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EVALUATION OF AVERAGE NEUTRON RESONANCE PARAMETERS OF ACTINIDES WITH THE ACCOUNT OF EXPERIMENTAL RESOLUTION AND DISCRIMINATION THRESHOLD

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ABSTRACT

New evaluation of actinide average resonance parameters (^{229}Th - ^{252}Cf) is accomplished with account of the level missing, due to poor experimental energy resolution and discrimination threshold. Obtained values of average level spacings produce a smooth systematics of the main level density parameter.

Evaluated values of average reduced neutron widths and level spacings in resolved resonance region used for fixing of optical and statistical model parameters are of major concern. Virtually trivial averaging of experimental resonance parameter never gives reliable results even for thoroughly investigated nuclei. Existing methods, taking resonance missing into account, give rather discrepant results. The drawback of available methods is due to consideration of the level missing caused by poor experimental energy resolution and discrimination threshold separately. However both factors are correlated. In other words two strong resonances are usually resolved even being close to each other, while weak resonance if shadowed by the strong one remains unresolved.

The present method of average resonance parameter evaluation is described elsewhere [1]. Both neutron reduced widths distribution and level spacings one take into account possible existence of two systems of resonances with different spins. In case of even nuclei they become the well known Porter-Thomas [2] and Wigner [3] distributions. Resonance spacing distributions involved in our approach for even and odd nuclei differ considerably (see Fig.1). Resonances with the same spin are repulsed, hence small resonance spacing are improbable. In case of odd nuclei the level spins may be different and the influence of level repulsion is diminished. This may result in much greater experimental resonance missing for odd nuclei.

The probability to resolve resonances in the experiment $\Psi(x,y,E)$ is modelled by:

$$\Psi(x,y,E)=(1+a)/\{a+\exp[c\Delta(E)/(x^s y\langle D\rangle)]\}\{(x_0/x)^p+1\}^{-1}$$

where $\Delta(E)$ - is experimental energy resolution; x_0 -is diffusive threshold of widths discrimination; p - determines the curvature of the discrimination threshold; s - defines correlation between weak resonance and poor resolution level missing; c - a parameter, which determines rate of the level missing when the energy resolution deteriorates; a - is normalization constant; $x=g\Gamma_n^0/\langle g\Gamma_n^0\rangle$ and $y=D/\langle D\rangle$. Model function $\Psi(x,y,E)$ describes

typical experimental situation. It decreases to zero when x, y, x^5y, $1/x_\theta$ or $\langle D\rangle/\Delta(E)$ urge towards zero, and becomes unity when x, y, x^5y, $1/x_\theta$ or $\langle D\rangle/\Delta(E)$ are growing.

Table. Average level spacings and neutron strength functions of s-resonances for actinides recommended by different laboratories.

Isotope	<D>,eV BNL	<D>,eV Obninsk	<D>,eV Bologna	<D>,eV PRESENT	s_0x10^4 BNL	s_0x10^4 Bologna	s_0x10^4 PRESENT
^{228}Th	.53±.15	.53±.15	2.12±0.31	.455±.069	.62±.16	.51±0.17	1.388±0.687
^{230}Th	9.6±1.3	9.6±1.3	13.8±5.5	12.386±1.338	1.5±0.4	1.465±0.435	1.390±0.398
^{232}Th	16.8±1.0	16.8±1.0	16.55±1.25	17.380±0.600	.84±.07	.84±.07	.800±.080
^{231}Pa	.45±.05	.45±.05	.55±.10	.444±.059	.81±.10	.45±.05	.775±.353
^{233}Pa	.59±.09	.59±.09	.695±.195	.503±.095	.75±.06	.355±.045	.802±.411
^{232}U	4.6±0.7	4.6±0.7	5.7±1.1	4.717±0.381	.91±.20	.97±.07	.881±.296
^{233}U	.55±.05	.55±.05	.55±.05	0.508±0.025	1.04±0.07	.545±.035	1.073±0.144
^{234}U	10.6±0.5	10.6±0.5	12.15±1.65	11.488±0.551	.86±.11	.755±.105	.809±.112
^{235}U	.44±.06	.43±.01		.488±.018	1.0±0.1		1.013±0.104
^{236}U	14.7±0.8	15±1	16.45±2.55	15.261±0.687	1.0±0.1	.97±.13	1.028±0.130
^{237}U	3.5±0.8	3.5±0.8		3.609±0.386			
^{238}U	20.9±1.1	21.7±0.9	22.3±1.3	20.761±0.799	1.2±0.1	.94±.04	1.169±0.130
^{237}Np	.52±.04	.56±.05	1.8±0.4	.553±.022	1.02±0.06	.315±.095	.954±.075
^{238}Pu	9.0±0.7	9.0±0.7		8.301±0.598	1.3±0.3		1.285±0.269
^{239}Pu	2.3±0.1	2.2±0.5	2.38±0.18	2.308±0.076	1.3±0.1	.795±.015	1.302±0.126
^{240}Pu	13.6±0.7	12.4±0.7	15.0±1.15	13.440±0.720	.93±.08	.935±.085	1.065±0.164
^{241}Pu	.9±.1	.73±.08	.96±.16	1.070±0.056	1.06±0.14	.56±.50	1.073±0.162
^{242}Pu	15.5±1.7	13.3±0.4	37.7±2.6	13.526±0.812	.9±.1	.52±.03	.912±.154
^{244}Pu	17±3			18.992±2.868	.9±.3		1.243±0.522
^{241}Am*	.55±.05	.58±.04	.66±.16	.551±.034	.90±.09	.475±.025	.896±.115
^{242m}Am*	.40±.08	.45±.10	.33±.08	.271±.024	1.4±0.3	1.0±0.4	1.215±0.247
^{243}Am *	.60±.06	.64±.06	.77±.17	.621±.042	.98±.09	.51±.04	.900±.131
^{242}Cm	25±8	12.8±2.7	22.9±10.1	10.082±1.976	.9±.3	.98±.38	.763±.395
^{243}Cm*	1.1±0.2	.81±.10	1.3±0.2	.809±.078	1.30±0.26	.60±0.4	1.050±0.230
^{244}Cm	12±1	11.8±1.2		11.571±1.041	.92±.17		1.061±0.272
^{245}Cm*	1.4±0.1	1.38±0.10	1.47±0.13	1.006±0.056	1.18±0.27	1.225±0.075	1.151±0.185
^{246}Cm*	34±7	30±5	36±6	17.58±4.0	.50±.16	.5±.1	.91±.34
^{247}Cm	1.4±0.1	1.4±0.2	2.0±0.1	1.181±0.164	.75±.18	.35±.01	.935±.278
^{248}Cm	33±5	25±5	40±8	38.478±3.578	1.0±0.2	1.0±0.2	1.013±0.238
^{249}Bk	1.0±0.1	1.0±0.1	1.6±0.2	1.195±0.136	.90±.20	.48±.06	1.095±0.300
^{249}Cf	.7±.1	.7±.1	1.0±0.1	1.094±0.078	1.00±0.17	.48±.06	1.031±0.199
^{252}Cf	27±3	27±4		26.747±2.407			

