Harmonic Unity of Atom Spectrum

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Recent discovery of the laws of atomic electron shells formation [1] enables to have absolutely new view at the nature of atom spectrum. In particular, the fractional values of a main quantum number testify to excitation of multiple resonances of electronic shells of atoms making for each atom a «special» spectrum.

In spite of all diversity of characteristics the regularities showing harmonic unity of each atom clearly appear, that, undoubtedly, becomes reliable guiding line for researchers and will be useful at the analysis and systematization of atomic spectrums.

This article is a continuation of study of atomic electron shells properties on the basis of reference data confirmed by trusty experiments.

The analysis of the experimental data [1] has shown that atomic electron shells are resonant structures, and consequently the Bohr postulate about electron moment of momentum quantization in atom actually is a resonance condition: the electron shell comprises the integer number of wave lengths of an electron *h/p* (though mathematically this is the same):

$$2\pi R = n\lambda = n\frac{h}{p}, \qquad pR = n\hbar, \qquad (h = 2\pi\hbar). \tag{1}$$

The number *n* is termed as main quantum number, *R* - radius of electron shell, *p* - electron momentum, *h* - Planck's constant.

Thus, the expression (1) determines «allowed» resonant values of spatial phase factor of electron shell

$$k = \frac{2\pi}{\lambda} = \frac{n}{R}. \tag{2}$$

It was also ascertained that the main quantum number can have fractional values (N_1/N_2) as a result of multiple harmonics excitation. For determining of concrete values the reference data about atoms ionization potentials were used. In particular, for atoms having one electron on an outer shell (hydrogen-like atoms) these calculations are most simple and have confirmed electron shells multiple resonances presence.

Let's make corresponding calculations for lithium atom. The wave length of an electron was evaluated proceeding from its kinetic energy, which, in turn, numerically meets the ionization potential

$$\frac{p^2}{2m} = e\varphi_i, \qquad p = (2me\varphi_i)^{1/2}. \tag{3}$$

Therefore electron wave length and conditional orbit radius R_λ (defining spatial phase factor) are determined by formulas:

$$\lambda = 2\pi R_\lambda = \frac{h}{p} = \frac{h}{(2me\varphi_i)^{1/2}}, \qquad \frac{R_\lambda}{R_B} = \frac{h}{2\pi R_{\text{Б}}(2me\varphi_i)^{1/2}}. \tag{4}$$

For example, substituting in (4) ionization potential of lithium *5,39 eV*, we get following concrete values:

$$\lambda = 5{,}296 \cdot 10^{-10}\,m, \qquad R_\lambda = 0{,}843 \cdot 10^{-10}\,m = 1{,}593\,R_B\,.$$

Here R_B - Bohr radius, and conditional radius R_λ (rate of spatial changes) actually was already represented in (2).

Thus, the outer electron shell of lithium is characterized by a main quantum number *n=1,593*, which is not integer and is between *1* and *2*!

However actually outer electron shell of lithium is also resonant and has the integer number of wave lengths. It is achieved due to excitation of multiple harmonics.

For atom of lithium the integer number of wave lengths is $N_1=8$, characterizing a resonance of outer electron shell as a result of multiplication of *1,593* by number $N_2=5$, representing the number of a harmonic component. That is, the fifth harmonic «makes» eight wave lengths resonance of electron shell of lithium atom. At the same time formula for a shell radius appears to be also valid for not integer *n*

$$R = n^2 R_B. = (1{,}593)^2 R_B = 2{,}54 R_B. \qquad (5)$$

This value really meets the actual radius of outer electron shell of lithium atom evaluated from expression for ionization potential of one-electron outer shell [1]

$$e\varphi_i = \frac{e^2}{8\pi\varepsilon R}, \qquad R = \frac{e}{8\pi\varepsilon\varphi_i} = 2{,}52 R_B \qquad (\varphi_i = 5{,}39 eV). \qquad (6)$$

Similar calculations for atoms with only one electron on the outer electron shell (as lithium) were carried out. The results of calculations are shown in table 1, which we here cite to make convenient comparison with similar calculations for excited energy levels.

The numerals, given in the table 1, evidence of natural character of obtained results: the outer shells in an unexcited state have fractional values of main quantum number. It is important that main quantum numbers are close to vulgar fractions, in which numerator and in denominator are integer numbers.

Thus, in article [1] was shown that the Nature uses in atomic electron shells not only «common» resonances, but also those excited on multiple harmonic components, so that atoms are more compact and, simultaneously, have ability to «place» on electron shells greater number of electrons (in antinodes of multiple resonances).

Unexcited outer electron shells of atoms. Table 1

Atom	φ_1, *eV*	*n*	n^2	R/R_B	$n \approx N_1/N_2$
3 (Li)	5,39	1,593	2,54	2,52	8/5,02
11 (Na)	5,138	1,632	2,66	2,65	5/3,06
19 (K)	4,339	1,775	3,15	3,13	7/3,94
55 (Cs)	3,893	1,875	3,51	3,49	15/8,00
37 (Rb)	4,176	1,81	3,27	3,26	9/4,97
47 (Ag)	7,574	1,342	1,8	1,79	4/2,98
78 (Pt)	8,96	1,236	1,53	1,52	5/4,04
81 (Tl)	6,106	1,498	2,24	2,23	3/2,00

Convincing confirmation of this regularity is the similar phenomenon detected at the analysis of excited states of atoms and the appropriate absorption (radiation) spectrums.

As an example in article [1] the spectrum of lithium atom was discussed. In fig. 1 the Grotrian diagram for lithium atom is shown [2], which exposes the plurality of excited energy levels and of corresponding quantum transitions.

As a matter of convenience of diagram analysis some supplementary calculations were produced.

First, the energy levels it is more convenient to count off from «absolute» zero (that is, from electron energy at infinite distance from atom), but not from the lowest level corresponding to ionization energy (as it is done in diagram).

Secondly, all the same electron characteristics at excited levels were calculated, just as it was presented in table 1.

The total table 2 includes also main quantum number n (first column), which marks each excited level in the diagram (fig. 1). It was made as bases of comparison with calculated values n (ratios N_1/N_2).

The results shown in table 2 have appeared rather eloquent. Calculated values of main quantum number ($n_{calc.}$) in most cases with good precision coincide with integer values (first column) used for marking of the relevant energy levels in Grotrian diagrams.

However in six cases (almost each third of excited levels) authors of the diagram, probably, long could not determine appropriate integer main quantum number, as it should be fractional (N_1/N_2) instead of integer, as it is shown in the diagram. Numbers N_1, and N_2 can be determined with good precision by simple calculations.

So, the excited energy levels of lithium atom approximately in *2/3* cases meet the integer (usual) values n, but in *1/3* cases - fractional values of a main quantum number. These last levels in the Grotrian diagram «forced» are marked with integer values.

Excited states of lithium atom. Table 2

n (diagram)	W, eV (diagram)	W, eV abs.	n calc.	n^2 calc.	R/R_B	$n \approx N_1/N_2$
2	1,848	3,544	1,963578	3,85564	3,837472	2
3	3,373	2,019	2,601519	6,7679	6,736008	13/4,997
3	3,834	1,558	2,961498	8,770468	8,72914	3
3	3,879	1,513	3,005216	9,031321	8,988764	3
4	4,341	1,051	3,605735	13,00132	12,94006	18/4,998
4	4,522	0,87	3,963104	15,70619	15,63218	4
4	4,541	0,851	4,007101	16,05686	15,9812	4
4	4,542	0,85	4,009458	16,07575	16	4
5	4,749	0,643	4,60988	21,25099	21,15086	23/4,99
5	4,837	0,555	4,961907	24,62052	24,5045	5

5	4,847	0,545	5,007222	25,07227	24,95413	5
5	4,848	0,544	5,011822	25,11836	25	5
6	4,958	0,434	5,611129	31,48477	31,33641	28/4,99
6	5,008	0,384	5,965262	35,58435	35,41667	6
6	5,014	0,378	6,012419	36,14918	35,97884	6
7	5,079	0,313	6,607284	43,6562	43,45048	33/4,99
7	5,11	0,282	6,960983	48,45528	48,22695	7
7	5,114	0,278	7,010883	49,15248	48,92086	7
8	5,156	0,236	7,609202	57,89995	57,62712	38/4,99

