E3-2000-133

V.A.Khitrov, A.M.Sukhovoj

NEW TECHNIQUE FOR A SIMULTANEOUS ESTIMATION OF THE LEVEL DENSITY AND RADIATIVE STRENGTH FUNCTIONS OF DIPOLE TRANSITIONS AT $E_{ex} \leq B_n - 0.5$ MeV

Submitted to «Nuclear Instruments and Methods A»

1 Introduction

The observed parameters of the cascade γ-decay of the compound nucleus can be reproduced in the calculation if one determines (in the frameworks of some model) at least

(a) the mean density ρ of the excited states with given spin and parity J^π, and
(b) the mean width Γ_{fs} of γ-transitions between the arbitrary states f and s.

The objects of primary interest are the total radiative width Γ_γ of the compound nucleus (neutron resonance) and the spectrum of γ-emission. It may be, for example, the intensity $I_{\gamma\gamma}$ of the cascades of two successive γ-transitions between the compound state and given low-lying level via a great number of intermediate levels. The experimental data on $I_{\gamma\gamma}$ are obtained for over 30 nuclei from the mass region $114 \leq A \leq 200$ (see, e.g., [1]) with a precision of approximately 10%. The experimental values of Γ_γ are known within the same accuracy. Unfortunately, such accuracy cannot be achieved in the calculation of these parameters for an arbitrary nucleus because there are no models that would predict ρ and Γ_{fs} with the mentioned above precision. Precise γ-decay parameters are, however, necessary for the calculation of the interaction cross-sections of neutrons with unstudied target nuclei and the understanding of the behavior of nuclear matter with increasing excitation energy. An analysis of the existing methods for the determination of the level density [2,3] and radiative strength functions (RSF) [4]

$$f = \Gamma_{fs}/(E_\gamma^3 \times A^{2/3} \times D_f) \tag{1}$$

in deformed nuclei, for example, shows that it is not possible to obtain sufficiently precise experimental level densities for certain intervals of their energies and quantum numbers as well as the widths of the corresponding transitions. Therefore, without developing new methods for the determination of nuclear parameters under discussion one cannot expect any progress in the modification of the existing nuclear models.

A new and sufficiently perspective way to obtain such information for the entire energy interval below B_n seems to be the investigation [5,6] of the two-step γ-cascades between the compound state λ and the given low-lying level f through all possible intermediate states i. The algorithms [7-9] developed for the analysis of $\gamma - \gamma$ coincidences registered by ordinary Ge detectors allow one to determine the intensity distribution of the cascades as a function of the energy of the cascade intermediate levels over the whole energy region up to $E_{ex} \simeq B_n$ with an acceptable systematic error (which decreases as the efficiency of the γ-spectrometer increases).

The intensity $i_{\gamma\gamma}$ of an individual cascade is

$$i_{\gamma\gamma} = \frac{\Gamma_{\lambda i}}{\Gamma_\lambda} \times \frac{\Gamma_{if}}{\Gamma_i}, \tag{2}$$

where $\Gamma_{\lambda i}$ and Γ_{if} are the partial widths of the transitions connecting the levels $\lambda \to i \to f$, Γ_λ and Γ_i are the total widths of the decaying states λ and i, respectively. The sum intensity $I_{\gamma\gamma}$ of the cascades is related to an unknown number of intermediate levels $n_{\lambda i} = \rho \times \Delta E$ and unknown widths of primary and secondary transitions via the equation

$$I_{\gamma\gamma} = \sum_{\lambda,f}\sum_{i} \frac{\Gamma_{\lambda i}}{\Gamma_\lambda}\frac{\Gamma_{if}}{\Gamma_i} = \sum_{\lambda,f} \frac{\Gamma_{\lambda i}}{<\Gamma_{\lambda i}> m_{\lambda i}} n_{\lambda i} \frac{\Gamma_{if}}{<\Gamma_{if}> m_{if}} \tag{3}$$

The summation is over a certain set of quantum numbers of intermediate, initial, and final states for the purpose of comparison with the experimental data. The thermal neutron capture cross-section for two possible spins of compound states are listed in [10], for example. The J^π values for the initial and final cascade levels are also known. The latter, however, is true if the energy E_f of the final state does not exceed ~ 1 MeV. The optimal width of the interval ΔE and the number N of such intervals in eq.(3) are determined by the statistics of $\gamma - \gamma$ coincidences (as a square detector efficiency) and the necessity to obtain detailed energy dependence for $I_{\gamma\gamma}$. The width of ΔE does not exceed 0.5 MeV even in the case of a 10% efficiency detector, however. The total radiative widths Γ_λ of the capturing states are also known from the corresponding experiments for all stable nuclei [10]. The mean partial widths $<\Gamma_{\lambda i}>$, $<\Gamma_{if}>$ and the total numbers $m_{\lambda i}$, m_{if} of levels excited by $E1$ and $M1$ transitions after the decay of the states λ and i, respectively, to be found in the analysis are related to the total radiative widths as

$$\begin{aligned} \Gamma_\lambda &= <\Gamma_{\lambda i}> \times m_{\lambda i} \\ \Gamma_i &= <\Gamma_{if}> \times m_{if} \end{aligned} \tag{4}$$

