Fine and superfine structures in neutron resonance positions

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Parameters of fine (ε'=1.2 keV) and superfine (ε''=1.34 eV) structures were introduced empirically in 1972 [1] from the analysis of maxima in distributios of neutron resonance positions, nuclear excitations and binding energies of wide range of nuclei.

In some papers [1] attention was drawn to the "structure" in the spacing between neutron levels D_{ij} for some N-odd (compound) heavy nuclei. If single particle or to be more precise few-particle effects play any role in the complex spectra of levels in heavy nuclei they will first of all manifest itself in N-odd compound nuclei. These systems are thought as N-even excited core plus neutron. If the structure in D_{ij} is due to anomalously strong statistical fluctuations then, these data taken together for the large number of nuclei, will give smooth distributions. But it doesn't happen, and distinguishing effect in D_{ij} near 5.5 eV maintains even in cases in levels with relatively broad neutron widths which, as one would expect, correspond to larger contribution of single particle configurations (Fig. 1 in [1]). The distinguishing effect of the interval (5.5 eV) has also been confirmed by the analysis of the summary data on positions (E_o) of neutron resonances, e.g. distances from levels to the binding energies of neutron [2,4,5].

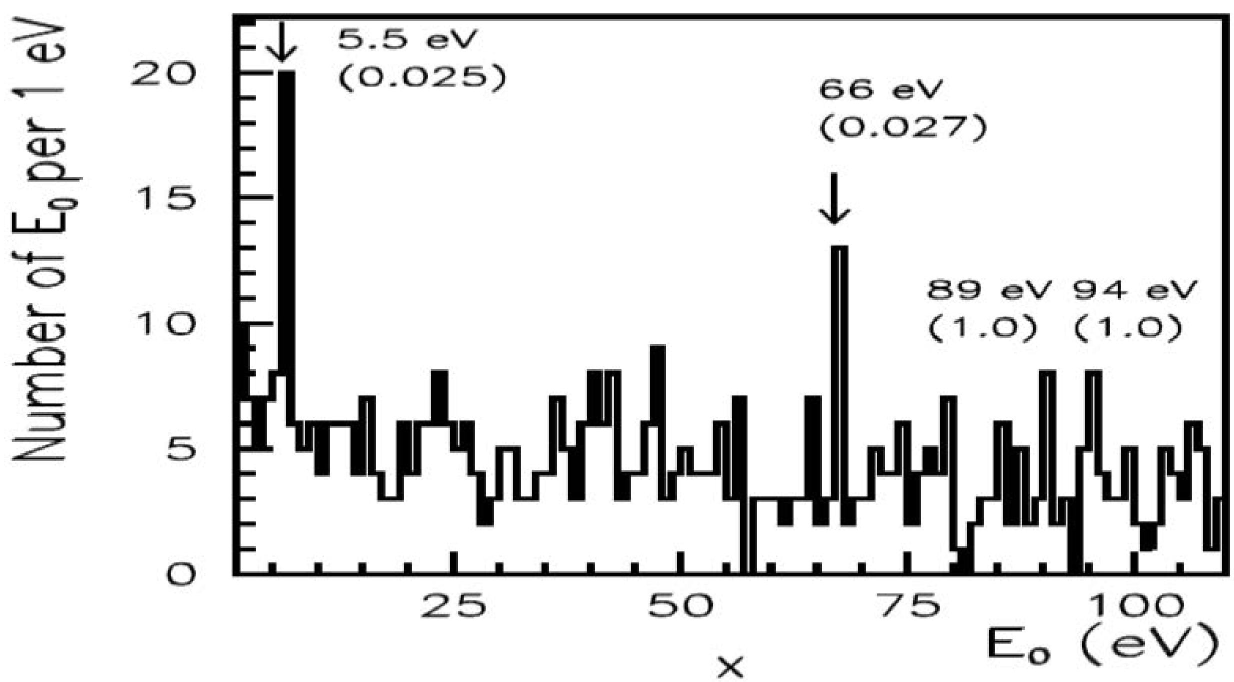

Figure 1: Distribution of neutron resonance positions known in 1966 year. Selection of one strongest resonance (max Γ^o_n) in the interval 10 eV (random probability is given in parentheses).

A large amount of information on neutron resonances of heavy nuclei with Z=90-96 allows us to perform the analysis of the levels positions and spacings to check the distinguishing character of the superfine structure parameter. There is a system of stable energy intervals that are multiples of each other [4]. The superfine structure parameter ε''=1.34 eV was found in spacing distribution of neutron resonances of compound nucleus ^{238}Np: maximum at 1.1 eV. This value is close to the position of the first strong resonance at E_n=1.321 eV in this nucleus. The next strong resonance at E_n=5.777 eV is four times larger than the position of the first strong resonance and is close to the parameter 5.5 eV observed in N-even target nuclei of U: 5.98 eV ^{232}U, 5.1570 eV ^{234}U, 5.45 eV ^{236}U [5]. The intervals 5.5 eV=4ε'' and ε', as well as intervals that are multiples of them, were found in many heavy nuclei as maxima in positions and spacings distributions of neutron resonances.

