ANALYSIS OF NUCLEAR EXCITATIONS IN DIFFERENT ELEMENTS

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1. Introduction

Nuclear Physics deals with nucleons and their interactions. The nucleon masses (m_n, m_p and the nucleon mass difference δm_N) are well known [1]. Their numerical relation to the mass of the electron (m_e) makes it possible to obtain a very simple representation, called the "CODATA relations" with a period $\delta = 16m_e$=8176.0 keV:

$$m_n = 115 \cdot 16m_e - m_e - \delta m_N/8, \qquad m_p = 115 \cdot 16m_e - m_e - 9(\delta m_N/8). \qquad (1)$$

The difference of 8.67 keV between the two CODATA parameters $m_e/3$=170.33 keV and $\delta m_N/8$=161.66 keV is close to the empirically determined period of the fine structure δ'=9.5 keV in the neutron resonance data [2] and the value $m_e/(18{\times}3)$=9.46 keV, corresponding to the proposed ratio 18:17 in the CODATA parameters:

$$\delta' = 9.5\,\mathrm{keV}, \quad \delta' = m_e/(18 \times 3) = 9.46\,\mathrm{keV}, \quad \delta' = (\alpha/2\pi) \cdot (\delta = 16m_e) = 9.48\,\mathrm{keV}. \quad (2)$$

The fine structure effects in the distribution of positions and spacings of neutron resonances were connected [2-5] with the empirical observation that the fine structure parameter 9.5 keV=δ' in the resonance positions is close to the difference between the CODATA parameters 161 keV and 170 keV. This may be due to QED correction $\alpha/2\pi$ to the pion mass and nucleon Δ-excitation, the effect of the influence of physical condensate [6]:

$$\delta m_n = 161\,\mathrm{keV} = \delta m_N/8 = (\alpha/2\pi)m_\pi, \qquad m_e/3 = 170\,\mathrm{keV} = (\alpha/2\pi)\Delta M_\Delta. \qquad (3)$$

The parameter $\delta' = 8\varepsilon'$ was introduced [7-9] from the empirically found proximity of the ratios between the stable mass/energy intervals in neutron data (ε''=1.35 eV and ε'=1.2 keV), nuclear spectroscopic data (ε'=1.2 keV and $\varepsilon_\circ$=1.02 MeV) and intervals in particle mass values (M_q=441 MeV) noticed by R. Sternheimer and P. Kropotkin [10,11]:

$$(\varepsilon'' = \delta''/8) : (\varepsilon' = \delta'/8) : (\varepsilon_\circ = 2m_e) : 2M_q = \alpha/2\pi = 115.9 \cdot 10^{-5}. \qquad (4)$$

The values $16\varepsilon' = 2\delta'$=19 keV and $4\varepsilon'$=4.7 keV were observed independently in the neutron resonance positions and other nuclear spectroscopic data [1,2,12]. The parameters δ'=9.5 keV and $\varepsilon'=\delta'/8$=1.2 keV were introduced by M. Ohkubo and others from the proximity in the positions of strong resonance in the N=82 near-magic ^{141}Ce, ^{142}Pr, ^{140}La etc. In Fig. 1, the observed nonstatistical character of the sum of the positions of neutron resonances of different nuclei is shown (maxima at $4\delta''$=44 eV and at 572 eV=$13{\times}\delta''$) [2].

2. Analysis of data on excitations in light nuclei

The position of the neutron resonance corresponds to the difference between the energy of the excited compound nuclear state E^* and the binding energy of the neutron S_n in this compound nucleus. The effect of systematic grouping of resonance positions means

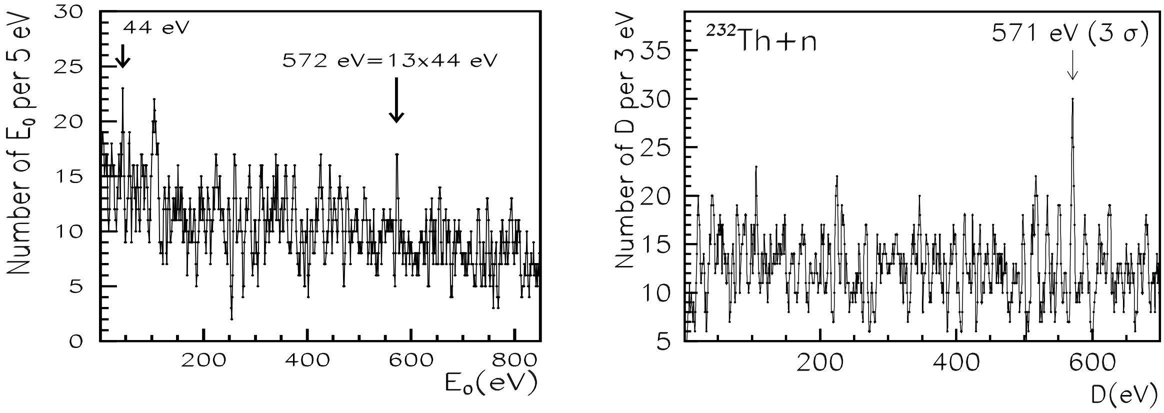

Fig. 1. Distributions of resonance positions in nuclei Z=33-56 [13] and spacings (Γ_n°) in ^{233}Th.

that E^* and S_n are not independent. The observed width of the maxima in the grouping effects shown in Fig. 1, is several eV. Similar structure in D-distributions between neutron resonances were noticed by many authors (W. Havens, M. Ohkubo, K. Ideno, C. Coceva and others). The maxima appear with the averaging interval of ideohistograms of 3-5 eV in heavy nuclei and 3-5 keV in light nuclei. This new approach to the development of nuclear physics is based on the confirmation of CODATA relations with an exact mass presentation with the period $\delta=16m_e$. In Figs. 2a, 2b spacing distributions in three near-magic light nuclei ^{42}Ca, ^{58}Ni (two valence neutrons) and ^{55}Co (one proton hole) are presented together with the spacing distributions D^{AID} adjusted to stable intervals D_{ij}=2×511 keV=$2m_e = \varepsilon_\circ$ (see relation (3) above). The strong maxima observed with the averaging interval of the ideohistogram 3 keV, and rational relations between their values correspond to exact integer relations with the value m_w in CODATA relations (1).

We describe here a global analysis of nuclear data collected at PNPI [14] and published in the Springer Landolt-Boernstein Library New Series, in accordance with a comment of the editor-in-chief of the LBL W. Martienssen [15] that data compilations could serve as bridges between different branches of science. These nuclear files were used to check the observed relations in the particle masses due to the well-known fact that the QCD-based theoretical models provide the description of the origin of the nucleon masses, and QCD is a general theory of nuclear excitations and nuclear binding energies.

We use two new methods of data analysis based on the selection of data for all isotopes of each element and the location of the grouping effect in the excitation energies.