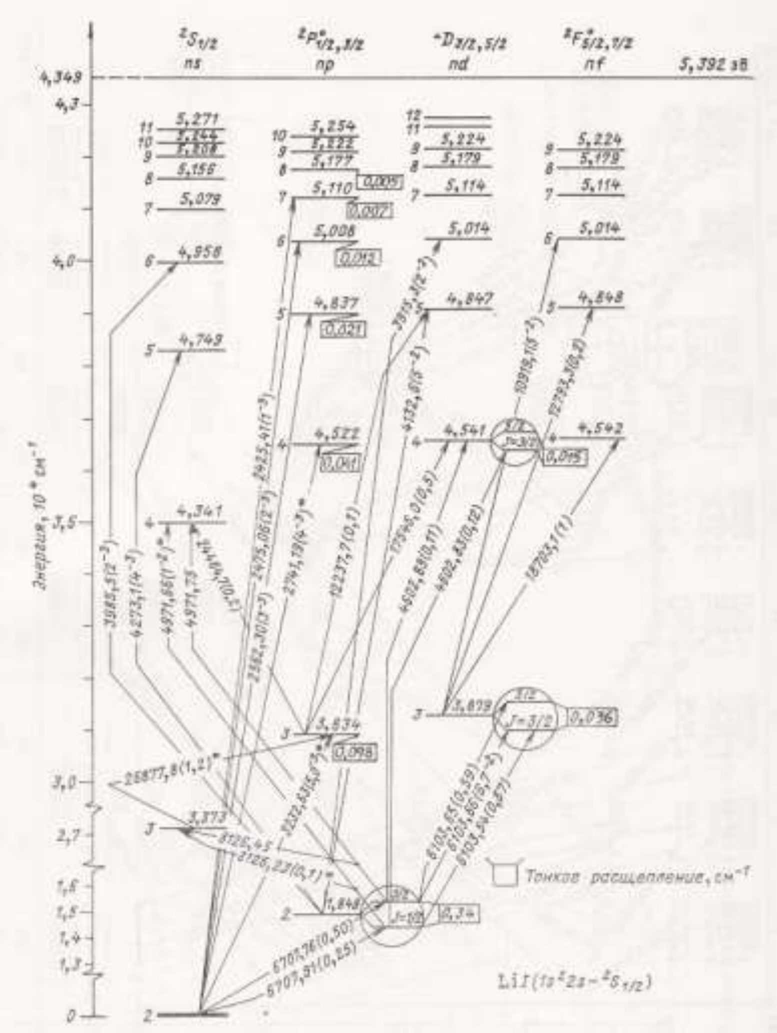

Fig. 1. The Grotrian diagram of lithium atom [2].

From the given table follows that fractional main quantum numbers (between integers) make series of values increasing by unit *13/5, 18/5, 23/5 … 38/5*, naturally proceeding from «unexcited» value *8/5* for lithium atom (tab. 1)!

Besides, draws attention how wide apart (R/R_B) sits outer shell electron from atomic core on excited levels with large numbers *n*. Such remoteness apparently should bring to nothing influence of atomic core on electron «movement», so that parameters of excited states should be close to those of hydrogen atom. But really it is not quite so. Further we'll yet discuss this «strangeness».

We have cited here some results got in previous article [1] (and at the same time have slightly improved the last column of tab. 2) to bring the reader up to date to enable further proceed of atom spectrums study.

It turned out that the visualization of the information, which table 2 already contained, opens extra opportunities for calculation results analysis. In fig. 2 «spectrum» of main quantum number of excited states of lithium atom are represented. That is, the medial column of table 2 is set down in graph (values *n* are simply placed in ascending order).

This graph (diagram), representing spectrum of excited states of lithium atom, visually testifies to crucial role of frequency interrelations in atom. Namely, it appears that atom skeleton «generates» a certain frequency set, with which outer electron interacts being on an excited energy level.

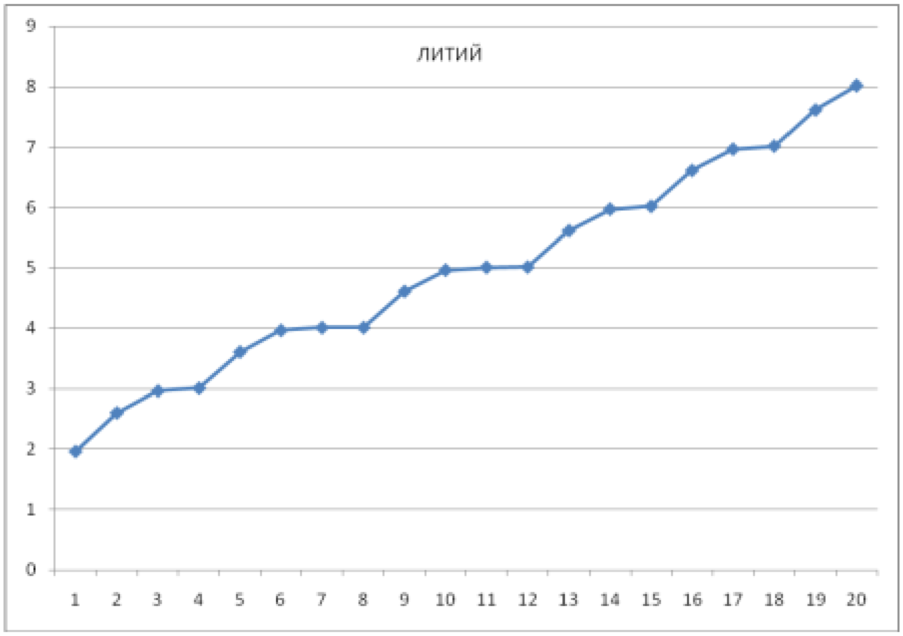

Fig. 2. Spectrum *n* of excited states of lithium atom.

The fact is, that on upper excited levels an electron really is widely apart from atom skeleton (table 2), and on such distances skeleton sizes are insignificant. Moreover, the skeleton sizes of hydrogen-like atoms are really small (they are given in [1], the table 3), and, therefore, characteristics of high levels should be close to those of hydrogen atom. However spectrums do not follow this «apparent» rule.

Radiuses of atom skeletons [1]. Table 3

Atom	R_o/R_B
11 (Na)	0,408
19 (K)	0,695
37 (Rb)	0,816
55 (Cs)	0,816

Nevertheless, Grotrian diagrams interpret essential differences of spectrums of hydrogen-like atoms (proceeding from «basic» hydrogen atom spectrum) by the influence of other quantum numbers. Such approach, as it was already mentioned, cannot explain variety of atoms spectrum.

It is essential to confirm that the unsatisfactory state of affairs in classification and systematization of atoms spectrum is caused not only by its complexity, but also as a consequence of apparent inconsistency of existing theory of atomic electron shells.

This problem actually is necessary to solve anew using other physical representations. Namely, it is crucial to proceed from nonlinear resonant nature of electron shells and from harmonic unity of each atom spectrum.

To be convinced of it, it is enough to compare «spectrums» of main quantum numbers of excited states of different atoms. For such comparison, besides the table 2 from the previous article [1], the results of similar calculations for atoms of hydrogen, helium, potassium, sodium, silver, cesium and rubidium are below given.