The contribution of higher multipolarities to eqs.(3) and (4) is smaller than the error of the determination of $I_{\gamma\gamma}$. Equations (3) and (4) and their obvious combination

$$\Gamma_\lambda \times I_{\gamma\gamma} = \sum_{J,\pi} \Gamma_{\lambda i} \times n_i \times (\Gamma_{if}/ <\Gamma_{if}> m_{if}) \tag{5}$$

allow three ways of the estimation of the parameters of the cascade γ-decay using the experimental data on $I_{\gamma\gamma}$ and Γ_λ:

(a) the level density can be estimated from eq.(3) using model calculated partial radiative widths;

(b) the partial widths of cascade transitions can be estimated from eq.(5) using model calculated level densities with certain J^π;

(c) simultaneous estimation of the intervals of probable level densities and radiative strength functions which satisfy eqs. (3) and (4) in general.

It is clear that the level density and strength functions found according to variants (a) and (b) inevitably contain errors caused by the uncertainties of experimental and model values used as parameters of the analysis. However, the influence of these uncertainties on the final result is suppressed because of the correlation (determinated by the type of the functional relations used, (3) and (5)) between the experimental Γ_λ^{exp}, $I_{\gamma\gamma}^{exp}$ and the parameters under study ρ, Γ.

In accordance with the variant (a) the sufficiently narrow interval of probable ρ was determined for almost 30 nuclei from the mass region $114 \leq A \leq 200$ for some set of possible models of γ-transition strength functions. An important conclusion made in [11] is that the best description of the level density in the interval from $\sim 0.5B_n$ to B_n was achieved in the framework of the generalized model of the superfluid nucleus [12]. Besides, simple enough models of radiative strength functions cannot provide a correct description of the experiment and also need modification. An analysis by variant (b) was performed by us, as well. The main result is that there are no strength function models for $E1$ and $M1$ transitions in deformed nuclei which could reproduce of the dependence $\Gamma_\lambda \times I_{\gamma\gamma}$ at primary transition energies $E_1 \leq 2-3$ MeV if the level density is set by the model of a non-interacting Fermi-gas. Therefore, the understanding and correct description of the γ-decay of the compound nucleus with a high level density requires experimental determination of the level density and radiative strength functions over the entire excitation energy region.

Further investigations [13] have shown that the level density at excitations from 1-2 to 3-4 MeV deviates strongly from the exponential energy dependence derived on the basis of the idea that the nucleus is a non-interacting Fermi-gas [14]. Moreover, it is not excluded that the level density in this energy interval can be almost constant or even decrease with increasing excitation energy. These confirm and complement the results obtained in [11].

2 Analysis

The variant (c) of analysis of the experimental intensities of two-step γ-cascades between the capturing state and several low-lying levels allowed us to suggest an original method for the solution (although partial) of this problem. It is based on an obvious circumstance that $N+1$ equations (3) and (4) together with $6N$ conditions

$$\begin{aligned} \rho(\pi=+) > 0; \qquad \rho(\pi=-) > 0 \\ \Gamma(E1) > 0; \qquad \Gamma(M1) > 0 \end{aligned} \tag{6}$$

(separately for primary and secondary transitions in the case of radiative widths) restrict some interval of possible level densities and partial radiative widths which provide a simultaneous reproduction of Γ_λ^{exp} and $I_{\gamma\gamma}^{exp}$. This interval can be estimated using modern computers and the existing computational algorithms. It should be added that $I_{\gamma\gamma}$ in the form of eq.(3) is inversely proportional (qualitatively) to the total number of states excited in the process under study and is proportional to the ratio of cascade transition widths to their mean values. Therefore, the method of analysis described below has a maximum sensitivity at minimum density of the excited states (unlike the method [2]).

As in the case of other reactions (followed by γ-emission) used for the determination of ρ all values obtained experimentally in the (n_{th}, γ) measurements are determined by the product $\Gamma_{fs} \times \rho$. Hence, in the calculation deviation of one of the two parameters from its mean value is compensated by deviation of the other one with the corresponding magnitude and sign. This circumstance should be taken into account in data processing — a minimum or maximum value of the level density derived from the experimental data results, e.g., in a maximum or minimum value of the corresponding strength functions.