The first method of data analysis consists in a production and the analysis of the combined data for isotopes of the neighboring near-magic elements (nuclei with Z=8, 9, 10, Z=20, 22 etc.). The first step was the grouping effect in the values of the excitation energies of different isotopes of a certain element, which was considered in the previous subsection. The second step is based on the observation of similarities in excitations of several near-magic nuclei. For example, it was noticed long ago that the first excitations of ^{18}O and ^{24}Ne $E_1^*(2^+)$=1982.1(1) keV and $E_1^*(2)$=1981.6(4) keV are unexpectedly close to each other. Now we find that the grouping effect in the sum of the usual D-distributions in neighbor elements Z=8, 9, 10 at the first excitations of ^{18}O and ^{24}Ne at D=1982 keV (161 intervals with a deviation of 2.4σ over the mean value) can be compared with the maximum at a same value (Fig. 3, deviation of 3.0σ) in a similar analysis of the combined spectrum of the same three elements (n=546+804+701=2051, for Z=8, 9, 10). The mean value n≈1200 in the combined spectrum of all 55 isotopes of these three elements is much larger than the mean value n=126 (the sum of results of the separate analyses), and the effect of about 160 values (over the mean level, in the combined analysis) is much larger than the effect of 35 values obtained during the usual analysis of separate data.

To study this effect, we use the AIM-method of data analysis [3-5,13]. Fixing the intervals x=1982 keV in the combined spectrum (Fig. 3 center), we observe the strongest maximum at exactly twice the value of 3963 keV (marked by an arrow), which is absent in the sum D^{AIM}-distribution for separately analyzed spectra of the same isotopes.

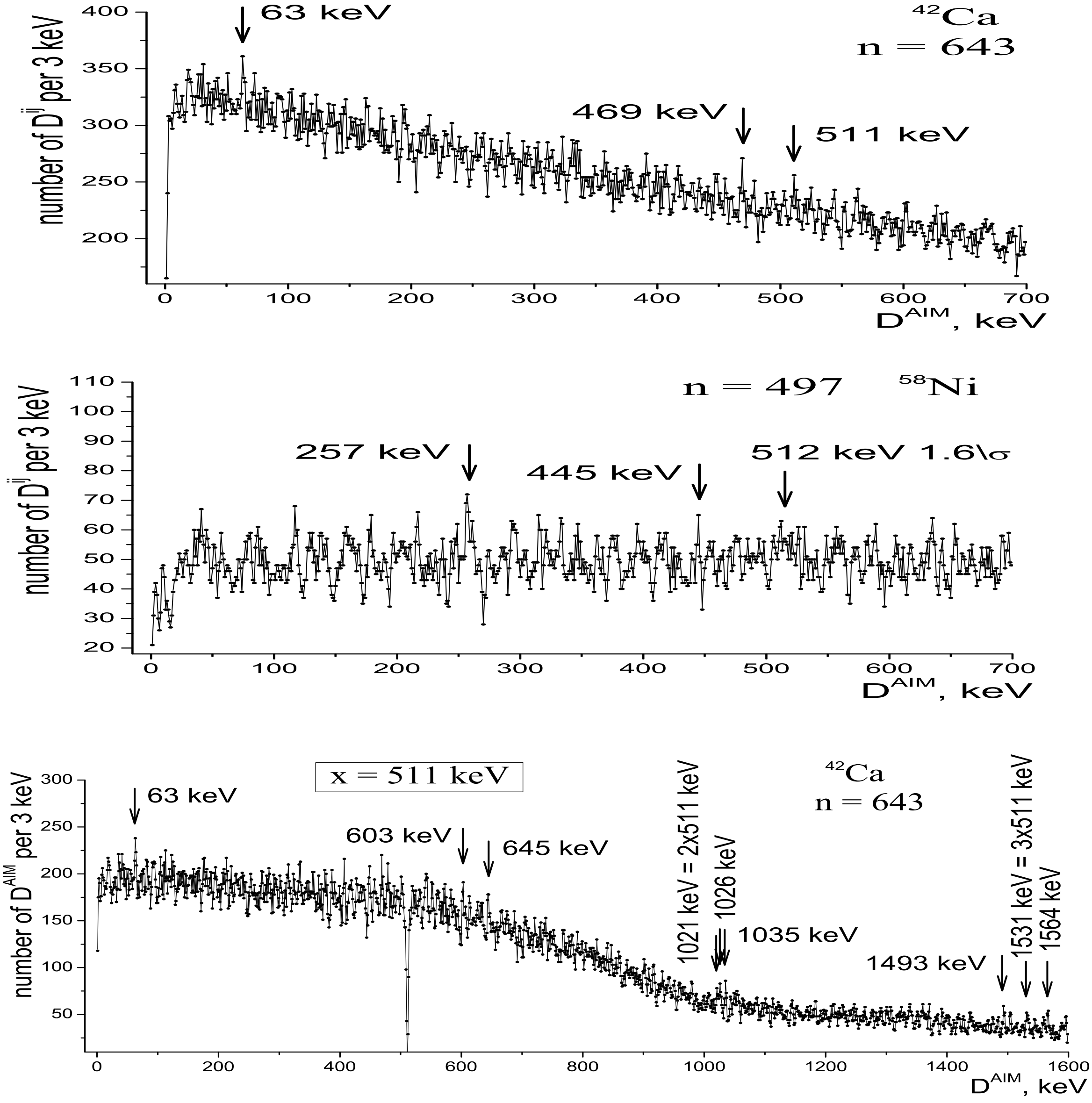

Fig. 2a. *Top:* D-distributions of levels in ^{42}Ca with maxima at 511 keV.
Center: The same for ^{59}Ni.
Bottom: D^{AIM}-distribution in ^{42}Ca for x=511 keV=m_e with maxima at $2m_e$ and $3m_e$.