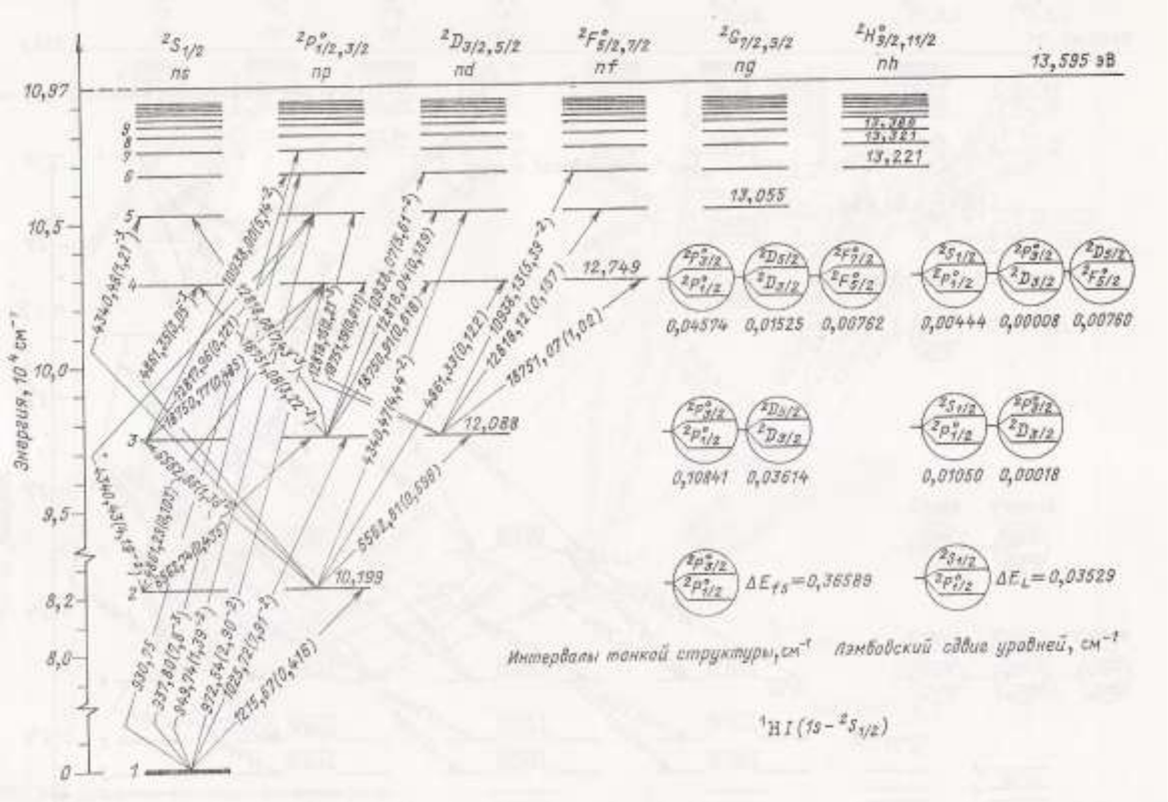

Fig. 3. Grotrian diagram of hydrogen atom [2].

It becomes clear that the simpler is atom skeleton the brighter is manifestation of regular harmonic components in spectrums of main quantum numbers. And on the contrary, more complex atom skeletons (Os, Rb) generate such abundance of frequencies that causes excitation of numerous electron states, so that spectrums of main quantum numbers become more and more dense.

Having begun this article by a reasoning of wave properties of an electron, we now reach a conclusion that these properties do not exist per se [3], but are determined by interaction of an electron with surrounding objects (oscillations). Accordingly, in atoms it is a question of interaction of atomic shells electrons with oscillations generated by atomic skeletons.

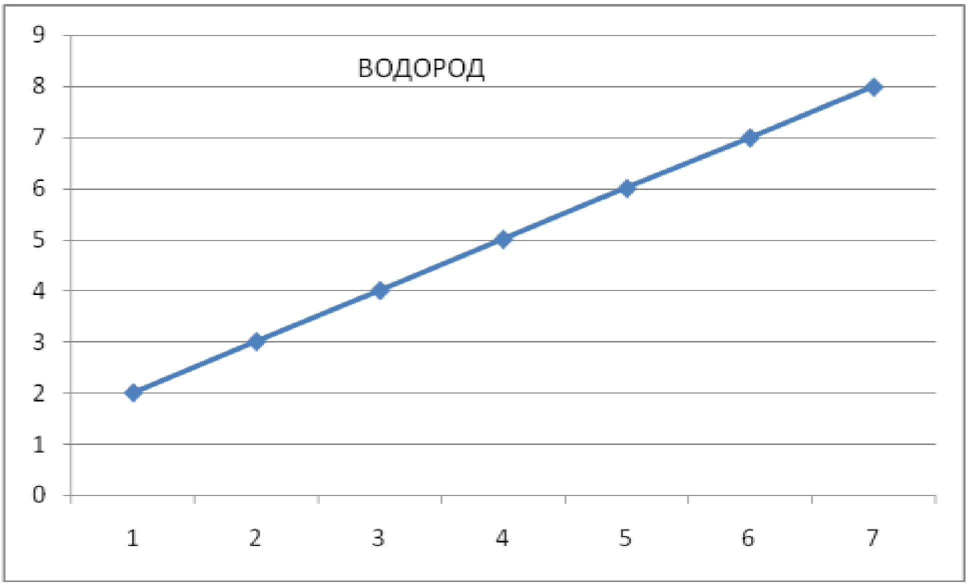

Fig. 4. Spectrum *n* of excited states of hydrogen atom.

Excited states of hydrogen atom. Table 4

n (diagram)	*W*, *eV* (diagram)	*W*, *eV* abs.	*n* calc.	n^2 calc.	R/R_B	$n \approx N_1/N_2$
2	10,199	3,401	2,004434	4,017756	3,998824	2
3	12,088	1,512	3,006209	9,037294	8,994709	3
4	12,749	0,851	4,007101	16,05686	15,9812	4
5	13,055	0,545	5,007222	25,07227	24,95413	5
6	13,221	0,379	6,004481	36,0538	35,88391	6
7	13,321	0,279	6,998307	48,97631	48,74552	7
8	13,386	0,214	7,990763	63,85229	63,5514	8

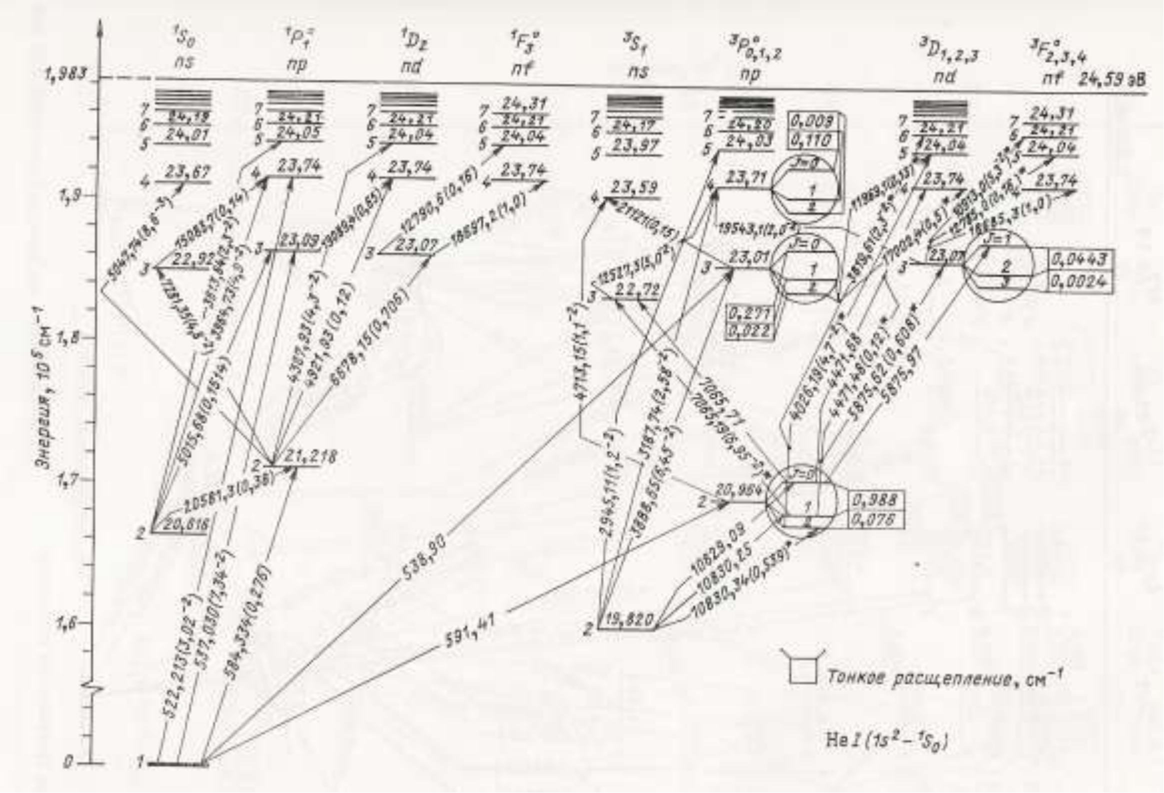

Fig. 5. Grotrian diagram of helium atom [2].