It should be noted that deviation of the calculated level density from the true value is completely compensated by deviation of strength functions when Γ_λ is only calculated. In the case of the calculation of $I_{\gamma\gamma}$ the compensation is incomplete. This very circumstance allows one to select the intervals of ρ and Γ_{sf} which provide the description of the $I_{\gamma\gamma}$ and Γ_λ parameters with an acceptable uncertainty. This analysis can be performed by means of finding large enough sets of random values of ρ and Γ_{sf} which reproduce completely the parameters Γ_λ^{exp} and $I_{\gamma\gamma}^{exp}$ and belong to intervals that contain true values. This means that most probable values of the level density and radiative strength functions of dipole γ-transitions and intervals of their uncertainties can be found by selection of pairs of random ρ and $RSFs$ which satisfy, in general, eqs. (3) and (4) or (3) and (5). This requires numerous repetitions of the procedure and statistical methods of analysis. In other words, one should assume that deviations of the random values obtained in the analysis from mathematical expectations are close, for example, to a normal distribution. A natural substantiation of the hypothesis is that a great number of small random variations of the studied parameters should provide approximately equal probabilities of their deviations of both signs from the true value.

It is clear that the widths of the intervals of probable ρ and $RSFs$ satisfying eqs.(3) and (4) increase with increasing number of unknown parameters in the equations. According to experimental conditions, the summation in eqs.(3) and (5) was over all intermediate states of the cascades. Since the summed data included cascade transitions of different multipolarities, we could not obtain the strength functions of $E1$ and $M1$ transitions and the level density for different parities separately with a good precision. In practice, from a combination of eqs.(3) and (5) the sum of strength functions and the sum of level densities of both parities should be only derived and compared with model predictions. The corresponding summation reduces considerably the uncertainty of the observed result due to anticorrelation of elements.

Indeed, an analysis of the available data confirms that the dispersion of each set of $\rho(\pi = +)$, $\rho(\pi = -)$, $f(E1)$ and $f(M1)$ random values is too large to make any conclusions about independent correspondence of individual values to the model.

A sufficiently large N and the nonlinearity of eqs.(3) and (4) stipulate the choice of the way to solve the system of equations and inequalities - the Monte Carlo method. The simplest iterative algorithm [11] was used for this aim: we set some initial values for $\Gamma(E1)$, $\Gamma(M1)$, $\rho(\pi=-)$, and $\rho(\pi=+)$ and then distort them by means of random functions. If these distortions decrease the parameters $\Delta_1 = (I_{\gamma\gamma}^{exp} - I_{\gamma\gamma}^{cal})^2$ and $\Delta_2 = (\Gamma_\lambda^{exp} - \Gamma_\lambda^{cal})$ at this step of the iteration procedure, then the distorted values are used as initial parameters for the next iteration. Agreement between the experimental and calculated cascade intensities and the total radiative widths, respectively, is usually achieved after several thousand iterations. As a result we get two random ensembles of level densities and partial widths for every N energy intervals. Examples of intermediate and final results of one of many variants of the calculation for two nuclei are shown in Figs. 1 and 2. It is obvious that such iterative process can be realized in an unlimited number of ways. We chose a sufficiently simple and effective way: the Gaussian curve is used as a distorting function

$$f(E) = A \times \exp(-(E-E_0)^2/\sigma^2) \tag{7}$$

Its parameters are independently chosen for the level density and strength functions from the intervals [-0.2;0.2], $[E_d; B_n]$ and [0.3 MeV;B_n] for A,E_0, and σ, respectively using a standardized random value distributed uniformly in [0;1]. Here E_d is the maximum excitation energy of the known discrete level involved in the calculation. Numerous repetitions of the iterative calculation with different initial parameters (including obviously unreal values of Γ and ρ) for ~30 nuclei from the mass region $114 \leq A \leq 200$ show that this algorithm yields rather narrow intervals of the sum level density of both parities and of the sum partial widths of $E1$ and $M1$ transitions. Some examples of the obtained results are given in Figs. 3 and 4.

3 Approach used in calculations

An insufficient experimental data on cascade γ-transitions (only cascades terminating at low-lying levels of nuclei are studied [1]) does not allow us to determine the level densities and gamma-widths without the following assumption: the strength functions of transitions of a given multipolarity only depend on the transition energy and do not depend on the structure and energy of the corresponding excited states. Their nonequal values for γ-transitions of equal energies but populating different levels is, in part, compensated by the circumstance that the left part of eq.(5) depends on absolute radiative strength function values of primary transitions and depend only on the ratio of strength functions in the case of secondary transitions. These decrease the effect of the discussed assumption on the $f(E1)+f(M1)$ values but do not remove it completely. This problem can be solved experimentally: the use of a Compton-suppressing spectrometer consisting of $HPGe$ detectors with an efficiency of not less than 30-40% allows the selection from a mass of $\gamma-\gamma$ coincidences of two-step cascades for a considerably larger number of their final levels than at present. From a combination of eq. (3) for the sum over all final levels of cascades and an individual final level f one can determine the ratio $\Gamma_{if}/<\Gamma_{if}>\times m_{if}$ for all possible values of i and f, i. e., determine the experimental sum $f(E1)+f(M1)$ for any possible secondary transitions, get rid of the only approach used in the analysis, and reduce the number of parameters in the analysis.