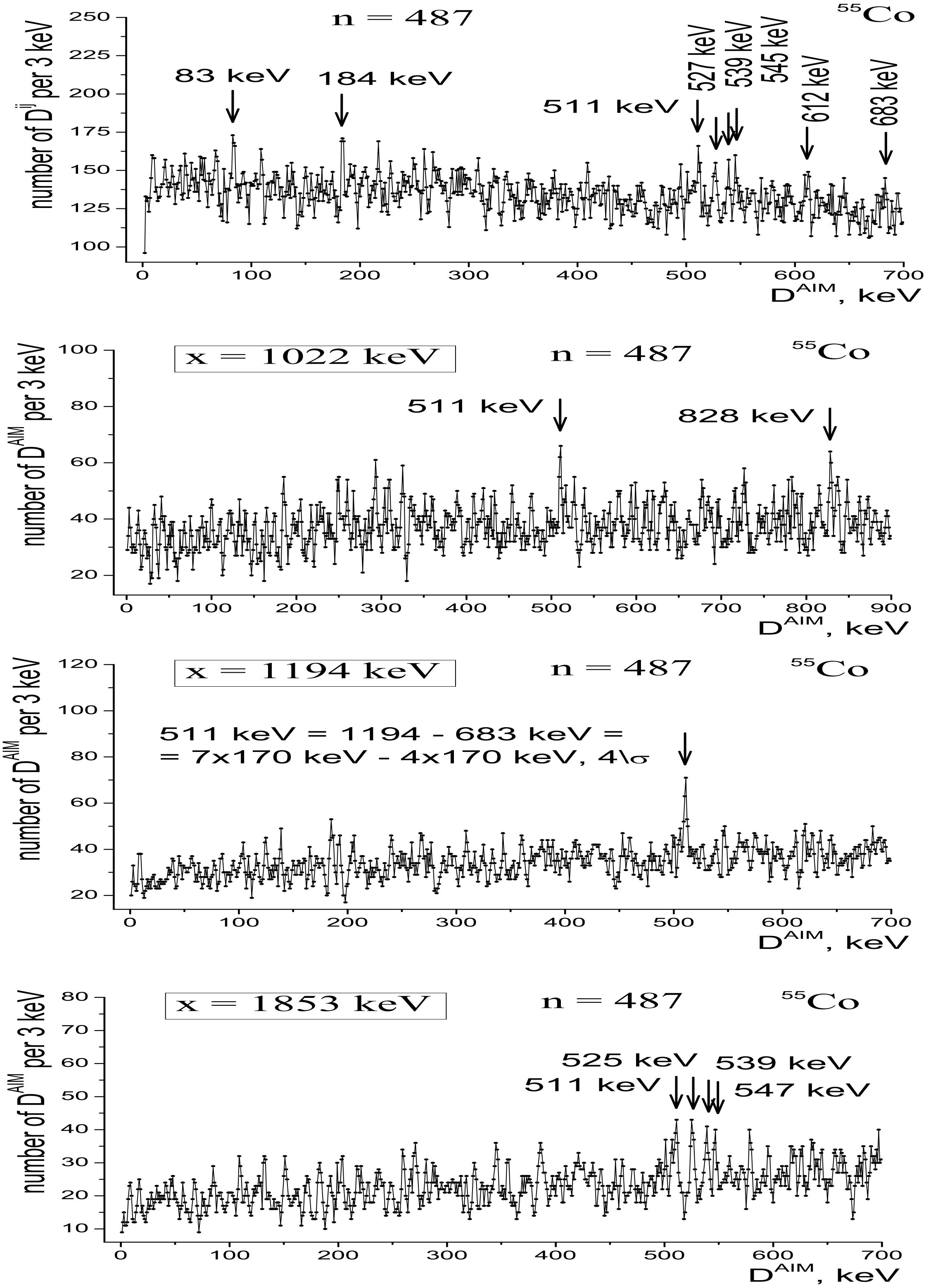

Fig. 2b. *Top:* D-distribution in ^{55}Co.
2nd line: D^{AIM}-distribution in ^{55}Co for x=1022 keV with maxima at 511 keV and 828 keV.
Center: D^{AIM}-distributions in ^{55}Co for x=1194 keV.
Bottom: D^{AIM}-distributions in ^{55}Co for x=1853 keV with four closely spaced maxima started with 511 keV, also observed in D-distribution in ^{55}Co (right part of the top figure).

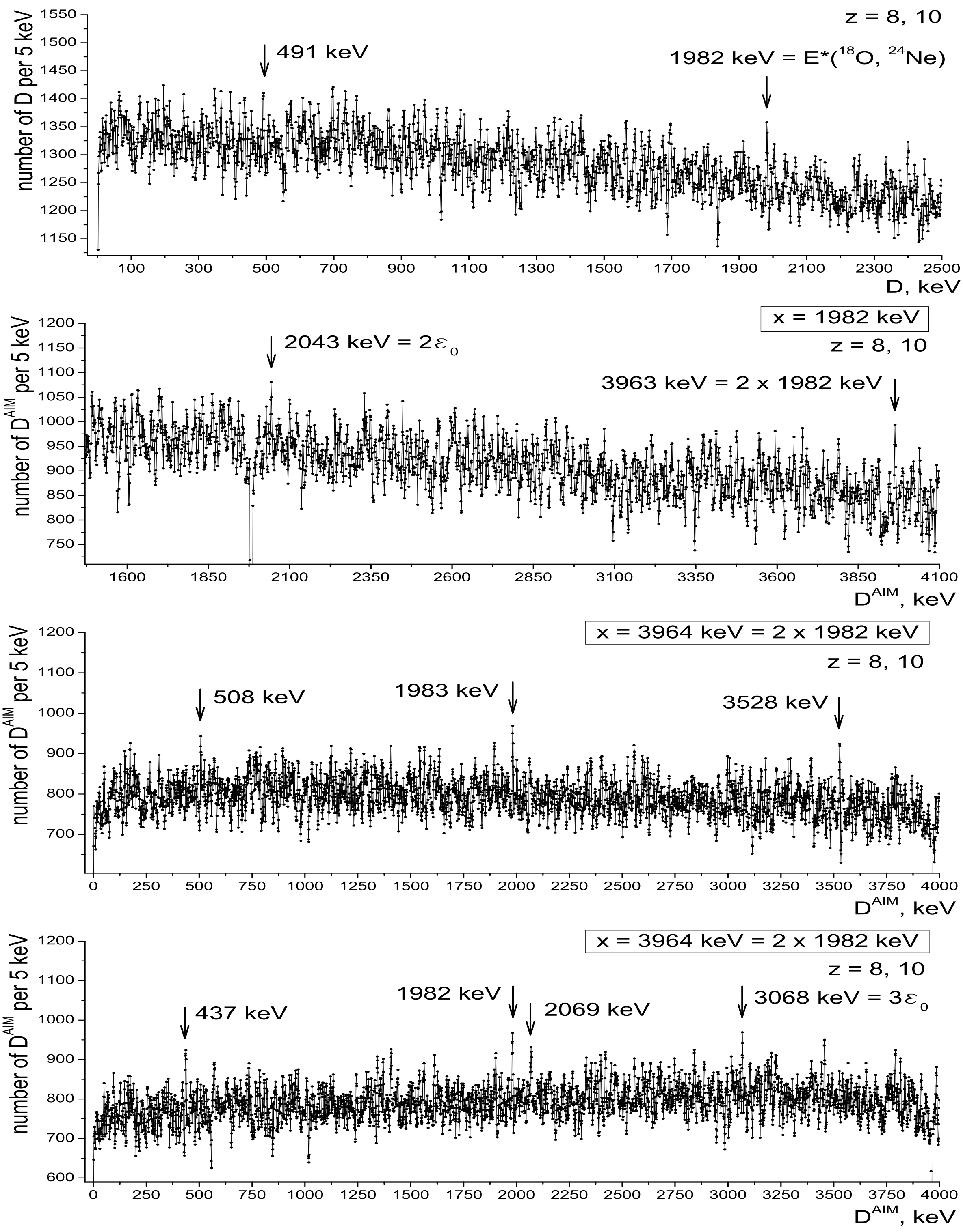

Fig. 3. *Top:* D^{AIM}-distributions for x=1982 keV in the combined spectrum of isotopes with Z=8, 9, 10 (number of levels n=546+804+701). *2nd line:* The same for x=2043 keV. The interval D^{AIM}=347 MeV is close to 2043 keV/6=341 keV. *Center:* The same for x=2×1982 keV (upward AIM direction). *Bottom:* The same for x=2×1982 keV (downward AIM direction). Maximum at 1982 keV in all distributions is marked by an arrow.