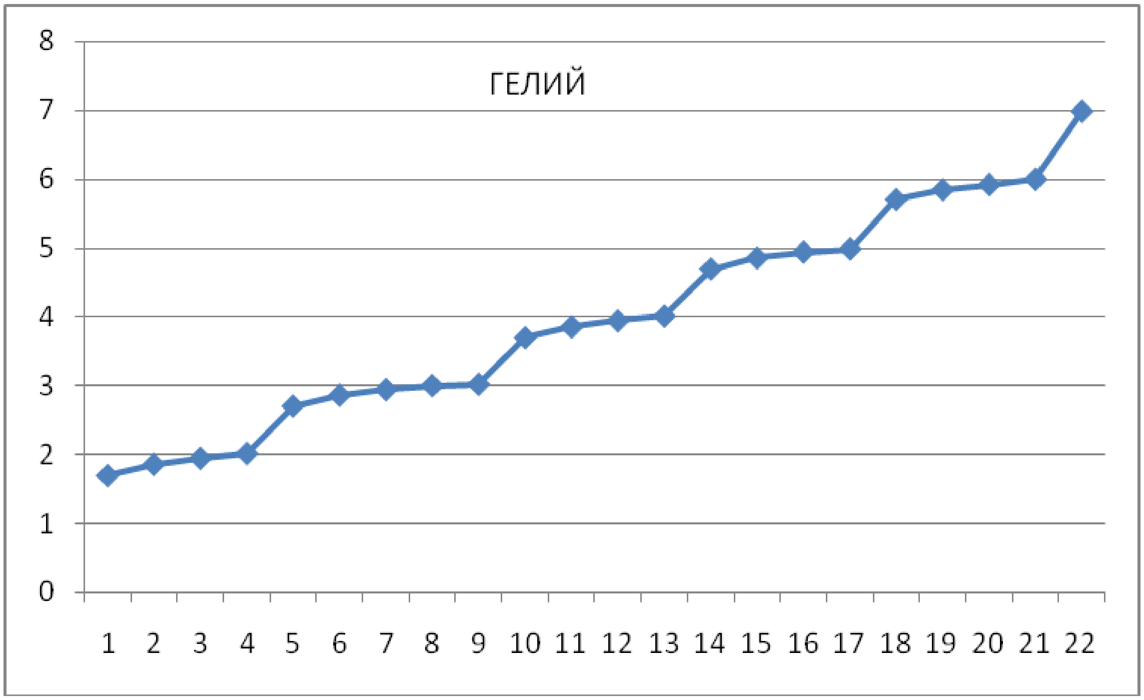

Fig. 6. Spectrum *n* of excited states of helium atom.

The energy of an excited level of atomic outer electron, as well as a stationary state energy, is determined by value of a main quantum number [4]

$$W = -\frac{me^4}{8\varepsilon^2 h^2}\frac{1}{n^2}. \qquad (7)$$

Therefore spectrum of main quantum number of excited states of any atom «automatically» determines ensemble of according energy levels and spectrum of radiation (absorption). But the analysis of spectrum of main quantum numbers, as it has become clear, is much easier in view of its particular periodicity (though not quite strict).

Excited states of helium atom. Table 5

n (diagram)	*W, eV* (diagram)	*W, eV* abs.	*n* calc.	n^2 calc.	R/R_B	$n \approx N_1/N_2$
2	19,82	4,77	1,692528	2,864652	2,851153	17/10,04
2	20,616	3,974	1,854305	3,438447	3,422245	13/7,01
2	20,964	3,626	1,941249	3,768447	3,750689	33/17
2	21,218	3,372	2,013035	4,05231	4,033215	2
3	22,72	1,87	2,703176	7,30716	7,272727	27/9,99
3	22,92	1,67	2,860467	8,182269	8,143713	20/6,99
3	23,01	1,58	2,940807	8,648348	8,607595	50/17
3	23,07	1,52	2,998288	8,98973	8,947368	3
3	23,09	1,5	3,01821	9,109593	9,066667	3
4	23,59	1	3,696537	13,66439	13,6	37/10,01
4	23,67	0,92	3,853907	14,8526	14,78261	27/7,00
4	23,71	0,88	3,940522	15,52771	15,45455	67/17,00
4	23,74	0,85	4,009458	16,07575	16	4
5	23,97	0,62	4,694607	22,03934	21,93548	47/10,01
5	24,01	0,58	4,853791	23,55929	23,44828	34/7

5	24,03	0,56	4,939706	24,40069	24,28571	84/17,00
5	24,04	0,55	4,98441	24,84434	24,72727	5
6	24,17	0,42	5,703881	32,53426	32,38095	57/9,99
6	24,19	0,4	5,844739	34,16097	34	41/7,01
6	24,2	0,39	5,919197	35,0369	34,87179	101/17,06
6	24,21	0,38	5,996576	35,95892	35,78947	6
7	24,31	0,28	6,985799	48,80139	48,57143	7

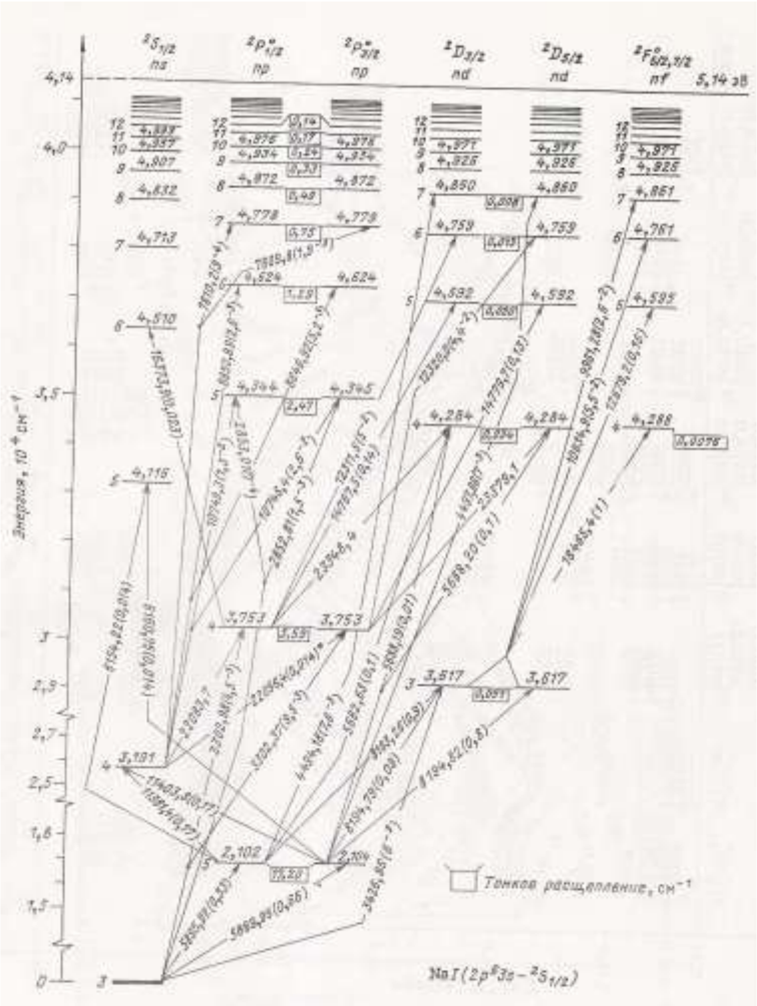

Fig. 7. Grotrian diagram of sodium atom [2].