4 Sources of errors in the determination of strength functions and level densities

Uncertainties of the measuring of terms in eqs. (3) and (5) result in errors of strength functions and level density. Owing to a linear relation between Γ_λ, $I_{\gamma\gamma}$ and $\Gamma_{\lambda i}$ in eq.(5), $\sim$ 10% errors of Γ_λ and $I_{\gamma\gamma}$ cause rather a small error in the determination of $\Gamma_{\lambda i}$ and ρ as compared to dispersion of the data shown in Figs. 3 -4.

Another source of uncertainty in the determination of strength functions and ρ is a systematic error of decomposition [8,9] of experimental spectra into two components corresponding to solely primary and solely secondary transitions. The analysis [13] showed that the error in $\Delta I_{\gamma\gamma}$ caused by this procedure does not usually exceed $\sim$ 20% for primary transition energy $E_1 < 3-4$ MeV. In order to estimate the influence of $\Delta I_{\gamma\gamma}$ on the final results, $I_{\gamma\gamma}$ values were varied within a level of 25%. These variations caused changes in $f(E1)+f(M1)$ and ρ which did not exceed the dispersion of the plotted data.

In other words, the main uncertainty of the level density and strength functions is not related with experimental errors of Γ_λ and $I_{\gamma\gamma}$ but is determined by the relationship of Γ_λ, $I_{\gamma\gamma}$ and $\Gamma_{\lambda i}$ in the measured functionals of the γ-decay process. As for the radiative strength functions and level density plotted in Fig. 3-4, their probable dispersion includes only uncertainties which are due to unambiguous values of the parameters obtained within iterative algorithm. On the whole, one can conclude that at the given stage of the experimental investigation of the cascade γ-decay of compound states, the results given in this work should be considered as most probable in spite of their uncertainties mentioned above.

5 Main results of analysis

The type of relation between $RSFs$ and ρ on the one hand and between Γ_λ and $I_{\gamma\gamma}$ on the other hand does not allow one to determine $RSFs$ and ρ unambiguously and independently. Some deviation of, for example, ρ from a real value is inevitably compensated by deviation of strength functions of the corresponding magnitude and sign. Nevertheless, the results obtained in the present analysis can be used for the verification of nuclear models and, if necessary, for the determination of the direction of the further development of these models. The main argument in favour of this statement is relatively week dependence of the final results on the initial values of strength functions and ρ in the iterative process. As an example, Figs. 1 and 2 show the strength function and ρ values obtained for their unreal initial values: $\rho(E_{ex}) = \rho(B_n)$, the strength functions decrease linearly as the transition energy increases. Nevertheless, the final results of the iterative process quite agree with a general picture obtained for a large enough set of different real and unreal initial values of $RSFs$ and ρ.

The strength functions $f(E1) + f(M1)$ and level densities ρ obtained in the present analysis are plotted in Figs. 3 and 4, respectively. For every set of random ρ at a given excitation energy E_{ex} and $f(E1) + f(M1)$ at a given primary transition energy $E_1 = B_n - E_{ex}$ there were determined both their mean values and probable dispersion using usual relationships of statistical mathematics. Besides, the mean values of $f(E1)+f(M1)$ and ρ obtained with the help of the iterative procedure for absolutely unreal initial level densities $\rho(E_{ex}) = \rho(B_n)$ are given in the figures, as well. The results of the analysis are compared with predictions of the level density models [12,14] and models of radiative widths [15,16]. In the case of radiative strength functions a comparison is performed in the following manner: the $f(E1)$ values calculated according to the models [15] and [16] (upper and lower curves, respectively) are summed with $f(M1) = const$ which is normalized so that the ratio $\Gamma(M1)/\Gamma(E1)$ would be approximately equal to the experimental data at $E_\gamma \sim B_n$.

A comparison of $f(E1) + f(M1)$ and ρ obtained for different initial parameters of the iterative process shows sufficiently weak or absent dependence of the strength functions and level density on the initial parameters and the course of computation. This testifies to the above made conclusion that the strength functions and level density obtained from a joint analysis can be considered as most probable.