Average resonance and resolution function parameters are found by fitting theoretically expected neutron widths and level spacings distributions to experimental ones within framework of the best likelihood method.

Evaluated values of average level spacings and s-wave strength functions are compared with other evaluations in Table. Resonance parameters in this evaluation were taken from BNL-325, except marked *, which had been taken from our evaluations. We claim our results seem to be more reliable, since we rely simultaneously on both reduced neutron widths and level spacings distributions. With the proposed method we may treat experimental data sets with up to 50% resonance missed.

The main parameter of the level density a was obtained by fitting the neutron resonance spacing **<D>**. The total level density is calculated with a phenomenological model by Ignatyuk et al. [4], which takes into account shell, pairing and collective effects. The equilibrium deformation is assumed axially symmetric. The shell corrections were calculated with liquid-drop Myers-Swiatecki parameters and experimental nuclear masses. The **A**-dependence of **a/A** is shown on Fig. 2. It is evident that global systematics of a over actinide region is hardly possible. On the contrary, the isotopic dependences of a/A seem to be rather smooth for Th, Pu, Am and Cm nuclei. The local systematics of $a/A = \alpha + \beta A$ could be readily obtained.

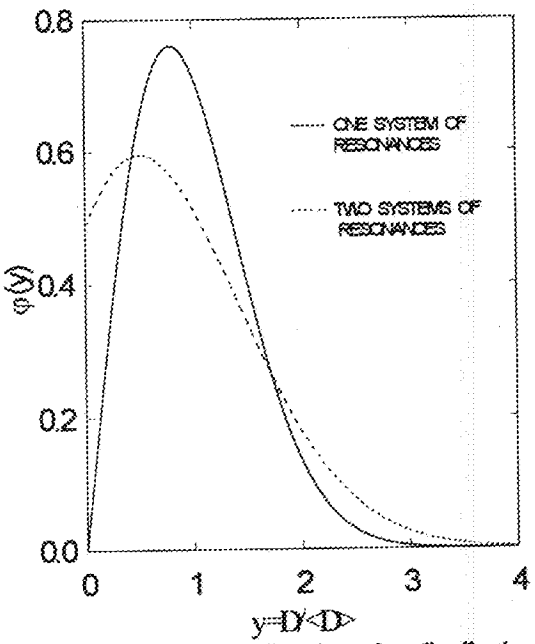

Fig.1 Comparison of level spacing distributions with one and two systems of resonances

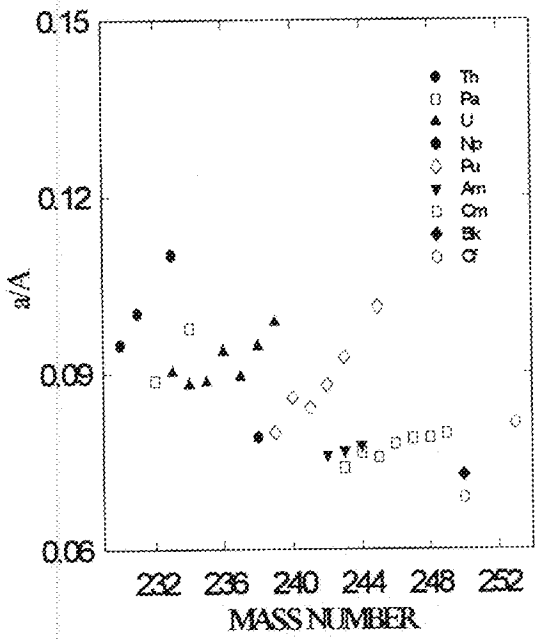

Fig.2 The main parameter of level density dependence for actinides

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