambda g}$ [35,38], shows that the shape of the energy dependence of $<\Gamma_{\lambda g}><\rho_g>$ changes little (dashed lines in figs. 2,3) with a maximum at $E_1 \cong 2$ MeV and the width $\Delta E_1 \geq 2$ MeV.

Comparison of the data of these two nuclei favours the use of the simple Lorentzian shape of GDER [38] for the calculation of dipole strength functions.

Since the collected data cover just 80% of Γ_λ one can make no firm conclusion about the shape of the energy dependence. Thus for the final solution of the γ-strength problem we have to continue efforts on developing the theory and collecting more complete experimental data.

Some points in figs.4 and 5 indicate a sharp rise in the strength function value, which is an unexpected fact. In these energy bins, the experimental values for level density were used and the strength enhancement might be attributed to the level structure.

It is characteristic of these two nuclei that their compound- states have relatively large single - particle components, due to the 4S resonance region of the neutron strength function. On the other hand, their final states have single particle components ($3P_{1/2}$ and $3P_{3/2}$ states in ^{137}Ba and a fragmentated 3P-state due to nuclear deformation in ^{181}Hf). The enhanced transitions 3S ⇒ 2P and 3P ⇒ 3S were observed earlier [39]. It is difficult to detect the 4S ⇒ 3P transitions in deformed nuclei because of the 3P strengths being fragmentated to many states. But this conclusion is correct for single γ-spectra detection only and not for γ-cascades. Summation over intermediate cascade levels removes this restriction. Thus one can conclude that the observed cascade intensity enhancement is due to single particle transitions between 4S and 3P shells. For ^{137}Ba there are two strong transitions, E_1 = 4742 keV and 4242 keV, to the states at E_f = 2183 keV and E_f = 2663 keV. According to ref.[23] these two states are the $3P_{1/2}$ and $3P_{3/2}$ states, respectively.

For ^{181}Hf there are the primary transitions in cascades with the energy E_1 = 3.7 MeV and high-energy primary transitions, E_1 = 5.5 MeV. According to ref.[40] the main components of the wave function of the levels in this band are the $3P_{1/2}$ and $3P_{3/2}$ states. Calculation within the semi-microscopical approach [20] has demonstrated qualitative agreement between two - step cascade intensity enhancement and strength concentration of single particle states with asymptotic quantum numbers $1/2^-[510]$, $1/2^-[521]$, $1/2^-[501]$ and $3/2^-[501]$ for the nuclei ^{165}Dy, ^{175}Yb and ^{179}Hf [41].

Earlier [34] we have already made notes on the correlation between the cascades intensity to final single particle states of deformed nuclei and the single particle component of the compound state wave function. In accordance with ref.[42] the reduced neutron width Γ_o^n is the measure of this correlation. This aspect of the research considering two - step γ-cascades is discussed in more detail in ref.[34].

5.The main open problems of the experimental determination of the RSF

The radiative strength function is determined from experimental primary transition intensities, I_γ, by expressions (3) and (4).

As the transition energy, E_γ, and the spacing between neutron resonances, D_λ, can be measured with good precision now, the resulting error in determination of K(E1) depends on:

a) how near to unity is the coefficient κ (i.e. how completely the primary transition intensity is distinguished in the experimental spectra);

b) the possibility of determination of the value $<\rho_g>$ from the experiment in the most wide range of excitation energies;

c) the conformity of the average value Γ_λ for neutron resonances to the total radiative width value of a compound-state excited on thermal neutron capture.

The first problem can be solved effectively by using appropriate instruments, e.g. the HPGe detectors having the efficiency of 30÷50% and even higher instead of the 10% ones of ours.

At that almost automatically will be solved the problem of measuring the $<\rho_g>$ value.

The third problem seems most important in the determination of the RSF for the near-magic nuclei, such as ^{137}Ba. The data presented in fig.5 are obtained by using the value Γ_λ=125 meV from [37]. In the investigated s-resonances of ^{137}Ba the Γ_λ varies from 78 to 186 meV.