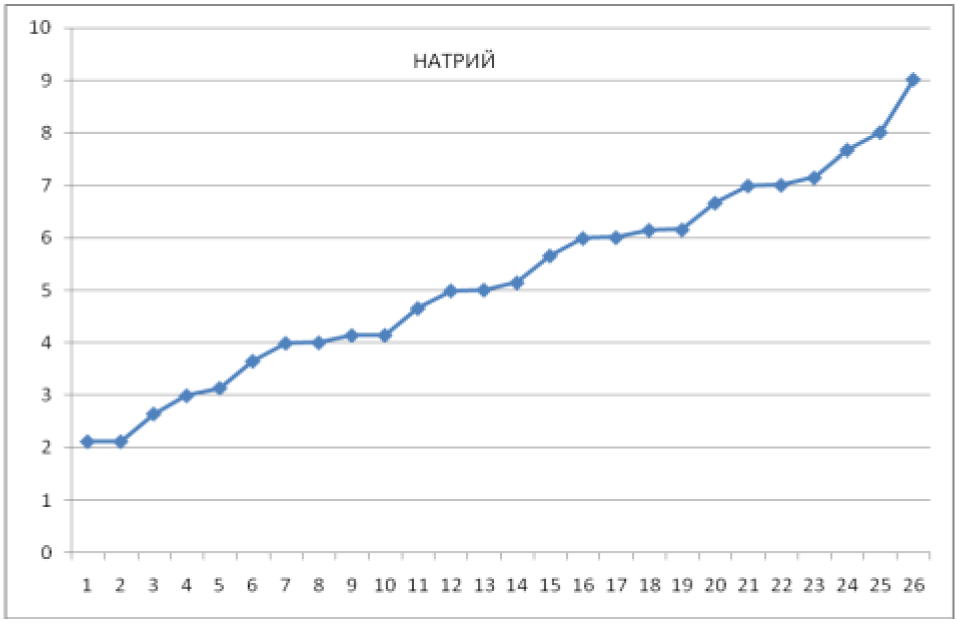

Fig. 8. Spectrum *n* of excited states of sodium atom.

Excited states of sodium atom. Table 6

n (diagram)	*W, эВ* (diagram)	*W, эВ* abs.	*n* calc.	n^2 calc.	R/R_B	$n \approx N_1/N_2$
5	2,102	3,037	2,121157	4,499305	4,478103	17/8,01
5	2,104	3,035	2,121855	4,50227	4,481054	17/8,01
4	3,191	1,948	2,648504	7,014573	6,98152	8/3,02
3	3,617	1,522	2,996317	8,977917	8,935611	3
4	3,753	1,386	3,139883	9,858867	9,81241	22/7,01
5	4,116	1,023	3,654747	13,35717	13,29423	11/3,01
4	4,284	0,855	3,997717	15,98174	15,90643	4
4	4,288	0,851	4,007101	16,05686	15,9812	4
5	4,344	0,795	4,145831	17,18791	17,10692	29/6,99
5	4,345	0,794	4,14844	17,20956	17,12846	29/6,99
6	4,51	0,629	4,6609	21,72399	21,62162	14/3,00
5	4,592	0,547	4,99806	24,9806	24,86289	5
5	4,595	0,544	5,011822	25,11836	25	5

6	4,624	0,515	5,150999	26,53279	26,40777	36/6,99
7	4,713	0,426	5,663571	32,07603	31,92488	17/3,00
6	4,759	0,38	5,996576	35,95892	35,78947	6
6	4,761	0,378	6,012419	36,14918	35,97884	6
7	4,778	0,361	6,152357	37,85149	37,67313	43/6,99
7	4,779	0,36	6,160896	37,95664	37,77778	43/6,98
8	4,832	0,307	6,671537	44,50941	44,29967	20/3,00
7	4,86	0,279	6,998307	48,97631	48,74552	7
7	4,861	0,278	7,010883	49,15248	48,92086	7
8	4,872	0,267	7,153844	51,17749	50,93633	50/6,99
9	4,907	0,232	7,674518	58,89823	58,62069	23/2,99
8	4,926	0,213	8,009498	64,15206	63,84977	8
9	4,971	0,168	9,018628	81,33565	80,95238	9

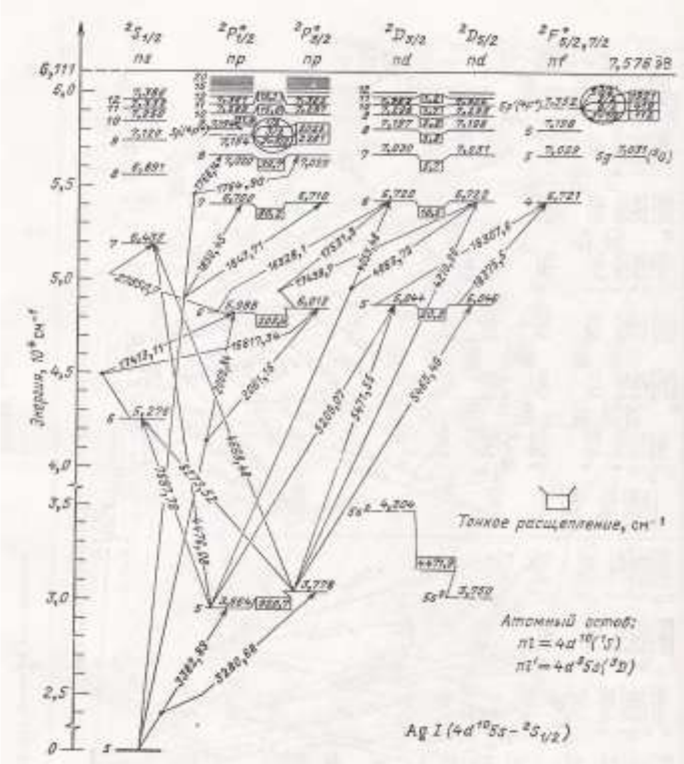

Fig. 9. Grotrian diagram of silver atom [2].

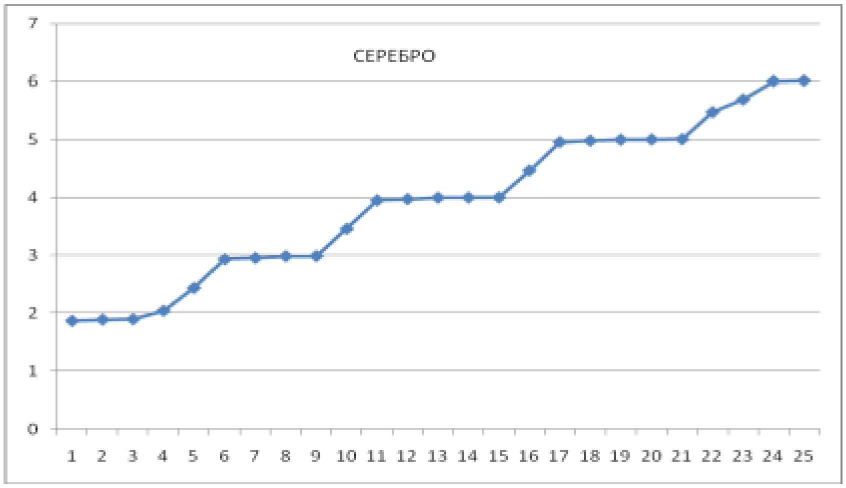

Fig. 10. Spectrum *n* of excited states of silver atom.