The obtained result means that the excitations in individual nuclei with different nucleon configurations in the case of near-magic nuclei are not independent. This is a manifestation of traces of the common general quantitative effect of the quark structure in the case of a nucleon in a few-particle configuration. To study these unexpected effects, we use the presence in Fig. 3 (top) of the second strong maximum at D=2043 keV, which coincides with $2\varepsilon_o = 4m_e$=2044 keV (the main CODATA parameter). The strongest maximum at 1982 MeV in the D^{AIM} distribution for x=2043 keV (Fig. 3, 2nd line) and the same maxima (in Fig. 3, center and bottom), corresponding to the upward and downward directions in the AIM-analysis with x=2×1982 keV. This allows us to conclude that the position of the strongest maximum in the D^{AIM}-distribution in the combined spectrum (at $2x$=3963 keV) reflects the very general and systematic character of the intervals, considered earlier as examples of the distinguished character of the parameters involved in the CODATA relations. The appearance of maxima at $D = 3\varepsilon_o$=3068 keV and at D=508 keV=$\varepsilon_o/2$ in the D^{AIM}-distribution for x=2×1982 keV (Fig. 3, center and bottom) and maxima at $2\varepsilon_o$=2043 keV and 4096 keV≈ $4\varepsilon_o$ in D^{AIM}-distribution for x=347 keV (close to $(2/3)\varepsilon_o$=341 keV), confirms the role of the main CODATA fine structure parameter directly connected with m_e. This new method of the indirect confirmation of CODATA fine structure parameters was applied to the data for nuclei situated at all other closed nucleon shells (Z=20, 28, 40, 50 and 82).

We conclude that the analysis of nuclear data is a part of an empirical approach to the further SM development and consequent production of the nuclear microscopic models based on the fundamental aspects of nucleon quark structure [16]. This new nuclear spectroscopy will possess, according to F. Wilczek [17], a very unexpected high accuracy.

The presence of strong maxima at doubled values of the initial intervals x in the combined spectra of the light near-magic nuclei, namely, ^{18}O, ^{24}Ne, D^{AIM}=3963 keV for x=1982 keV=E^* means that there exists a number of fixed mass/energy intervals ("expanded intervals") in the total combined spectrum, which are not observed in excitations of the individual nuclei. The AIM-method allows one to observe their interconnection with the fine structure parameters associated with the quark structure of nucleons.

Table 1. Stable spacing in the combined spectra of light near-magic nuclei with Z=8-10. The relations between the observed maxima in the distributions of spacing D and D^{AIM} and other nuclear parameters are commented on the right and are discussed in the text.

No	Z	D, x	D^{AIM}	D^{AIM}	D^{AIM}	D^{AIM}	Comments	Parameters	
1	8,9,10	1982	2043			3963	Fig.3	top	$2\varepsilon_o$
	Signif.		5.5σ						
		3964	1982	3068		508	Fig.3	$3\varepsilon_o$	ε_o
	Signif.		5.5σ	5.5σ					
		2043	1982		347		Fig.3	2-nd line	
	Signif.				5.5σ		Δ	=5 keV	

3. Analysis of nuclear excitations in different elements

To find out a presence of stable nuclear excitations similar to fine structure intervals observed in CODATA relations (periods $16m_e/3{=}\delta$, $m_e/3{=}170$ keV and $\delta m_N/8{=}161$ keV), a global analysis of excitations E^* in all nuclei was performed. About 100 independent sum E^*-distributions for all isotopes for each of known element were obtained. This second new method of nuclear data analysis is to search for areas of the nuclear chart where groupings of nuclear excitations can be found.

The grouping of E^* at integer values of m_e is presented in Table 2. The value m_e is known from CODATA relations as the parameter connected with the nucleon quark structure. It has been suggested that the up-quark mass m_u is close to half of the groupings of E^* at $9{\times}(m_e/3){=}3m_e$, namely at $E^*{=}6m_e{=}3.07$ MeV (14 boxed values in Table 2, observed in the region $E^*{=}3057$-3075 keV, can be compared with the expected number $n{\leq}3$ for a random distribution, the small probability of occasional grouping is about 10^{-5}).

Here we consider groupings at nm_e ($3nm_e/3$, the first fine structure period) together with groupings at integer values of the second CODATA parameter, period 161 keV$=\delta m_N/8$. In Fig. 4, the first maximum at 1454 keV$=9\Delta^{TF}$ corresponds to the discreteness in E^* nuclei around Z=20-28 with parameter 161 keV (Table 3).

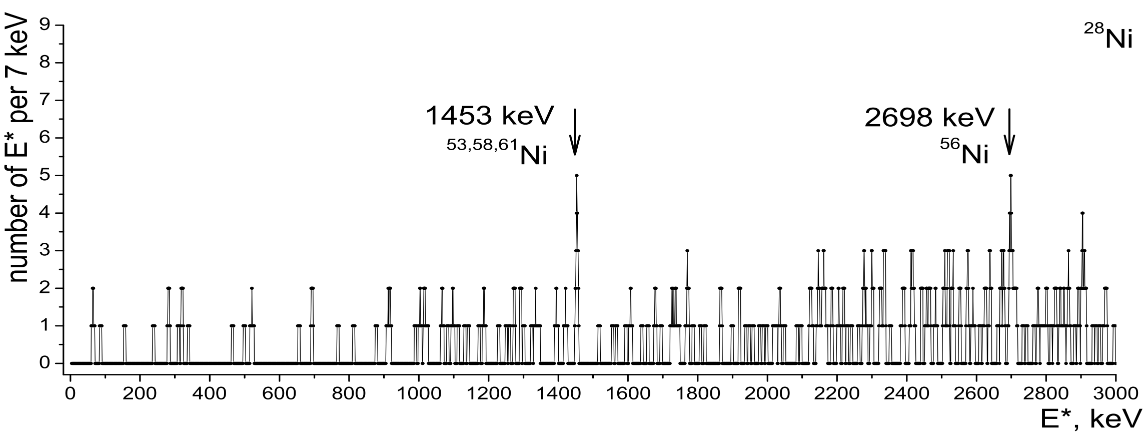

Fig. 4. Sum E^*-distribution for isotopes with Z=28.

Values close to 1454 keV$=9\Delta^{TF}$ are double-boxed in Table 5, where other values of the sequence $E^*{=}k{\times}\Delta^{TF}$ in near-magic nuclei are boxed and compared (in the bottom lines of each section) with integers k of parameter 161 keV $=17\delta{=}\Delta^{TF}$.

The values of 1942 keV:1454 keV:1292 keV:646 keV:322 keV=12:9:8:4:2 can be represented as rational to the value $E^*{=}321$ keV, which is the effect of the residual interaction of a neutron hole in the subshell $1f_{7/2}$ ($\Delta N{=}7$) and a pair of protons in $1d_{3/2}$ subshell in the nucleus ^{43}S. The corresponding E^* is double-boxed in the fourth section, where the linear trend in the excitation energies (in keV) in nuclei with N=21, 22 (ΔN=1, 2 over N=20, boxed) is compared with the number of valence proton pairs (Z-14)/2 (also boxed). The interval from the residual interaction of three valence neutrons in ^{61}Ni (339 keV) and the similar interval from the interaction of three neutron holes in ^{53}Ni (320 keV, which coincides with E^* in ^{43}S) – this is twice the CODATA fine structure parameters (340 keV and 322 keV).

Table 2. Stable excitations E^* (keV) in all isotopes of different elements (Z, El. N^m), observed as maxima in E^*-distributions with the averaging parameter of the ideohistogram Δ=7 keV. N^m-$N^{minimal}$ corresponds to the minimal number of neutron in the sequence of isotopes under the study. Boxed are values close to the integers of the parameter $\varepsilon_o/2$. One asterisk marks E^* close to 1454 keV=9×Δ^{TF}, two asterisks – close to the first E^* of double-magic nuclei.