The thermal neutron capture cross section is σ_γ=0.68(17) b according to [26]. It differs from the value of σ_γ=0.4(4) in [37] and is mainly defined by the resonance E_0=-250 eV. These resonance parameters, Γ_λ, and, $g\Gamma_n^0$, cannot be determined with the same precision as the parameters of a resonance at E_0>0, and thus the use of the value Γ_λ=125 meV in the determination of K(E1) leads to systematic deviations at a level of ≈30%. The direct capture cross section σ(D)=0.2 b [37] for ^{136}Ba makes about 30% of the total thermal neutron capture cross section and also introduces some additional uncertainty to our results. This fact leads to further decrease of the experimentally obtained relative intensity of the primary transitions to high-lying states with complex structure and accordingly decreases the RSF value at $E_\gamma \le 3$ MeV.

In result we have the absolute value of RSF for ^{137}Ba obtained with a systematical error of up to 30% (and, possibly, higher). The relative error in determination of the difference between K values for different primary transition energies is, naturally, smaller than that given in fig.5 due to fully correlated existing systematical deviations.

This is the only reason why we state here that the model [38] describes the RSF of the low energy primary transitions in ^{137}Ba better than it does the model [35].

However, it seems quite necessary to further develop the model of interaction of low energy γ-qanta with the excited nucleus in order to have better description of the experimental data.

6. Conclusion

The information on the two - step γ-decay of a number of nuclei in the mass range 137 ≤ A ≤ 187, which was collected from the thermal neutron capture experiments conducted at Dubna and Salaspils , formed the basis for the full study of the characteristics of the γ-decay of compound-states. The values obtained for the radiative strength functions in ^{137}Ba and ^{181}Hf in a wide range of primary transitions were compared with the predictions of two modifications of the giant dipole resonance model.

In the case of even-odd nuclei the results obtained do not allow one to reliably verify the correspondence with the γ-decay statistical theory predictions. Strong nonstatistical effects were observed (see also [12,13,19,20,35,41]) reflecting mainly the shell structure effects. The most probable reason for a certain part of transitions to become enhanced is the 4S ⇒ 3P single particle transition.

In conclusion we would like to emphasise that the application of the described method allows one to observe up to 80% of the total primary transitions intensity over a wide range of excitation energies and to extend γ-decay schemes of heavy nuclei up to 3.5 MeV. With higher efficiency detectors, one will both improve data accuracy and reveal further details of the capture decay processes.

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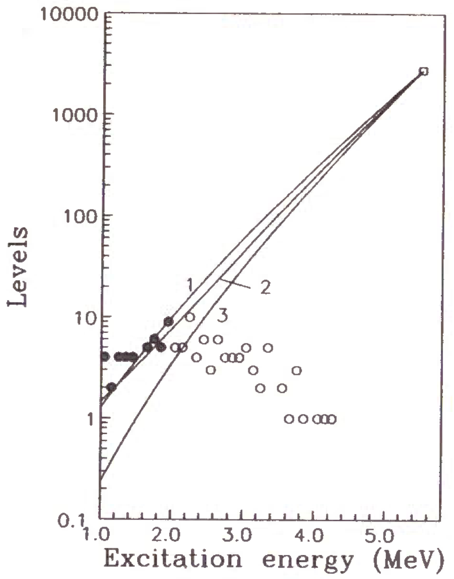

Fig.1: A comparison between the experimental data (points) and the predicted values of level density for $J=1/2^-$ and $J=3/2^-$ states of ^{181}Hf at an excitation energy above 1 MeV using different models. (Levels are summed over 100 keV energy interval).

Curve 1: represents calculations using the BSFG model ref. [32] with the momentum of inertia equal to 0.5 of the rigid body value momentum and the parameters $a=17.61$ MeV^{-1} and $\delta=-0.41$ MeV.