A comparison of the results of the joint analysis with predictions of the models [12,14-16] (often used by experimentalists) shows that:

(a) the sums $f(E1) + f(M1)$ and ρ are not monotonic functions of the energy and, probably, reflect the most common peculiarities of the structures of the states connected by the corresponding γ-transitions;

(b) the energy dependence of $f(E1) + f(M1)$ differs strongly from predictions of the models [15,16] in the case of even-even compound nuclei from the region of the 4s-resonance of the neutron strength function, at least;

(c) the $f(E1) + f(M1)$ functions increase from near-magic to deformed nuclei and from complicated highly-excited states to simpler low-lying levels which are populated by γ-transitions under consideration;

(d) relative deviations of the obtained strength functions and level densities from the mean values are characterized by strong negative correlation. In the majority of nuclei the correlation coefficient changes from -0.6 to -1.0. This means that the strength functions and level densities are not independent variables in eqs. (3) and (5), which provides the possibility of their simultaneous determination;

(e) the probable level density determined in the present analysis conforms to the picture obtained in previous experiments [11,13]: up to the excitation energy 1-2

MeV, our data are not in contradiction with the exponential extrapolation of $\rho(E_{ex})$ predicted by the Fermi-gas back-shift model [14]. The energy dependence of the level density in the interval from 1-2 to some threshold value E_b is considerably weaker than it follows from any existing level density model. Above $E_b \approx 3$ MeV for N-odd and ≈ 4 MeV for N-even nuclei, the level density, most probably, corresponds better to the predictions of the generalized model of the superfluid nucleus in its simplest form [12].

This change in the behaviour of the level density in the vicinity of the excitation energy E_b may signify a qualitative change in the nuclear properties. The observation [17] of the probable harmonicity of the excitation spectra of the intermediate levels of the most intense cascades in a large group of nuclei from the mass region $114 \leq A \leq 200$ allows an assumption that a low energy the nuclear properties are mainly determined by vibrational excitations (probably, a few phonons of rather high energy). A very quick exponential increase in the level density above E_b says about the dominant influence of the inner, many-quasiparticle type of excitations of these states.

6 Conclusions

A new method is suggested for a simultaneous estimation of the probable level density populated by dipole primary transitions in the (n_{th}, γ) reaction and the sum strength functions $f(E1) + f(M1)$ of these transitions. Unlike other methods used for the investigations of nuclear properties below the excitation energy 6-9 MeV, this method allows the estimation of ρ, radiative strength functions, and intervals of their probable variations without any model notions of the nucleus.

The method is universal – it can be used for any nucleus and reaction with γ-emission. The latter is possible if the excitation energy interval of high-lying states is narrow enough in order to use the sum coincidence technique. Besides, the most probable quanta ordering in the cascades must be determined for the main part of the observed cascade intensity. It should be noted, that in the case of a lack of the experimental values of the total radiative widths of decaying high-lying states the absolute radiative strength functions cannot be determined. In this case only relative energy dependence of the radiative strength functions can be obtained.

Unlike the method [2], the method described here provides absolute values of the level density in fixed interval of their spins and has a maximum sensitivity at low excitations, i. e., in the excitation energy region where the nuclear properties undergoes a rather serious changes.

The most important (although preliminary and qualitative) physical result is that the level density below the neutron binding energy cannot be reproduced to a precision achieved in the experiment without accounting for the co-existence and interaction of superfluid and usual phases of nuclear matter in this whole excitation energy interval [12].

