HYDROGEN and HEAVY HYDROGEN

Glance at any textbook about a structure of substance, and you will read, that hydrogen is the simplest element in the nature. However, with hydrogen it is connected so many puzzles, that at times arises a doubt in a rigidity of this statement.
Take, for example, water which molecule consists of two atoms of hydrogen and one atom of oxygen. Physical and chemical properties of this, as it affirmed, simplest substance not one of existing theories cannot describe unambiguously.
We have decided to make one more attempt to solve structure of water with the help of our polytronic theory. We shall begin the decision of this task with research of crystal structure of two isotopes of hydrogen and some other elements.
The nature has presented for people six remarkable metals, which have constant type of a crystal lattice in all a range of temperatures of a solid phase, and besides, these elements have only one natural stable isotope – aluminium, gold, niobium, rhodium, thulium and caesium.
The combination of these two features allows us to estimate accuracy of modern experiment and probable mistakes at calculations and at theoretical interpretation of results.
In table 1 some properties of the set forth above metals are resulted.

Table 1

Properties of Elements at solid phase	The Elements					
	Al	Au	Nb	Rh	Tm	Cs
Atomic mass, u	**26.981540**	**196.966543**	**92.906377**	**102.905500**	**168.934212**	**132.905429**
Density, kg/m^3	2698	19320	8570	12410	9321	1873
Type of a crystal cell and parameters:	face-centered cubic	face-centered cubic	body-centered cubic	face-centered cubic	close-packed hexagonal	body-centered cubic
a, pm	404.959	407.833	329.86	380.36	353.75	614
c, pm	-	-	-	-	555.46	-
Number of atoms in a cell	4	4	2	4	6	2
Volume for one atom in a cell, Å^3	16.602	16.958	17.946	13.757	30.098	115.738
Volume for one atom under formula (1), Å^3	16.606	16.929	18.002	13.769	30.096	117.829

The volume of the crystal, falling for one atom, is calculated under the formula:

$$V_{at} = (M_{at} \times u)/d \quad |m^3| \qquad (1)$$

where M_{at} – relative mass of atom
d – density of an element
$u = 1.66053873 \cdot 10^{-27}$ kg – atomic mass unit.

The data adjusted in table 1 speak, that concerning simple refractory crystals, experiment and theory are in the good consent.

Further we shall pass to the analysis of similar physical and chemical properties of hydrogen and heavy hydrogen. In a solid phase hydrogen and heavy hydrogen consists of two-atomic molecules.
In table 2 these properties are resulted.

Table 2

Properties of isotopes		Hydrogen H_2	Heavy hydrogen D_2
Molecular mass, u		2×1.007825	2×2.01416219
Density, kg/m^3		86.67	~200
Volume for one molecule under formula (1), Å^3		38.618	~33.5
Type of a crystal cell and parameters			
Close-packed hexagonal:	a, pm	377.6	360.0
	c, pm	616.2	585.8
Number of molecules in a cell		6	6
Volume for one molecule in a cell, Å^3		38.043	32.873
Cubic:	a, pm	533.8	509.2
Number of molecules in a cell		4	4
Volume for one molecule in a cell, Å^3		38.026	33.007
Tetragonal body-centered:	a, pm	450	338
	c, pm	368	560
Number of molecules in a cell		2	2
Volume for one molecule in a cell, Å^3		37.26	31.998

The volume, falling for one molecule of water at melting-point and atmospheric pressure, is equal 29.915Å^3. The volume, falling for one molecule of ice under the same conditions, is equal 32.623Å^3. Thus, the molecule of water having same two atoms of hydrogen, occupies smaller volume, than a molecule of hydrogen. This fact speaks that crystal of hydrogen has regular porous structure.
In solid oxygen, which also consists of two-atomic molecules, on a share of each atom it is necessary 13.28Å^3 from volume of a crystal. Carrying out the elementary subtraction, we shall find, that in water on a share of each molecule of hydrogen remains about 16.5 Å^3 of free space. Hence, in any of three crystal cells of hydrogen, a molecule occupies less than half of space of a cell.
In our previous works it has been shown, that the molecule of hydrogen consists of eight polytrones (4 axial + 4 radial), which are connected with each other in such a manner that they make the form of the truncated octahedron. Eight sides of octahedron represent hexagons. Diameter of the circle entered into each hexagon, is equal to static diameter of hydrogen polytron D_s = 197.714 pm. Other six sides of a figure represent squares 114.15x114.15 pm.
In fig.1 the form of molecule of hydrogen H_2 in concepts of the polytronic theory is shown. The volume of the truncated octahedron is equal 16.828Å^3. In the ideal crystal the molecules of hydrogen are connected with each other by the square sides of the truncated octahedron, as shown in fig.2. Thus, in the ideal crystal of hydrogen the molecules occupy equally half of full volume of the crystal. Density of ideal crystal is equal 99.449 kg/m^3.