Excited states of silver atom. Table 7

n (diagram)	*W, эВ* (diagram)	*W, эВ* abs.	*n* calc.	n^2 calc.	R/R_B	$n \approx N_1/N_2$
5	3,664	3,912	1,868941	3,492942	3,476483	15/8,02
5	3,75	3,826	1,88983	3,571456	3,554626	17/8,99
5	3,778	3,798	1,896783	3,597785	3,580832	17/8,96
5	4,304	3,272	2,043565	4,176158	4,156479	2
6	5,276	2,3	2,437425	5,941039	5,913043	27/11,07
6	5,988	1,588	2,93339	8,604779	8,564232	44/15,00
6	6,013	1,563	2,956757	8,742412	8,701216	3
5	6,044	1,532	2,986522	8,919314	8,877285	3
5	6,046	1,53	2,988473	8,930973	8,888889	3
7	6,433	1,143	3,457578	11,95485	11,89851	38/11,00
7	6,7	0,876	3,949509	15,59862	15,52511	4
7	6,71	0,866	3,972246	15,77874	15,70439	4
6	6,72	0,856	3,995381	15,96307	15,88785	4
4	6,721	0,855	3,997717	15,98174	15,90643	4
6	6,722	0,854	4,000057	16,00046	15,92506	4
8	6,891	0,685	4,46632	19,94801	19,85401	49/10,97

8	7,02	0,556	4,957443	24,57624	24,46043	5
8	7,025	0,551	4,979885	24,79925	24,6824	5
5	7,029	0,547	4,99806	24,9806	24,86289	5
7	7,03	0,546	5,002635	25,02635	24,90842	5
7, 5g	7,031	0,545	5,007222	25,07227	24,95413	5
9	7,12	0,456	5,4741	29,96577	29,82456	60/10,96
5p	7,154	0,422	5,690349	32,38007	32,22749	17/2,99
8	7,197	0,379	6,004481	36,0538	35,88391	6
8, 6	7,198	0,378	6,012419	36,14918	35,97884	6

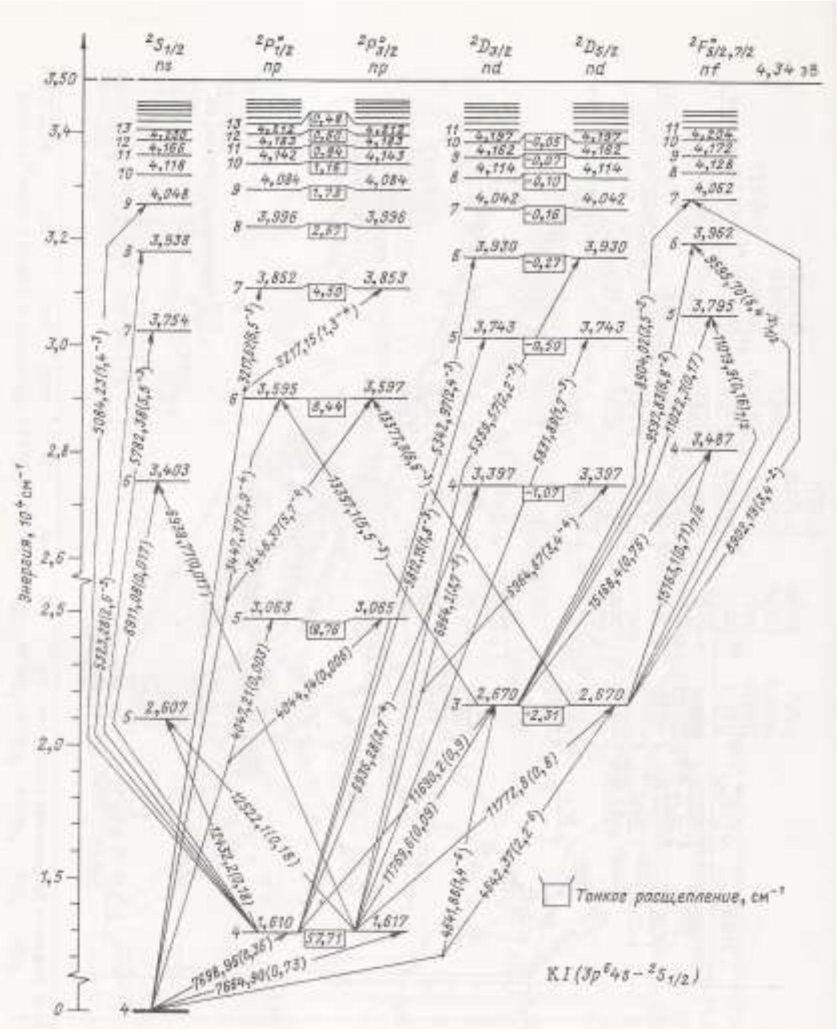

Fig. 11. Grotrian diagram of potassium atom [2].

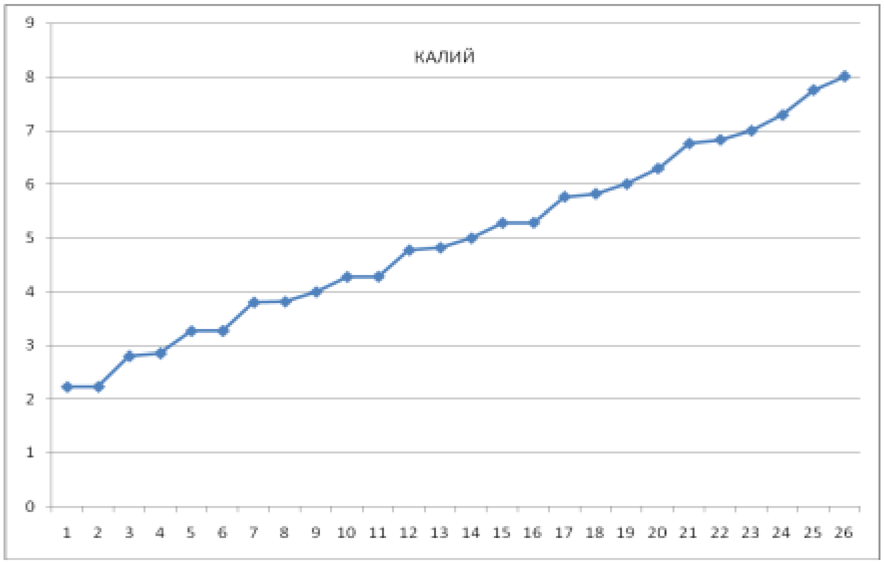

Fig. 12. Spectrum *n* of excited states of potassium atom.

Excited states of potassium atom. Table 8

n (diagram)	*W, эВ* (diagram)	*W, эВ* abs.	*n* calc.	n^2 calc.	R/R_B	$n \approx N_1/N_2$
4	1,61	2,731	2,236837	5,003438	4,979861	9/4,03
4	1,617	2,724	2,239709	5,016296	4,992658	9/4,02
5	2,607	1,734	2,807182	7,880271	7,843137	14/4,99
3	2,67	1,671	2,859611	8,177372	8,138839	20/6,99
5	3,063	1,278	3,269864	10,69201	10,64163	23/7,03
5	3,065	1,276	3,272426	10,70877	10,65831	23/7,03
4	3,397	0,944	3,804601	14,47499	14,40678	19/4,99
6	3,403	0,938	3,81675	14,56758	14,49893	19/4,99
4	3,487	0,854	4,000057	16,00046	15,92506	4
6	3,595	0,746	4,279822	18,31688	18,23056	30/7,01
6	3,597	0,744	4,28557	18,36611	18,27957	30/7,00
5	3,743	0,598	4,780183	22,85015	22,74247	19/3,97
7	3,754	0,587	4,824764	23,27835	23,16865	24/4,97
5	3,795	0,546	5,002635	25,02635	24,90842	5

7	3,852	0,489	5,286165	27,94354	27,81186	37/7,00
7	3,853	0,488	5,291578	28,0008	27,86885	16/3,02
6	3,93	0,411	5,765994	33,24669	33,09002	23/3,99
8	3,938	0,403	5,822944	33,90667	33,7469	29/4,98
6	3,962	0,379	6,004481	36,0538	35,88391	6
8	3,996	0,345	6,293403	39,60693	39,42029	44/6,99
7	4,042	0,299	6,7602	45,7003	45,48495	27/3,99
9	4,048	0,293	6,829066	46,63614	46,41638	34/4,98
7	4,062	0,279	6,998307	48,97631	48,74552	7
9	4,084	0,257	7,291696	53,16883	52,91829	51/6,99
8	4,114	0,227	7,758579	60,19555	59,91189	31/3,99
8	4,128	0,213	8,009498	64,15206	63,84977	8/1