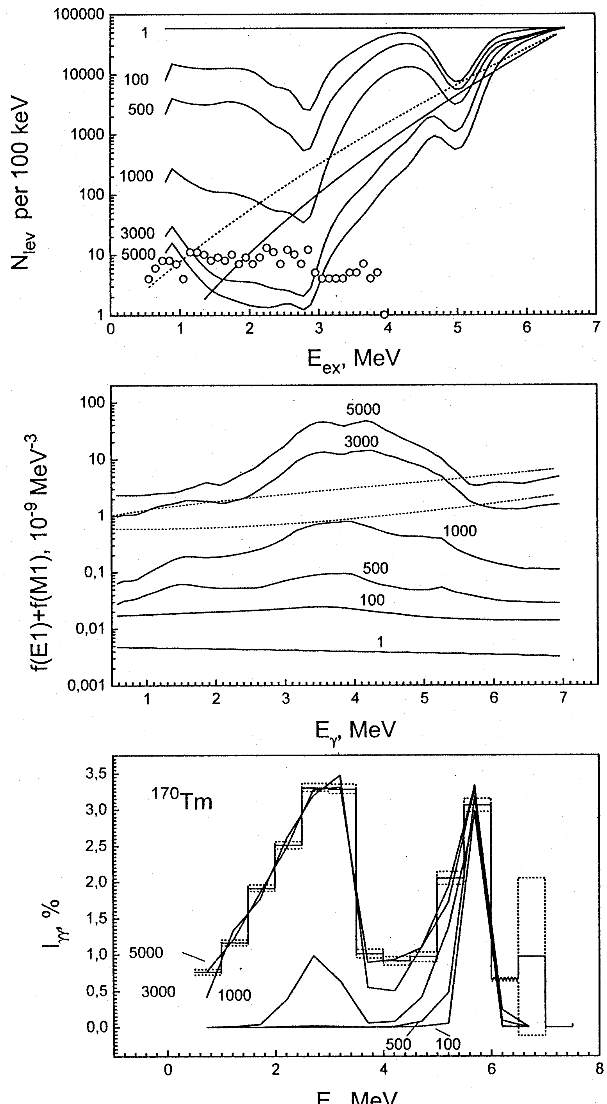

Fig. 1. The examples of ρ and RFSs intermediate values and the corresponding distributions of cascade intensities for the ^{170}Tm odd-odd nucleus. Letters next to the lines mean the number of iterations.

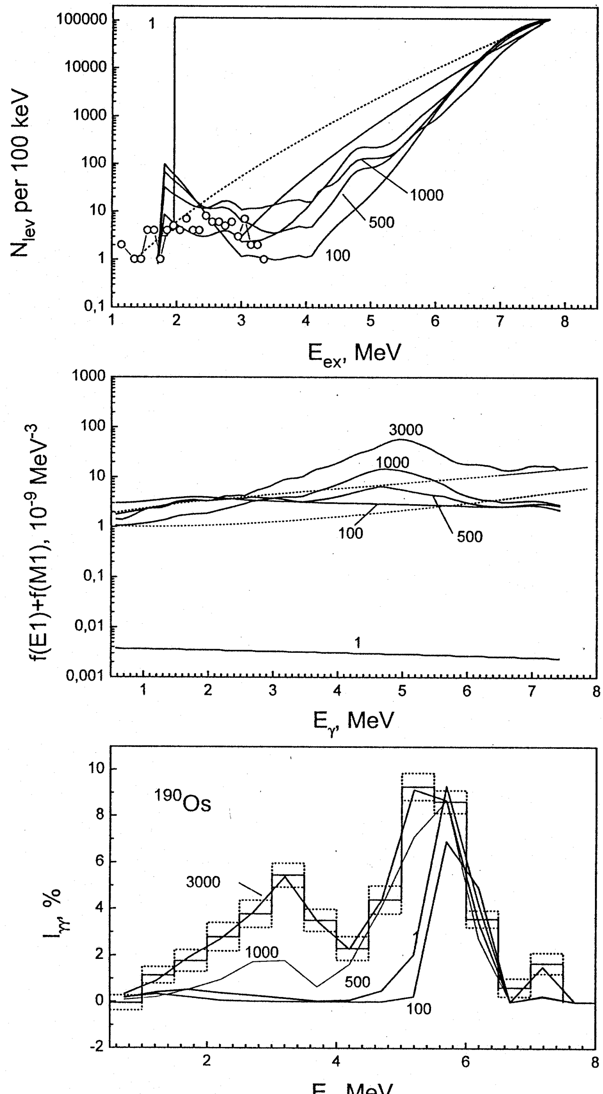

Fig. 2. The same as in Fig. 1, for the ^{190}Os even-even nucleus.