Curve 2: represents calculations using Gilbert-Cameron [27] model.

Curve 3: represents calculations using the Ignatyuk's thermo-dynamical model (ref.[33]).

o - experimental data from level scheme [22] in region of probably missing levels;

□ - experimental data from neutron resonance level density [37].

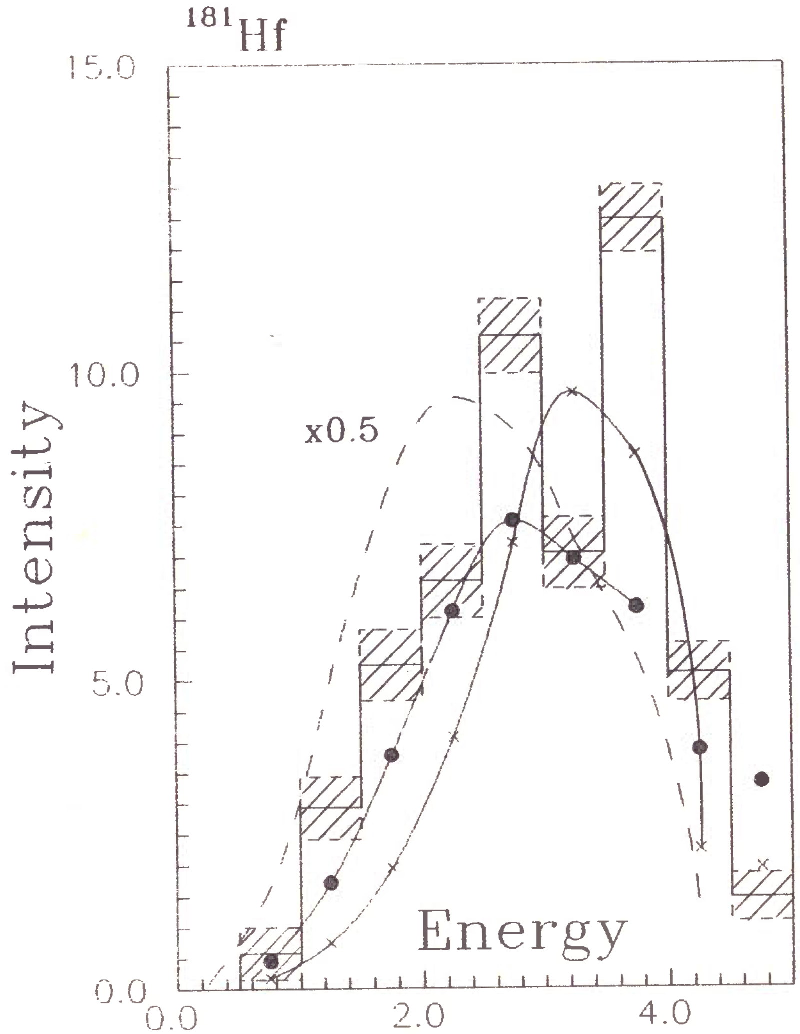

Fig.2: Experimental sum intensity of the cascades to 5 low - lying levels of ^{181}Hf (per 10^2 capture events) in dependence on the primary transition energies. Shaded are the statistical errors :

x - calculated with BSFG model of level density parameterization;

o - calculated with model [33].

The dashed line represents the calculated values of the sum $\Sigma\Gamma_{\lambda g}$ of partial widths of primary transitions, multiplied by 0.5.

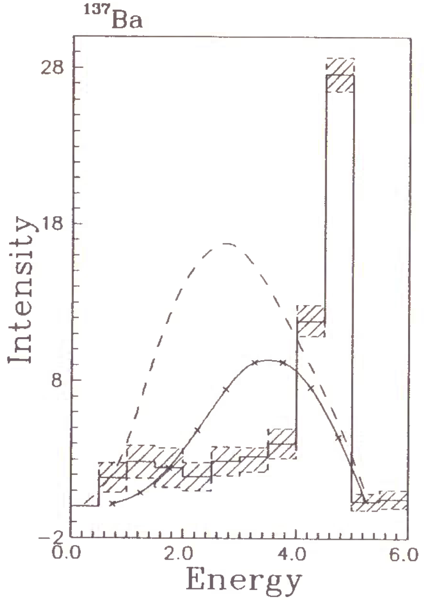

Fig.3: The same as fig.2 for ^{137}Ba.