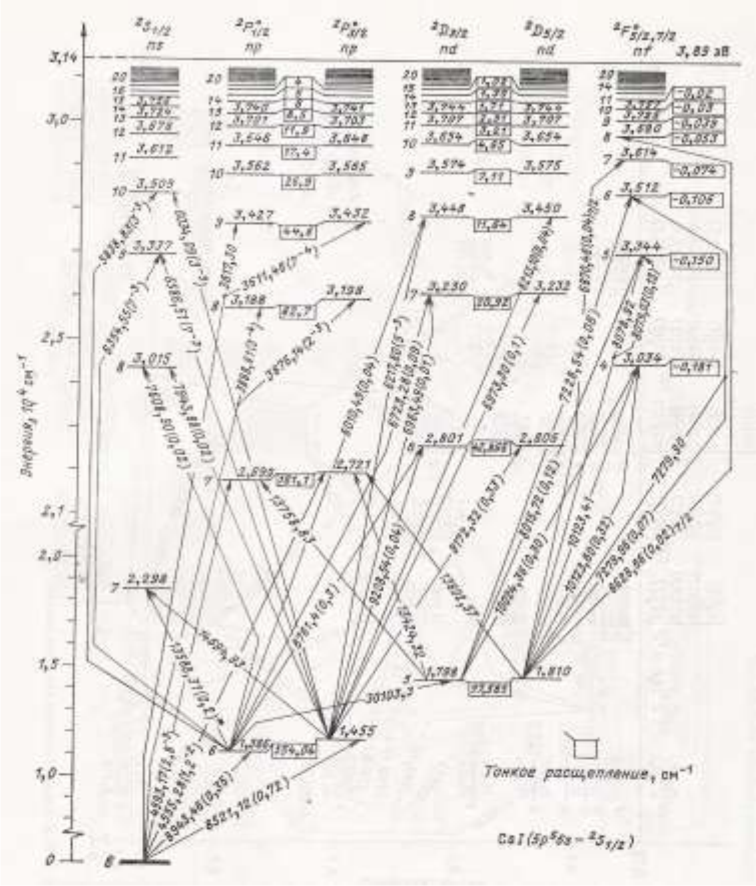

Fig. 13. Grotrian diagram of cesium atom [2].

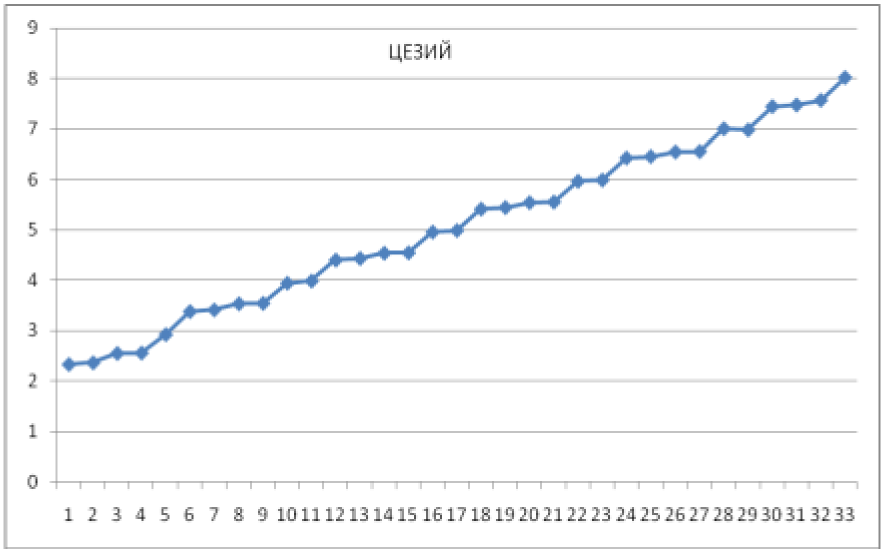

Fig. 14. Spectrum *n* of excited states of cesium atom.

Excited states of cesium atom. Table 9

n (diagram)	*W, эВ (diagram)*	*W, эВ abs.*	*n calc.*	n^2 *calc.*	R/R_B	$n \approx N_1/N_2$
6	1,386	2,507	2,334629	5,450494	5,424811	7/3,00
6	1,455	2,438	2,367436	5,604754	5,578343	19/8,02
5	1,798	2,095	2,553895	6,522381	6,491647	23/9,01
5	1,81	2,083	2,561241	6,559956	6,529045	18/7,03
7	2,298	1,595	2,926946	8,567015	8,526646	3
7	2,699	1,194	3,38293	11,44421	11,39028	27/7,98
7	2,721	1,172	3,414533	11,65904	11,6041	24/7,03
6	2,801	1,092	3,537397	12,51318	12,45421	39/11,02
6	2,806	1,087	3,545523	12,57074	12,5115	32/9,03
8	3,015	0,878	3,945008	15,56309	15,48975	4
4	3,034	0,859	3,988398	15,90732	15,83236	4
8	3,188	0,705	4,402512	19,38211	19,29078	22/5,00
8	3,198	0,695	4,434072	19,66099	19,56835	31/6,99
7	3,23	0,663	4,539817	20,60994	20,51282	50/11,01
7	3,232	0,661	4,54668	20,6723	20,57489	41/9,02
9	3,337	0,556	4,957443	24,57624	24,46043	5
5	3,344	0,549	4,988948	24,8896	24,77231	5
9	3,427	0,466	5,415046	29,32272	29,18455	27/4,99
9	3,432	0,461	5,444333	29,64076	29,50108	38/6,98

8	3,448	0,445	5,541344	30,70649	30,5618	61/11,01
8	3,45	0,443	5,553839	30,84512	30,69977	50/9,00
10	3,509	0,384	5,965262	35,58435	35,41667	6
6	3,512	0,381	5,988701	35,86454	35,69554	6
10	3,562	0,331	6,425118	41,28214	41,08761	32/4,98
10	3,565	0,328	6,454434	41,65972	41,46341	45/6,99
9	3,574	0,319	6,544851	42,83508	42,63323	72/11,00
9	3,575	0,318	6,555134	42,96978	42,7673	59/9,00
7	3,614	0,279	6,998307	48,97631	48,74552	7
11	3,612	0,281	6,973358	48,62772	48,39858	7
11	3,646	0,247	7,437837	55,32141	55,06073	52/6,99
11	3,648	0,245	7,468133	55,77302	55,5102	15/2,01
10	3,654	0,239	7,561295	57,17318	56,90377	68/8,99
8	3,68	0,213	8,009498	64,15206	63,84977	8

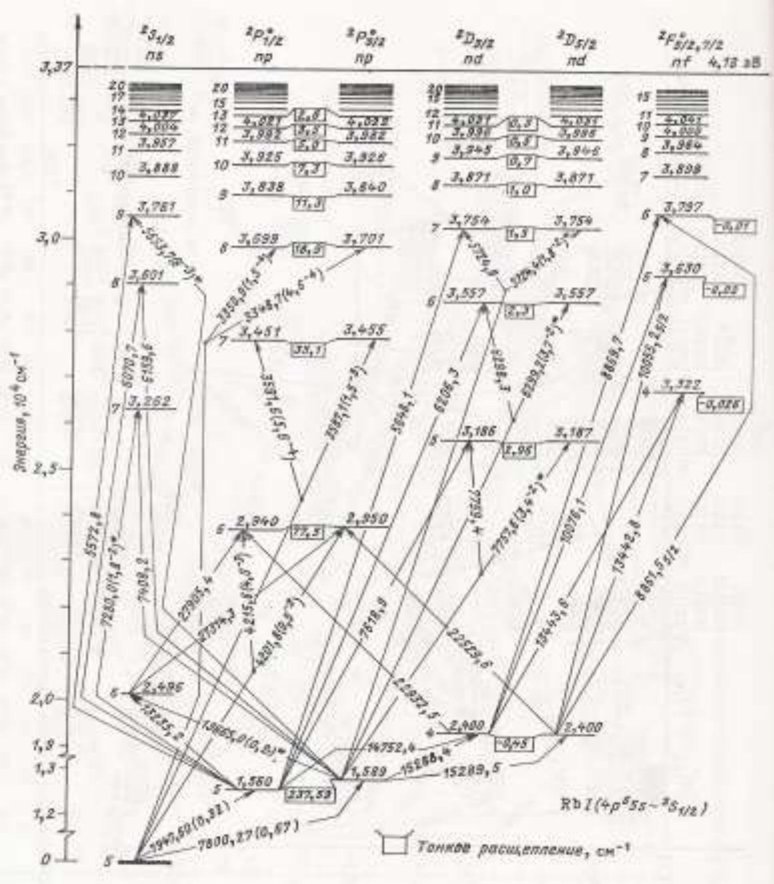

Fig. 15. Grotrian diagram of rubidium atom [2].