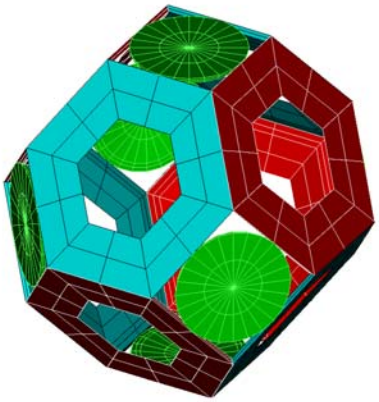


Fig.1
The **form of molecule of hydrogen in concepts of the polytronic theory**

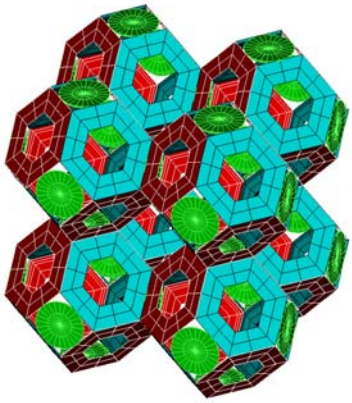


Fig.2
Connection of molecules of hydrogen in ideal crystal

In fig. 3 various projections of the ideal crystal of hydrogen, which explain principles of allocation of various types of crystal cells, are shown.