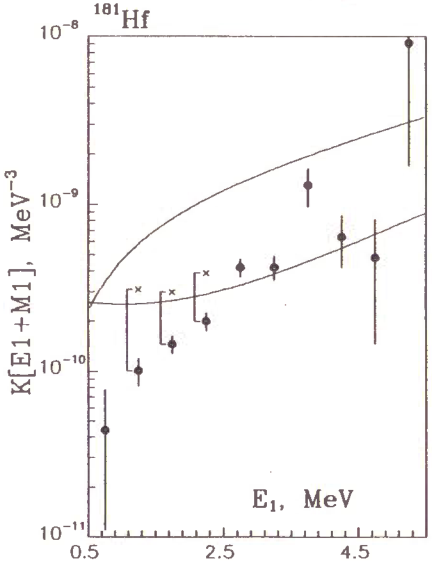

Fig.4: Experimental estimates on RSF (o - lower estimate, x- - upper estimate) in the case of the ^{181}Hf nucleus at the excitation energy $E_1 \geq 0.52$ MeV. The lower curve illustrates the use of the GDER model [38], the upper curve - extrapolation to the Lorentzian dependence with Γ_λ = const [35].

Table 1 : Intensities of primary γ-transitions following the neutron capture as measured in the experiment on two - step γ-cascade decay ($i_{\gamma\gamma}$) and single γ-ray decay (i_γ) to the low - lying level n_f. The intensities are given in the units of photon per 100 capture events (%).

Nucleus	^{137}Ba	^{165}Dy	^{175}Yb	^{179}Hf	^{181}Hf
$\sum i_{\gamma\gamma}$	76 (25)	55 (7)	69 (9)	67 (4)	52 (4)
$\sum i_\gamma$	2	14	12.5	10.5	28
n_f	3	7	9	10	5

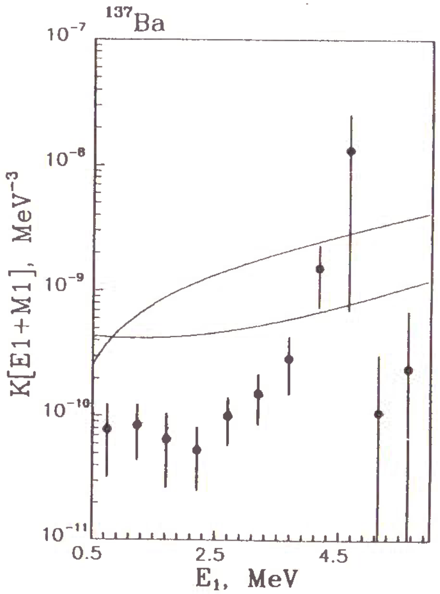

Fig.5: The same as fig.4 for ^{137}Ba.

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Экспериментальная оценка радиационной силовой функции низкоэнергетических γ-квантов при распаде четно-нечетных тяжелых ядер

Обсуждаются возможности метода суммирования амплитуд совпадающих импульсов с целью определения радиационной силовой функции в тяжелых ядрах. Эксперимент выполнен для захвата тепловых нейтронов в ^{136}Ba и ^{180}Hf. Полученные значения радиационной силовой функции в широкой области энергий первичных переходов сравниваются с предсказаниями двух модификаций модели гигантского электрического дипольного резонанса. Сделаны некоторые заключения об особенностях распада ряда ядер из области 137 ≤ A ≤ 187 испусканием двухквантовых каскадов.

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