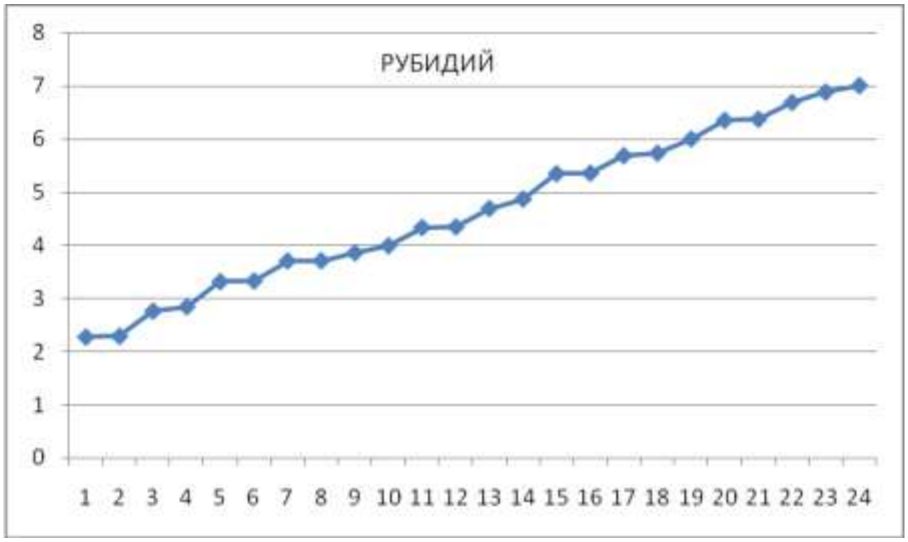

Fig. 16. Spectrum *n* of excited states of rubidium atom.

Excited states of rubidium atom. Table 10

n *(diagram)*	*W, эВ (diagram)*	*W, эВ abs.*	*n calc.*	n^2 *calc.*	R/R_B	$n≈N_1/N_2$
5	1,56	2,617	2,285037	5,221394	5,19679	16/7,00
5	1,589	2,588	2,297804	5,279903	5,255023	23/10,01
4	2,4	1,777	2,77301	7,689583	7,653348	36/12,98
6	2,496	1,681	2,851092	8,128726	8,090422	20/7,01
6	2,94	1,237	3,323612	11,04639	10,99434	10/3,01
6	2,95	1,227	3,337128	11,13642	11,08394	10/3
5	3,186	0,991	3,713285	13,78849	13,72351	26/7,00
5	3,187	0,99	3,71516	13,80241	13,73737	26/7,00
7	3,262	0,915	3,864422	14,93376	14,86339	27/6,99
4	3,322	0,855	3,997717	15,98174	15,90643	4
7	3,451	0,726	4,338372	18,82147	18,73278	13/3,00
7	3,455	0,722	4,350373	18,92575	18,83657	13//3,00
6	3,557	0,62	4,694607	22,03934	21,93548	14/2,98
8	3,601	0,576	4,870616	23,7229	23,61111	39/8,01
8	3,699	0,478	5,346643	28,58659	28,45188	16/2,99

8	3,701	0,476	5,357863	28,7067	28,57143	16/2,99
7	3,754	0,423	5,683619	32,30352	32,1513	17/2,99
9	3,761	0,416	5,731238	32,84709	32,69231	40/6,98
6	3,797	0,38	5,996576	35,95892	35,78947	6
9	3,838	0,339	6,348853	40,30793	40,11799	19/2,99
9	3,84	0,337	6,367664	40,54715	40,35608	51/8,01
8	3,871	0,306	6,68243	44,65487	44,44444	20/2,99
10	3,888	0,289	6,876163	47,28162	47,05882	55/7,00
7	3,898	0,279	6,998307	48,97631	48,74552	7

Analysis of the given tables and graphs shows that individual «sets» (spectrums) of main quantum numbers of excited states is unique for each atom. In intervals between integers there are sequences of common fractions differing by unit. That is, the excitation of electron shells really occurs on multiple harmonic components.

What is the cause of these sequences of common fractions?

Generally fractional numbers *n* appear due to soliton nature of electron and other elementary particles that «automatically» means nonlinearity of their properties and presence of great variety of harmonic components in ambient space [3].

It is notable that excited states of some atoms (Na, K, Cs), as well as of lithium atom, «correlate» with basic unexcited states of atomic outer shell (table 1). It once again testifies to the presence of oscillation frequencies of atom skeleton interacting with outer electron on excited and basic energy levels.

Common feature of all given results of calculations consists in great spectrum width of main quantum numbers of atomic excited states. Meanwhile, the same lower limit of main quantum numbers (about 2) of excited states of all atoms is the effect of small sizes of atomic skeletons (less or about Bohr radius).

It should be noted that in spite of Grotrian diagrams «popularity» among specialists studying atomic spectrums, usually they are not included in fundamental courses of lectures on quantum mechanics [5].

Probably, it is related with weaknesses of attempts to explain atomic spectrums.

It is known that the solution of equation of electron motion in a Coulomb field of atomic nucleus gives discrete spectrum of energy levels determined only by main quantum number. Other quantum numbers determine only degeneracy of each energy level. Such levels are splitting (degeneration is removed) only by outer actions (for example, in magnetic field). However, such split of energy levels, as a rule, is rather small [4].

Therefore, in consideration of great distance from atom skeleton up to outer electron on an excited level and small sizes of atom skeleton, it is difficult to explain so great spectrum differences of various atoms. That is, high-level excited states of hydrogen-like atoms should repeat appropriate excited levels of hydrogen atom, but they «obstinately» follow the periodic series of fractional main quantum numbers. Such «persistence» is impossible to explain in other way then by intense action of proper «set» of frequencies generated by each atom skeleton that determines atom spectrum.

As a result, it is quite explicable that there is some «concern» in point of Grotrian diagrams theoretical justification.

Whether it is necessary in this connection to abandon Grotrian diagrams?

Naturally no, as the practice has proven that their application is convenient. But the excited levels notation system is necessary to change so that it would follow a physical reality, namely it is indispensable to use fractional values of main quantum number for denotation of excited levels.

In any case the revision of Grotrian diagrams is vital, as many values of main quantum numbers put on the diagrams are beyond of any logical explanation. It is enough to see, for example, characteristics of rubidium atom (fig. 15, table 10).

Summary

The main finding of the experimental data analysis relative to atom spectrums consists in the following: the excited states of atoms are determined by resonant interactions of outer electrons with atom skeleton fundamental frequencies.

Resonant intra-atomic interactions create harmonic unity of atom spectrum. The abundance of various harmonic components of oscillations actually present at a microcosm level becomes apparent in diversity and complexity of atom spectrums.

The analysis of atom spectrums once again has shown that the wave-corpuscle properties of electron, figuratively speaking, are not «absolute», but embody a result of electron interaction with other particles. Therefore atomic electrons behavior depends on oscillations «background», created by atom skeleton. The quantum mechanics has simplified the question about wave properties origin that significantly lowered the theory potential. Therefore the existing theory of atom structure actually cannot adequately explain atom spectrum.

In the issue of experimental data examination given in previous articles [1, 3] were discovered regularities of atomic electron shells formation. Many-electron shells of atoms have appeared to be very compact resonant spherical formations (Bose condensates). The electron shell proximate to the atomic nucleus has properties of superconducting electron pair being the «base» of all subsequent shells formation.

In this article at some stage of atom spectrums analysis the new regularities in organization of atomic resonant interconnections were discovered. The experimental character of discovered atom spectrum regularities allows formulating them as the laws of nature, which are logical development and addition to the three earlier discovered laws of atomic electron shells formation [1].

The laws of atom spectrum formation:

1. The atom spectrum is determined by resonant interactions of excited electron states with oscillations generated by atom skeleton, therefore the harmonic unity and clearly marked uniqueness of each atom spectrum is formed.

2. Fractional values of a main quantum number give evidence of excitation of outer electron energy states on multiple harmonics and make, as a rule, sequences of common fractions differing by unit, which determine (alongside with integer values) a harmonic basis of atom spectrum.

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Supplementary information:

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