Z El.	N^m	E^*	E^*	E^*	E^*	E^*	E^*	E^*	E^*	E^*	E^*
$\boxed{20}$ Ca	16	3027	3335	4993	6159						
24 Cr	21	3163	3897	5859	$\boxed{6135}$	6257	6329	6377	7117		
26 Fe	22	367	2115	2756	$\boxed{3073}$	3309	4275	6669			
27 Co	25	$\boxed{508}$	1271	2105	2733	2910	2979	3869			
$\boxed{28}$ Ni	24	1453*	2698**	3010							
29 Cu	27	63	1430	$\boxed{3577}$							
31 Ga	30	65	$\boxed{513}$	711	1233	1619	1975	2600	2655		
32 Ge	29	1189	1409	1430	2140	2572	2694	3035	3680	$\boxed{4083}$	
33 As	32	310	$\boxed{507}$	517	1872	1902	3260				
35 Br	35	205	242	273	331	472	$\boxed{1023}$	1486	1515	2800	
36 Kr	34	147	485	674	985	1015	$\boxed{1027}$	1100	2106	2147	3286
37 Rb	37	190	617	1036	1352	1951	2093	2599	$\boxed{3057}$	3242	3409
39 Y	39	567	597	666	806	1214	2209	2242	2258	2277	
$\boxed{40}$ Zr	40	1063	2927	3018	3032	3213	3555	$\boxed{3577}$			
42 Mo	42	2221	2610	2962	3009	$\boxed{3066}$	3367				
43 Tc	43	141	267	684	689	709	885	1580	$\boxed{2555}$	3216	3886
44 Ru	44	616	1182	1844	2150	2523	2997	3017	$\boxed{3062}$	3074	3289
46 Pd	46	812	$\boxed{1537}$	2138	2281	2620	$\boxed{3068}$	3116	3625	3737	4638
48 Cd	50	$\boxed{508}$	1052	1325	1923	2166	2198	2759	2820	2976	$\boxed{3059}$
49 In	52	158	309	794	$\boxed{1025}$	2108	2372	$\boxed{3068}$	3190	3858	3970
$\boxed{50}$ Sn	51	31	924	1067	1909	1941	$\boxed{2053**}$	2161	2194	2258	3230
51 Sb	54	85	166	644	$\boxed{1020}$	1032	1045	1162	1328	1384	$\boxed{2038}$
52 Te	53	536	1484	1656	2518	2934	2965	2999	$\boxed{3072}$	3997	4174
54 Xe	56	243	527	1399	1582	2305	2969	$\boxed{3073}$	3213	3589	3959
58 Ce	64	133	255	1157	1810	2030	2153	2540	$\boxed{3070}$	3317	3533
59 Pr	66	60	289	382	680	977	1158	1173	1186	$\boxed{2048}$	2104
$\boxed{64}$ Gd	74	426	$\boxed{512}$	752	1013	1051	1059	2137	2302	2445	3010
$\boxed{70}$ Yb	81	485	1435	1533**	1674	$\boxed{2047}$	2138	2426	2481	2526	$\boxed{3074}$
71 Lu	79	434	594	960	1244	1337	1331	2086	2893	$\boxed{3068}$	3417
74 W	83	1440	$\boxed{1536}$	1711	1745	2060	2433	$\boxed{2555}$	2653	2720	3341
76 Os	86	437	791	889	1517	1878	1989	2017	2222	2818	$\boxed{3075}$
78 Pt	90	423	532	918	968	1442	2161	2437	2606	2629	$\boxed{3068}$
80 Hg	92	376	413	550	$\boxed{1027}$	1848	1974	2059	2427	2465	2199
81 Tl	96	255	999	1408	1552	1619	1713	2216	2643		
$\boxed{82}$ Pb	98	$\boxed{1019}$	1680	2624**	2702	3696	4001	4697	5286		
84 Po	105	685	1545	1583	2108	2295	2863	2978	3871		

Table 3. Excitations (in keV) ^{53}Ni, ^{53}Mn and ^{53}Co with the nucleon configuration of three holes in the magic ^{56}Ni are compared with the integer values of the tensor force parameter 161 keV=Δ^{TF}=$\delta m_N/8$ determined in the data for nuclei with Z=50, 51. Excitations close to the integers 161 keV=$\delta m_N/8$ are boxed, and close to $9\Delta^{TF}$ – double-boxed.

^AZ	^{53}Ni $2J_o$=7$^-$			^{58}Ni	^{59}Ni	^{61}Ni	^{63}Ni	1$^-$–5$^-$	^{69}Ni
E^*	320(3)	1292	1456	1454.2	339.4	1454.8	1289.1	1451	1450(3)
$2J^\pi$	(5$^-$)	(3$^-$)	(11$^-$)	2$^+$	3$^-$–5$^-$	7$^-$	9$^+$	(5,7,9)	(1$^-$,3$^-$)
$k\frac{\delta m_N}{8}$	322	1293	1454	1454	322	1454	1293	1454	1454
k	2	8	9	9	2	9	8	9	9

^AZ	^{53}Mn					^{55}Mn			
E^*	378	1289.9)	1441.3	2563.1	2573.1	1289.1	1292.1	1293.0	2582
$2J^\pi$	5$^-$	3$^-$	(11$^-$)	13$^-$	7$^-$	5$^-$–11$^+$	11$^-$	(1$^-$)	
$k\frac{\delta m_N}{8}$	322	1293	1454	2586	2586	1293	1283	1293	2586
k	2	8	9	16	16	8	8	8	16

^AZ	^{53}Co	^{59}Co				^{69}Cu	^{71}Cu		^{73}Cu
E^*	646.2	1291.6)	1459	2581.7	2585.8	1297.9	1453.3	2576(3)	1298.0
$2J^\pi$	7$^-$	3$^-$	11$^-$	3$^-$-7$^-$	7$^-$	3$^-$–1, 3$^-$	3$^-$–9$^-$	(13$^-$)	(3$^-$, 7$^-$)
$k\frac{\delta m_N}{8}$	647	1293	1454	2586	2586	1293	1454	2586	1293
k	4	8	9	16	16	8	9	16	8

(Z-14)/2	3		2	1	1	1	1	0	0
N				Δ N=1	ΔN = 2		ΔN = 7		
^AZ	^{41}Ca		^{39}Ar	^{37}S	^{38}S	^{33}S	^{43}S	^{32}Si	^{35}Si
E^*	0.0	1943	1267	646.2	1292	322	320.7	1942	973.9
$2J^\pi$	7$^-$	3$^-$	3$^-$	3$^-$	2$^+$	D	7$^-$	2$^+$	(3$^+$)
$k\frac{\delta m_N}{8}$	0.0	1941	1293	646	1293	322	322	1941	971
k		12		4	8	2	2	8	6

^AZ	^{33}Mg		^{41}K		^{47}Sc	^{47}V	^{50}V	^{51}V	^{55}V
E^*	159	484	980.4	1293.6	807.9	1294.9	320.2	320.1	323.3
$2J^\pi_o$	3$^-$		3$^+$		2$^+$	3$^-$	6$^+$	7$^-$	(7$^-$)
$2J^\pi$	(7$^-$)	(3$^-$)	4$^+$	7$^-$	3$^-$	11$^-$	4$^+$	5$^-$	(5$^-$)
k$\frac{\delta m_N}{8}$	161	483	971	1293	808	1293	322	322	322
k	1	3	6	8	5	8	2	2	2

The maximum in the E^*-distribution for indium isotopes (Fig. 5) at E^*=1025 keV≈ ε_o (deviation of about 2.8σ) corresponds to the phonon observed as two-phonon excitations $E^*(0^+, 2^+)$=2027, 2043 and 2057 keV of the core-nuclei ^{116,118}Sn. Similar phonon-like (ΔJ=2 and 1) excitation in ^{117}Sn at E^*=1020.0 keV=ε_o and E^*=1004.5 keV, ΔJ=1) and the same discreteness in many levels of ^{113}In and ^{116}Te was found in [1-2]. In Table 5, the excitations with ΔJ=1, 2 in ^{113}In are boxed.