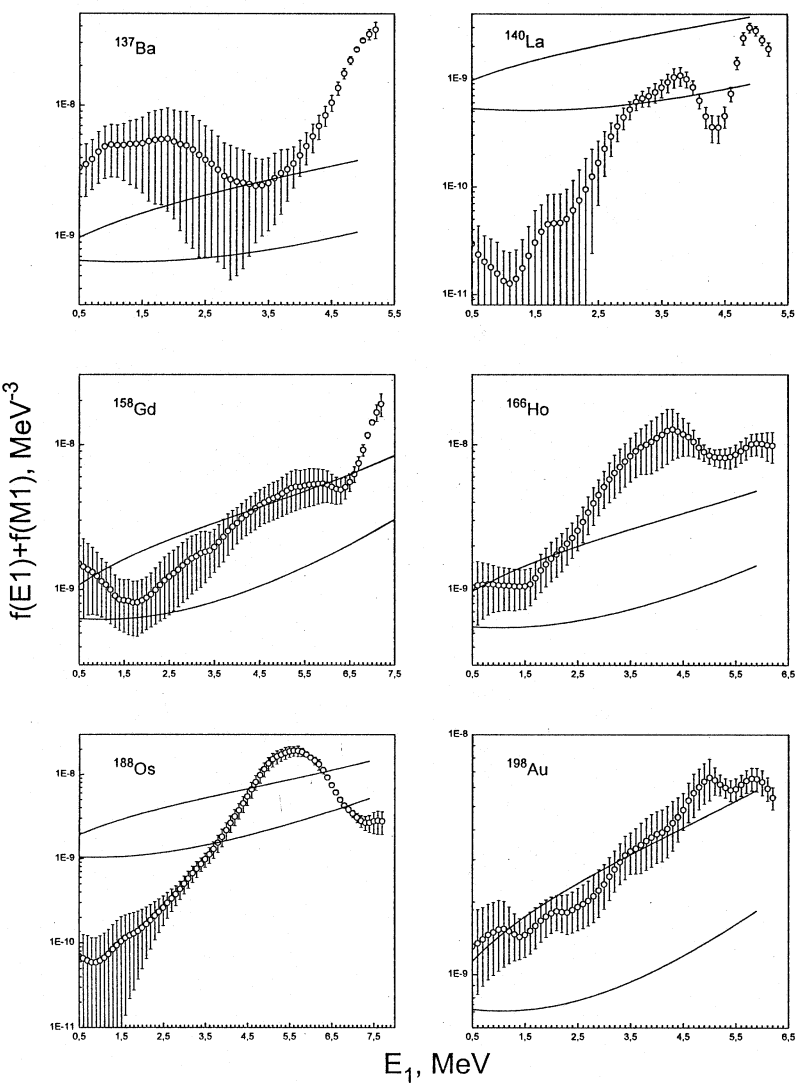

Fig. 3. The sum of the probable radiative strength functions of $E1$ and $M1$ transitions (with estimated errors) in the ^{137}Ba, ^{140}La, ^{158}Gd, ^{166}Ho, ^{188}Os, and ^{198}Au nuclei. The upper and lower curves represent predictions of the models [15] and [16], respectively.

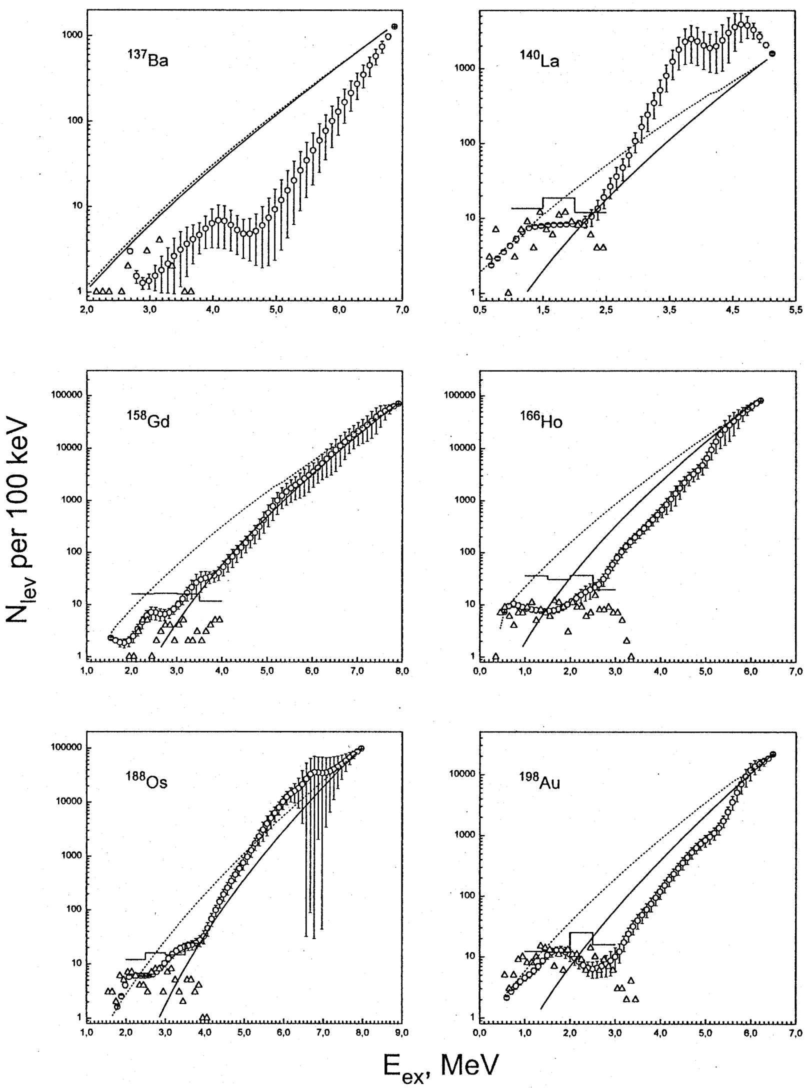

Fig. 4. The number of levels of both parities with errors (circles with bars) for ^{137}Ba, ^{140}La, ^{158}Gd, ^{166}Ho, ^{188}Os, ^{198}Au. The histogram represents the data [13], triangles show the number of intermediate levels of intense cascades observed earlier [1]. The upper and lower curves represent predictions of the models [14] and [12], respectively.