Table 1: Neutron resonance energies (eV) of heavy compound nuclei. Parameter of su-perfine structure $\varepsilon'' = 1.34$ eV and parameter 5.5 eV$\approx 4 \times \varepsilon''$ are boxed.

Nucl.	Z	E_n	E_n	E_n	E_n	E_n	E_n	E_n	
^{233}Th	90				21.819	23.470			570.25
^{234}Pa	91	$\boxed{1.341}$	1.644	2.830	3.386	4.288	$\boxed{5.152}$		
^{233}U	92	$\boxed{5.980}$	12.7	20.80	23.75				
^{234}U	92	1.452	$\boxed{5.805}$			22.20	22.61	23.06	23.69
^{235}U	92	$\boxed{5.157}$						22.1	23.7
^{236}U	92	$\boxed{5.407}$	11.665	12.390	15.417	16.089	16.646	19.296	23.591
^{237}U	92	$\boxed{5.45}$							29.8
^{238}U	92							46.2	52.4
^{239}U	92	6.67	20.87						
^{238}Np	93	$\boxed{1.321}$	1.478	3.865	4.264	4.863	$\boxed{5.777}$		
^{240}Pu	94	0.296	7.826						
^{242}Pu	94	0.264	$\boxed{5.813}$	9.938	14.77	26.43	28.86		
^{242}Am	95	0.3051	$\boxed{5.415}$	14.682					