Table 4. Stable excitations (keV) in all isotopes of different elements (Z) observed as maxima in E^*-distributions with averaging interval Δ=7 keV ((n)-number of E^*, Z=8-10, 8-14. 15-18 are marked by *). Groupings of E^* values close to $6m_e$=3066 keV and $9m_e$=4599 keV are boxed.

Z	E^*	E^*	E^*	E^*	E^*	E^*	E^*	E^*	E^*
7	3129(3)	11939(3)							
8*	3063(3)	3840(4)	4588(4)	6283(7)	6855(0)				
8*	52(4)	94(4)	654(6)	1615(7)	2791(6)	3065(6)	4582(9)	4719(8)	5454(10)
15	86(7)	7923(6)							
15*	87(8)	105(7)	904(6)	1989(6)	2231(7)	3288(9)	5009(12)	6357(17)	9157(20)
17	107(6)	4351(6)							
19	2787(5)	4663(5)	4735(5)	4747(6)	7833(11)				
20	3027(4)	3335(5)	4883(6)	4993(?)	6158(7)	8367(8)	8449(0)	8520(8)	
21	1326	1797(5)	1934(5)	2107(6)	2224(6)	2986(8)			
22	4793(7)	6042(7)	6458(6)	6709(7)	6977(6)	8181(8)			
23	1664(4)	1727(4)	1750(4)	2763(4)	3520(6)	3876(6)	4395(6)	6602(6)	6977(6)
24	3163(5)	3897(6)	5859(9)	6135(6)	6257(6)	6329(6)	6377(7)	7117(9)	8121(7)
25	112(3)	839(4)	885(5)	1140(5)	2560(6)	4001(7)			
26	367(4)	2115(4)	2756(4)	3073(5)	3309(8)	4295(6)	6669(10)	8418(11)	9557(13)
27	508(4)	1271(5)	1677(5)	2105(6)	2733(7)	2910(7)	2979(7)	3869(7)	8419(12)
28	1453(5)	2698(5)	3010(6)	3276(6)	3379(6)	3525(7)	4022(7)	4712(8)	5903(8)
29	63(5)	1430(6)	3577(8)						

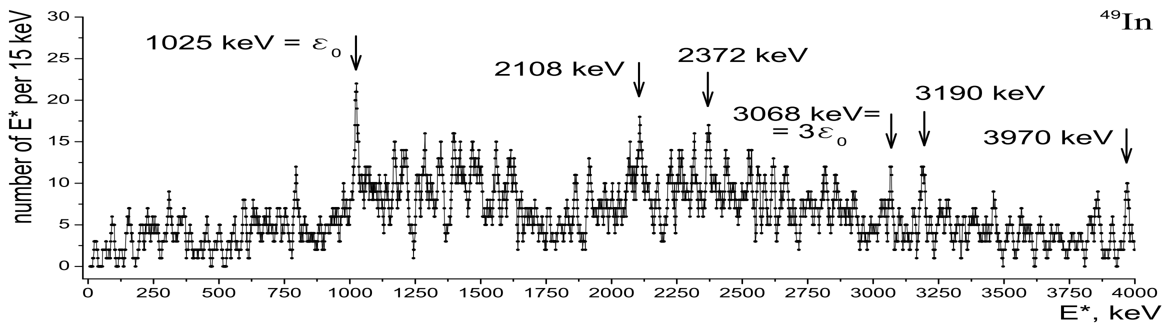

Fig. 5. Sum E^*-distribution for isotopes with Z=49 and maxima at 1026 keV≈1022 keV=$2m_e$ and 3068 keV≈3066 keV=$6m_e$.

Table 5. E^* (keV) in In isotopes corresponding to a maximum at 1026±7 keV in Fig. 5.

^{A}Z	^{106}In	^{106}In	^{108}In	^{109}In	^{110}In	^{110}In	^{110}In	^{113}In	^{113}In	^{114}In	^{114}In
$J^\pi_\circ$	7^+	7^+	7^+	$9/2^+$	7^+	7^+	7^+	$9/2^+$	$9/2^+$	1^+	1^+
E^*	1022.8	1027.1	1028.3	1026.4	1017.9	1020.8	1023.4	1024.3	1029.6	1018.7	1019.8
J^*	(4,5)	(4)	(4,3)	$11/2^+$	$9*-$	$5^+,6^+$	3^-	5^+	$1^+,3^+$	$4^-,5^-$	7^+

^{A}Z	^{114}In	^{116}In	^{116}In	^{117}In	^{117}In	^{118}In	^{119}In	^{121}In	^{123}In	^{125}In	^{129}In
$J^\pi_\circ$	7^+	7^+	7^+	$9/2^+$	$9/2^+$	1^+	$9/2^+$	$9/2^+$	$(9/2)^+$	$9/2^+$	$9/2^+$
E^*	1032.1	1019.0	1031.2	1028.4	1030.0	1028	1025.0	1020.8	1027.4	1027.4	1020.5
J^*	3^-	$3^-,4^-,5^-$	4^+	$(5/2^-)$	$3/2^+,5/2^+$		7/2-11/2	$9/2^+$-$11/2^+$	$11/2^+$	$11/2^+$	(5)

In addition to the maximum in Fig. 5 at a triple value of 3.07 MeV=$3\varepsilon_o$ and the above maxima at $3\varepsilon_o$ in many heavy elements (Figs. 6-8), one can notice the appearance of stable intervals close to $3\varepsilon_o$=3066 keV=$6m_e$ and $9m_e$=4599 keV in light nuclei around Z=8 (Table 4, boxed values).

Table 6. Stable excitations in light nuclei (Z=8-14), corresponding to maxima at E^*=3959-3063±4 keV (close to $6m_e$) and E^*=4582-4588±4 keV (close to $9m_e$) in E^*-distribution (Table 3, top). For comparison, the values $E^* = 12m_e$ and $9m_e$ in ^{16}O,^{18}Ne are given.