The obtained results demonstrate very serious and obvious discrepancies with the existing ideas of the nucleus. These data agree completely with an earlier obtained qualitative picture [17] of the studied process: considerable influence of vibrational excitations on the nuclear properties below the excitation energy E_b and a transition to dominant influence of quasiparticle excitations above this energy.

This work was supported by RFBR Grant No. 99-02-17863

References

[1] S.T. Boneva et al., Phys. of Atomic Nuclei, **62(5)** (1999) 832
[2] M.I. Svirin, G.N. Smirenkin, Yad. Fiz, **47** (1988) 84
[3] A.V. Ignatyuk et al., Sov. J. Nucl. Phys., **29** (1978) 875
[4] G.A. Bartholomew et al., Advances in nuclear physics, **7** (1973) 229
[5] S.T. Boneva et al., Part. Nucl. **22(2)** (1991) 232
[6] S.T. Boneva et al., Part. Nucl. **22(6)** (1991) 698
[7] Yu.P. Popov, A.M. Sukhovoj, V.A. Khitrov, Yu.S. Yazvitsky, Izv. AN SSSR, Ser. Fiz. **48** (1984) 1830
[8] S.T. Boneva, V.A. Khitrov, A.M. Sukhovoj, A.V. Vojnov, Z. Phys. **A338** (1991) 319
[9] S.T. Boneva, V.A. Khitrov, A.M. Sukhovoj, A.V. Vojnov, Nucl. Phys. **A589** (1995) 293
[10] S.F. Mughabghab, Neutron Cross Sections, V.1, part B, NY.: Academic Press, 1984, P.406
[11] V.A. Khitrov, A.M. Sukhovoj, Proc. of VI International Seminar on Interaction of Neutrons with Nuclei (Dubna, 1998) E3-98-202, Dubna, 1988, p.172.
[12] A.V. Ignatyuk, Proc. of IAEA Consultants Meeting on the use of Nuclear Theory and Neutron Nuclear Data Evaluation (Trieste, 1975) IAEA-190, Vol. 1 (1976) P.211.
[13] A.M. Sukhovoj, V.A.Khitrov, Yad. Fiz., **62(1)** (1999) 24
[14] W. Dilg, W. Schantl, H. Vonach, M. Uhl, Nucl. Phys **A217** (1973) 269
[15] P. Axel, Phys. Rev. **126(2)** (1962) 671
[16] S.G. Kadmenskij, V.P. Markushev, W.I. Furman, Sov. J. Nucl. Phys. **37** (1983) 165.
[17] A.M. Sukhovoj, V.A. Khitrov, Izv. RAN, Ser. Fiz. **61(11)** (1997) 2068

Received by Publishing Department
on June 5, 2000.

Хитров В.А., Суховой А.М. E3-2000-133

Новый метод одновременной оценки плотности уровней и радиационных силовых функций дипольных переходов для $E_{ex} \leq B_n - 0{,}5$ МэВ

Развит новый, модельно независимый метод одновременной оценки плотности возбуждаемых в реакции (n,γ) уровней и радиационных силовых функций дипольных переходов. Метод также может быть применен для произвольного ядра и реакции, сопровождаемой испусканием γ-квантов. Для этого необходимо только измерить интенсивности двухквантовых каскадов, разряжающих одно или несколько высоколежащих состояний и определить порядок следования основной массы каскадных переходов. Метод позволяет определить достаточно узкий интервал значений наиболее вероятной плотности уровней с заданными J^{π} и радиационных силовых функций возбуждающих их дипольных переходов.

Работа выполнена в Лаборатории нейтронной физики им. И.М.Франка ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна, 2000

Khitrov V.A., Sukhovoj A.M. E3-2000-133

New Technique for a Simultaneous Estimation of the Level Density and Radiative Strength Functions of Dipole Transitions at $E_{ex} \leq B_n - 0.5$ MeV

The new, model-independent method to estimate simultaneously the level densities axcited in the (n,γ) reaction and the radiative strength functions of dipole transitions is developed. The method can be applied for any nucleus and reaction followed by γ-emission. It is just necessary to measure the intensities of two-step γ-cascades depopulating one or several high-excited states and determine the quanta ordering in the main portion of the observed cascades. The method provides a sufficiently narrow interval of most probable densities of levels with given J^{π} and radiative strength functions of dipole transitions populating them.

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

Preprint of the Joint Institute for Nuclear Research. Dubna, 2000

Макет Т.Е.Попеко

Подписано в печать 15.06.2000
Формат 60 × 90/16. Офсетная печать. Уч.-изд. листов 1,44
Тираж 300. Заказ 52082. Цена 1 р. 70 к.

Издательский отдел Объединенного института ядерных исследований
Дубна Московской области