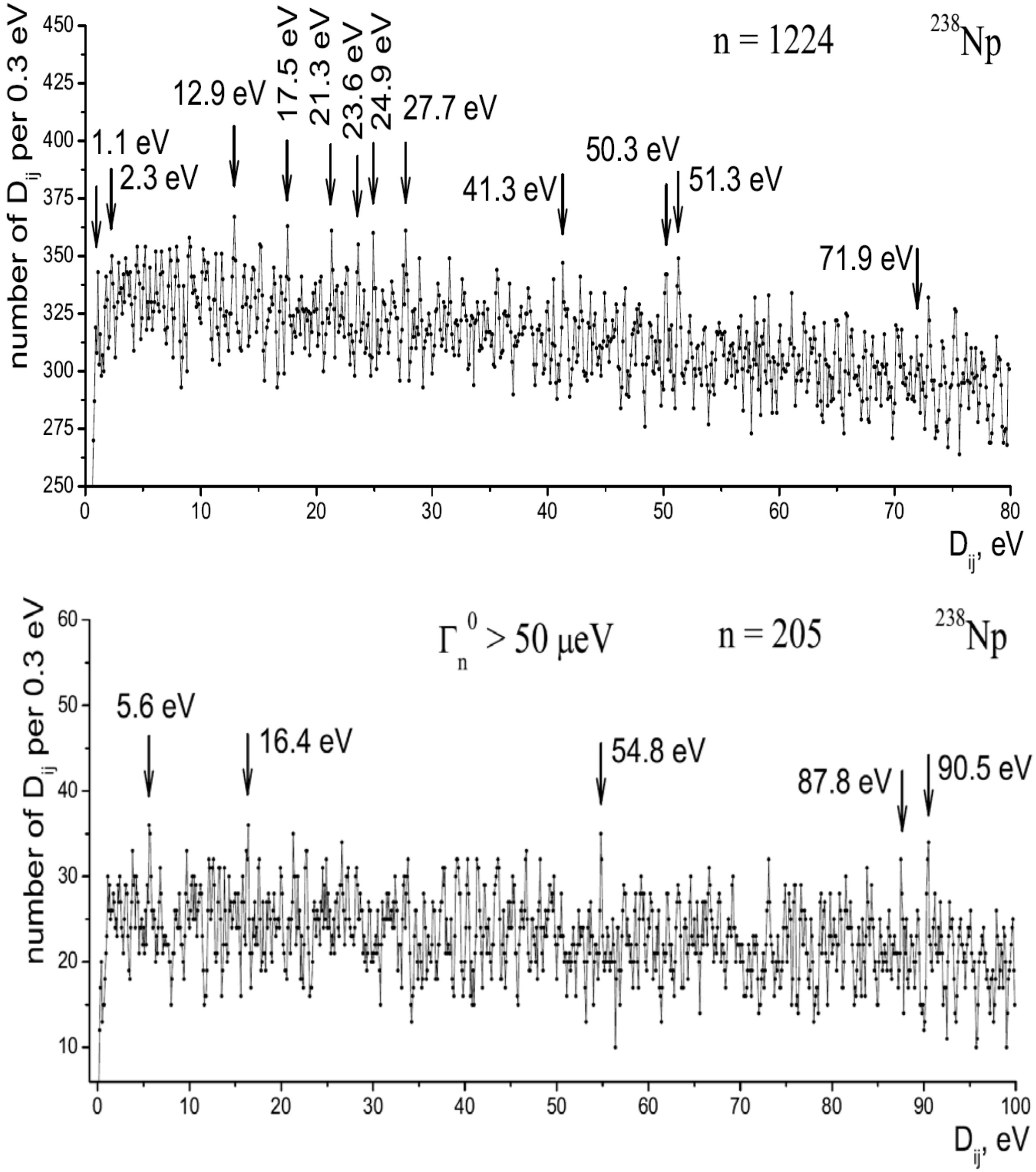

Figure 2: *Top*: Total spacing distribution of all resonances in ^{238}Np. *Bottom*: Spacing distribution of resonances in ^{238}Np with $\Gamma_n^\circ \geq 50\mu$eV [6].

Recently, particle masses distributions were added [2]. Some maxima values were noticed to be in relations close to the QED radiative correction to the magnetic moment of the electron $\alpha/2\pi = 115.9 \cdot 10^{-5}$ applied to the electron mass. This value is of a fundamental character and reflects the influence of the physical condesate, vacuum [3].

$$\alpha/2\pi = 115.9 \cdot 10^{-5} = \varepsilon'' : \varepsilon' = \varepsilon' : 2m_e = m_e : M_q = m_\mu : M_Z = M_q : 3M_{H^\circ} .$$

In this equation (1) there are parameters of superfine and fine structures ε''=1.34 eV and ε'=1.2 keV, as well as the constituent quark mass M_q, Z boson mass M_Z and the scalar boson mass $M_{H_\circ}$=125 GeV.

Table 2: (from [6]) Comparison of positions and spacings in light and near-magic nuclei with integer values of the fine structure parameter $\varepsilon' = \delta'/8 = 1.188$ keV.

Nucl.	Ca-Ni	^{61}Ni	^{61}Ni	^{61}Ni	^{61}Ni	^{61}Ni
l_n	l_n=0	D(keV)				
E_n	18.8	4.8	9.3	14.1	19.0	24.7
$k(\varepsilon')$	16	4	8	12	16	20
$k \times \varepsilon'$	19.0	4.8	9.6	14.4	19.0	24.7
Nucl.	**^{141}Ce**	**^{141}Ce**	**^{142}Pr**	**^{141}Ce**	**^{141}Ce**	**^{141}Ce**
J_i^π	$1/2^+$	$1/2^+$	$(5/2^-)$			
Γ_n^o,meV	660	3060	160	D	D	D
E_n	9.573	21.570	9.598	21.7	43.1	86.2
E^*,E_n'	[9.505]	[21.418]	[9.530]			
$k(8\varepsilon')$	1	9/4	1	9/4	9/2	9
$k\times8\varepsilon'$	[9.504]	21.384	[9.504]	21.4	42.5	85
Nucl.	**^{140}La**	**^{80}Br**	**^{82}Br**	**^{86}Rb**	**^{143}Ce**	**J_o^π=3/2$^-$**
J_i^π	3^+	l_n=0	l_n=0	l_n=0	$7/2^-$	$5/2^-$
Γ_n^o,meV	54	72.0	120	159	E^*	E^*
E_n	1.179	1.201	1.209	2.398		
E^*,E_n'	[1.170]	[1.186]	[1.194]	2.370	[18.9]	42.3
$k(8\varepsilon')$	1/8	1/8	1/8	2/8	2	9/2
$k\times8\varepsilon'$	1.188	1.188	1.188	2.376	19.0	42.77

In Table 2, top, positions E_n' (keV) of strong neutron resonances in light and magic nuclei and periodicity in the spacing distributions in resonances ^{61}Ni (right). At the center, values E_n (keV) in nuclei with N=83=82+1, maxima in spacing distributions ^{141}Ce. At the bottom (left) positions of strong neutron resonances in isotopes with Z=35-39 are compared with the integer of the period ε'=1.188 keV=9.505 keV/8, found in the positions of strong resonances in Z=57-59, N=83 nuclei (center). At bottom (right), excitation energies E^* (keV) of ^{143}Ce are given. Boxed are values ε' =1.188 keV=9.505 keV/8, δ', $2\delta'$and $(9/4)\delta'$, see also Fig. 3 in [4].

Combined analysis of the particle mass spectra and energies of nuclear states demon-strate the universal character of the parameters $\delta = 16m_e$ and m_e [2-7], which are inter-connected with the main SM parameters (fundamental bosons, quarks and leptons).

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