^{A}Z	^{19}O	^{19}O	^{18}F	^{20}Na	^{22}Na	^{29}Na	^{25}Al	^{29}Al	^{29}Si	^{16}O
$J^\pi_o 5/2^+$	$5/2^+$	1^+	2^+	3^+	$3/2^+$	$5/2^+$	$(5/2^+)$	$1/2^+$	0^+	
E^*, keV	3064(3)	3067.4	3061.8	3057(3)	3060.4	3059	3062.0	3061.8	3067.1	6129.80(4)
J^*	$(5/2^-)$	$(3/2^+)$	2^+	(4^-)	2^+			$5/2^+$	$5/2^+$	3^-
^{A}Z	^{19}O	^{22}O	^{20}F	^{20}F	^{21}F	^{22}Na	^{25}Al	^{27}Al	^{28}Al	^{18}Ne
$J^\pi_o 5/2^+$	0^+	2^+	2^+	$5/2^+$	3^+	5^+	$5/2^+$	3^+	0^+	
E^*, keV	4582	4584(9)	4584.6	4591.7	4584.0	4582.8	4582(2)	4580.0	4578.6	4590(8)
J^*	$3/2^-$	$(3)^+$			$3/2^+$,$5/2^+$	2^-	$5^+,2$	$7/2^+$		0^+

It can be seen from Table 6 that the spins of many excited states have not yet been determined, and an additional analysis of the excitations and binding energies of light nuclei is needed. The independent appearing of equal stable mass/energy intervals in the spectra of light and heavy nuclei confirms the CODATA relations and manifests on the fundamental properties of the nucleon structure, observed as a fine structure.

4. General remarks and conclusions

In Table 7 the components of the maximum in the E^*-distribution for the Z=70 isotopes at E^*=1533 keV=$3m_e$ (Fig. 6) are presented. The first excitations E^* of near-magic nuclei with N=82 and 82-1 (of elements with Z=66, 68 and 70) are given with differences between E^* of Z=82 and Z=81 isotopes of these elements. The coincidence of the first E^* ^{152}Yb and ^{151}Yb with $3m_e$ demonstrates that the tuning effect takes place only at Z=70, where all proton subshells (except the last, $1\pi i_{11/2}$) are filled.

At the top of Table 8, the values E^* (keV) of light A-odd lead isotopes, rational or equal to the $\varepsilon_o = 2m_e$, are boxed. The proximity of values within 1 keV is observed.
At the bottom of Table 8, the confirmation of the grouping E^* observed in other near-magic nuclei at the energy of the first excitation is shown (marked ** in Table 2).

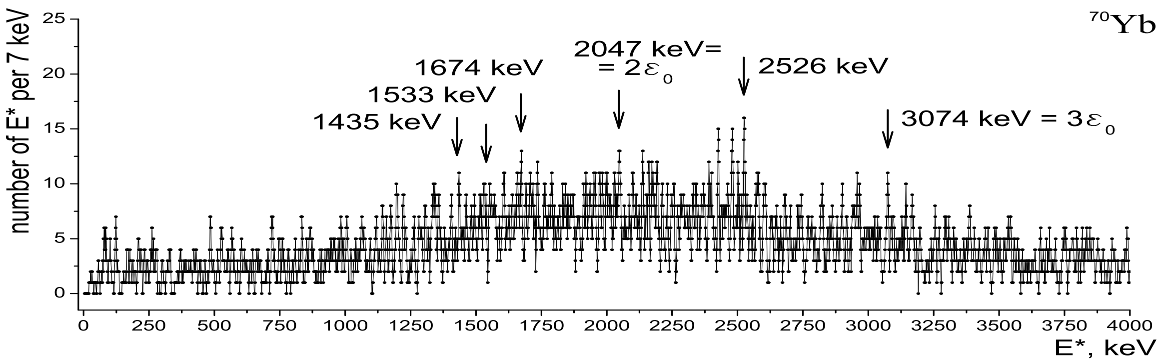

Fig. 6. The sum E^*-distributions for isotopes with Z=70. The positions of the maxima at k×$m_e, k = 3, 4, 6$ (for 1533 keV, 2047 keV and 3074 keV) are marked with arrows.

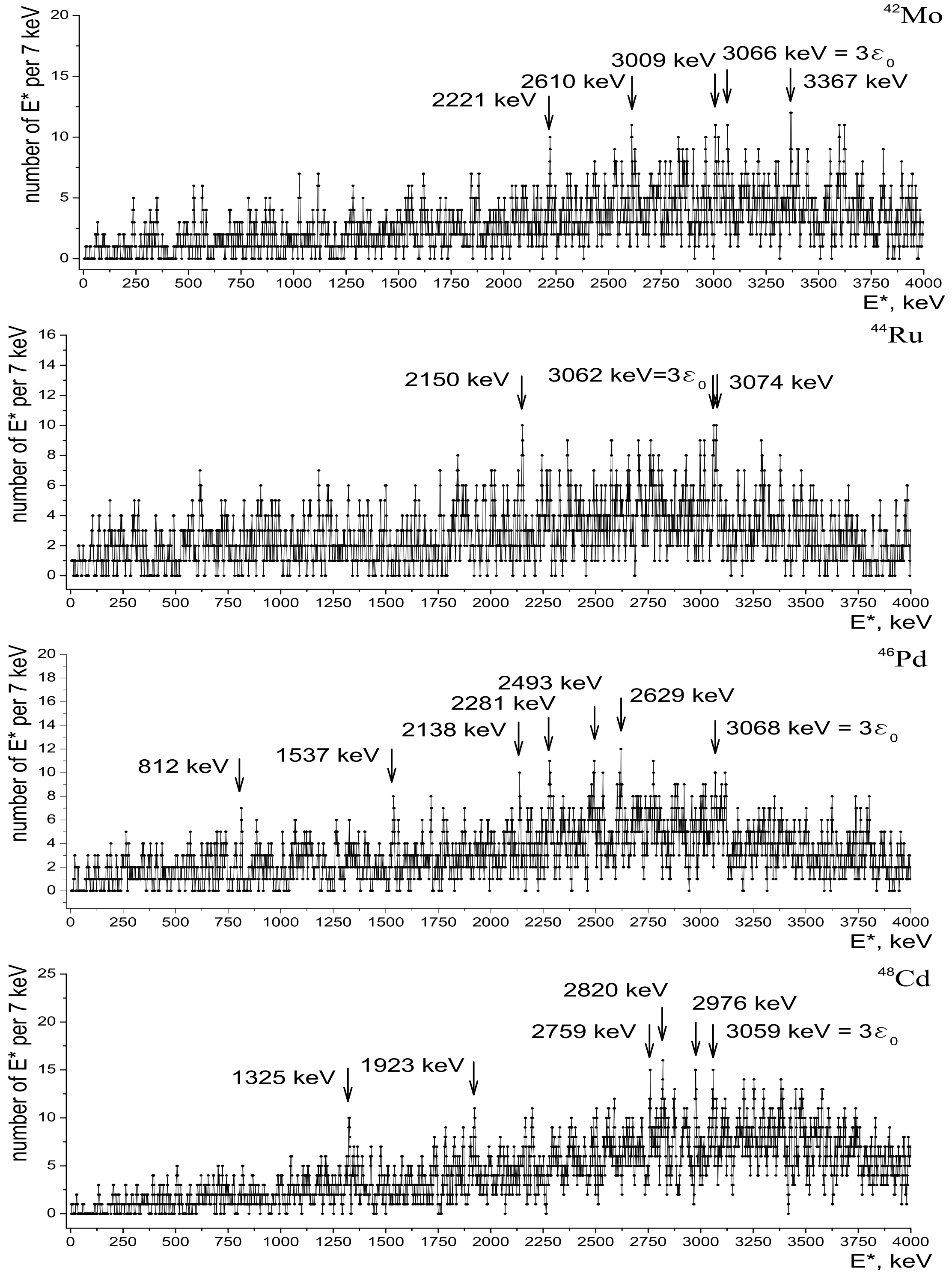

Fig. 7. Sum E^*-distributions for isotopes with Z=42 (*top*), Z=44 (*2nd line*), Z=46 (*center*) and Z=48 (*bottom*). In all four neighboring elements (even Z=42-48), the grouping effect observed in the values of E* in different isotopes takes place at nearly the same energy: 3068 keV, 3062-3073 keV, 3068 keV and 3059 keV (close to $6m_e$=3066 keV).

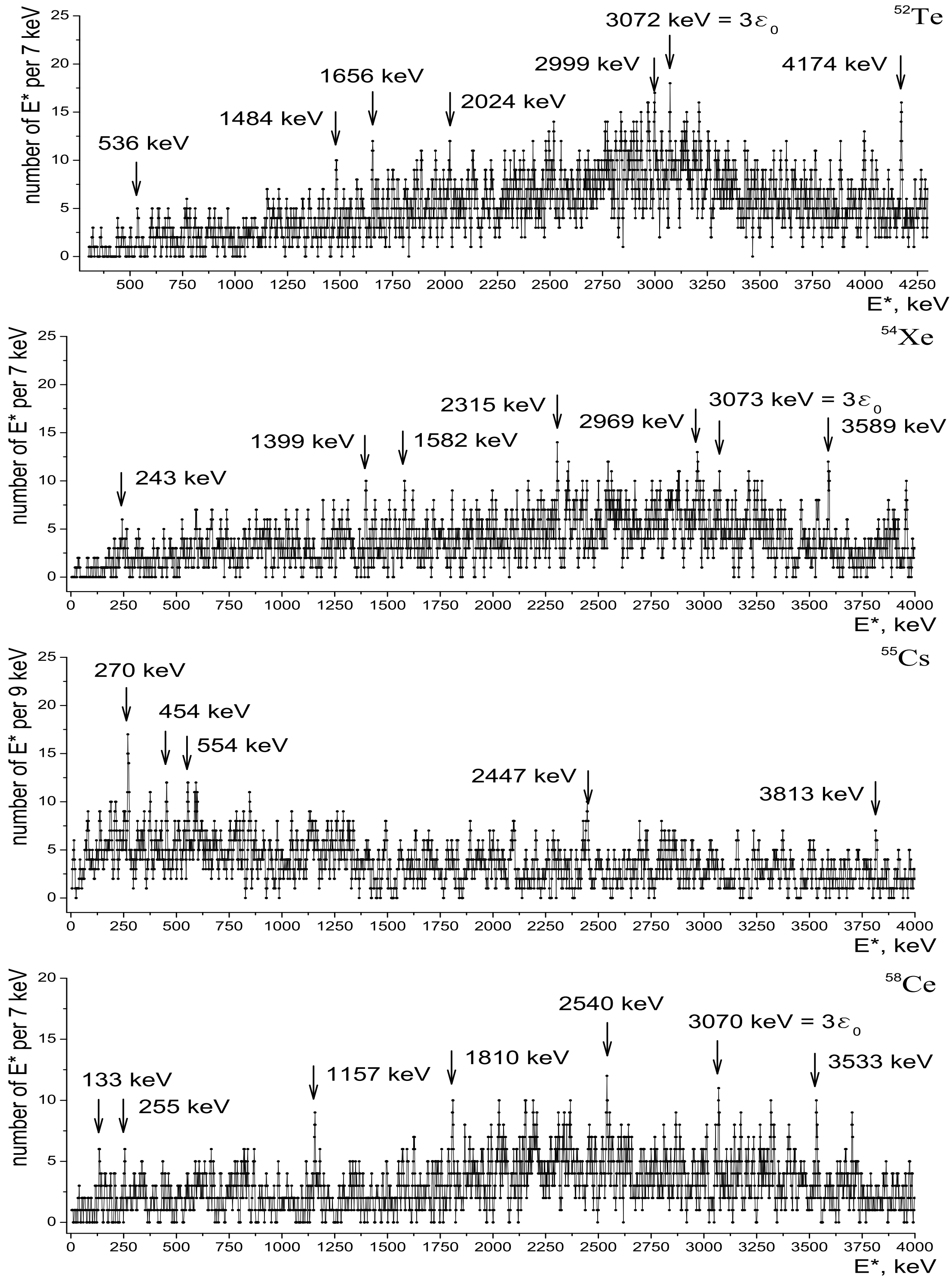

Fig. 8. Sum E^*-distributions for isotopes with Z=52 (*top*), Z=54 (*2nd line*), Z=56 (*center*) and Z=58 (*bottom*). In all four neighboring elements (even Z=52-58), the grouping effect observed in the values of E* in different isotopes takes place at nearly the same energy: 3072 keV, 3073 keV, 3072 keV (Table 4 for Z=56) and 3070 keV. The maximum in Cs (Z=55) corresponds to $\delta m_N - \varepsilon_o$=271 keV.

Table 7. Stable excitations E^* (keV) in neighboring near-magic Dy, Er, Yb, and the difference between isotopes with N=82 and 81=82-1.

Z	Elem.	$E^*(2^+)$	$E^*(15/2^-)$- $E^*(11/2^-)$	diff. $2^+, 15/2^-$	$E^*(15/2^-)$	$E^*(11/2^-)$
66	Dy	1677.3	1653.5	23.8	2404.0	750.5
68	Er	1578.3	1569.8	7.5	2311.6	741.8
70	Yb	1531.4	1531.3	0.1	1531.3	0.0

Table 8. E^* (keV) in light A-odd lead isotopes rational or equal to $\varepsilon_o = 2m_e$.

Nucleous	$2J^\pi$	E_1^*	$2J^\pi$	E_2^*	$E_{3,4}^*$	$2J^\pi$	
^{193}Pb	13^+	757(1)	(17^+)	881.7	(17^+)	1022.1(3)=ε_o	(15^+)
^{197}Pb	3^-	84.88(7)=$\varepsilon_o/12$	5^-	952.0	7^-	988.5	3^-,5^-
^{199}Pb	(5^-)	19.1	(X^-)	945.9	$(7^-, 9^-)$	1022.7(4)=ε_o	
^{201}Pb	5^-	88.5	$3^-)$	169.9(8)=$\varepsilon_o/6$			
^{208}Pb	0^+	2614.5	$3^-)$	3197.7	5^-		
ΣE^*		2620	n=13	3196	n=13	4697	n=16

We conclude that the analysis of the E^* values of all known nuclear excitations confirmed the distinguished character of the parameters derived from the correlations between the nucleon and lepton masses (CODATA relations and QED parameter $\alpha/2\pi$) [1,8]. A standard analysis of the up-quark mass m_u can provide a comparison with the value found here $E^* = 3m_e$. Observation of superfine and fine structures in positions and spacings of neutron resonances, together with the proximity of some low-lying excitations in near-magic nuclei to integers of the electron mass, was the starting point for particle mass analysis [3-5]. Two new methods of nuclear data analysis provide additional indirect check of CODATA relations – an important property of nucleon masses.

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