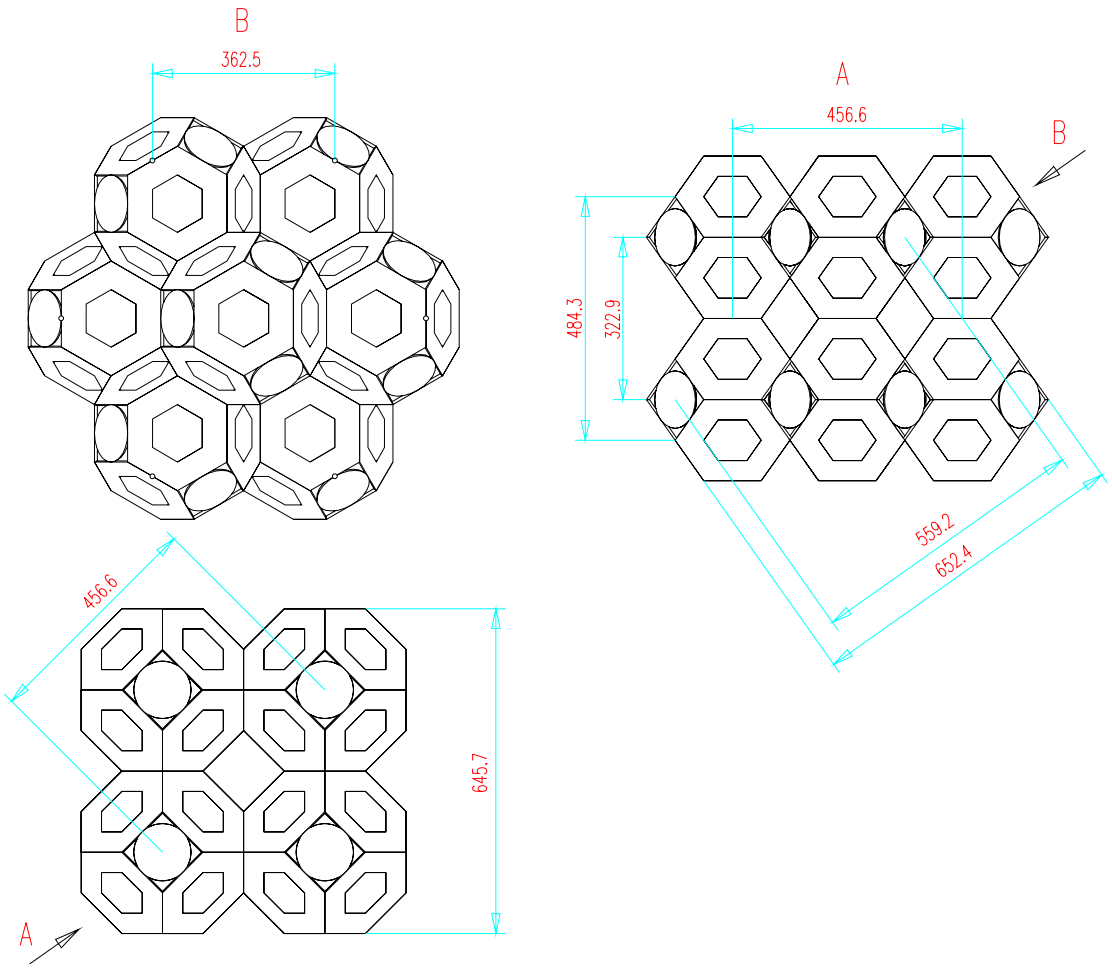


Fig.3
Parameters of various crystal cells in the ideal crystal of hydrogen

The size a=456.6pm concerns to face-centered cubic cell. On four of six sides of a cube the geometrical centers of molecules are located. In experiment the parameters of this cell are measured at temperature 11-13K (close to temperature of melting of hydrogen) and in conditions of imperfect structure of a crystal. Therefore, experimental value (a=533.8pm) considerably differs from theoretical (~17%).
The sizes a=362.5pm and c=652.4pm concern to hexagonal cell. Parameters of this cell are measured in experiment at temperature of transition of a cubic lattice into hexagonal (~4.5K). Experimental values differ from theoretical only by 5%.
The sizes 456.6pm and 322.9pm concern to tetragonal body-centered cell. These parameters are measured in experiment at temperature below 4K. In handbooks, rather approximate values, without the indication of temperature in experiment, are sited; therefore in some handbooks this cell is not mentioned. Generally, tetragonal body-centered cell is a fragment of a cubic cell.
At downturn of temperature of a crystal the amount of active points in polytrones increases, though intensity of these points decreases according to the binary law of radiation. Therefore, at lower temperatures the molecular crystal of hydrogen should show richer crystallographic variety.
In the article "New model of dissociation" we have shown the calculation of energy of dissociation of hydrogen molecule with the help of the polytronic equations. At absorption of energy, which is sufficient for translation of all polytrones of a molecule from frequency orders m=12 and higher into the frequency order m=6, the molecules of hydrogen become unstable and at the further absorption of energy the molecular hydrogen starts to dissociate into atoms. The process of dissociation becomes appreciable at temperature 2000ºC and higher. Hence, at temperature 1800–2000ºC, hydrogen should consist of molecular forms, as shown in fig. 4 (~99%), and from molecular forms, as shown in fig. 5 (~1%). Percentage of molecules in that and other condition can be determined by intensity of spectral lines. At dissociation of molecular hydrogen there should be an intensive line of absorption λ=1094109pm.

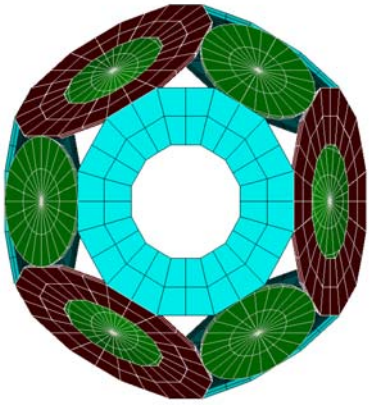


Fig.4
Hexagonal projection of a molecule of hydrogen at the frequency order m=12

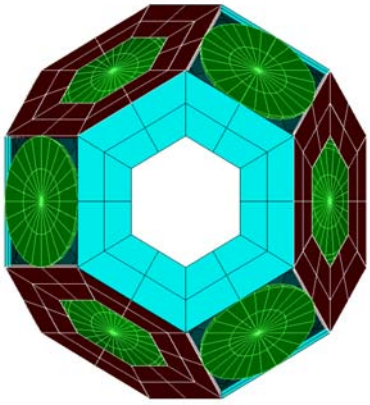


Fig.5
Hexagonal projection of a molecule of hydrogen before disintegration into atoms (m=6)

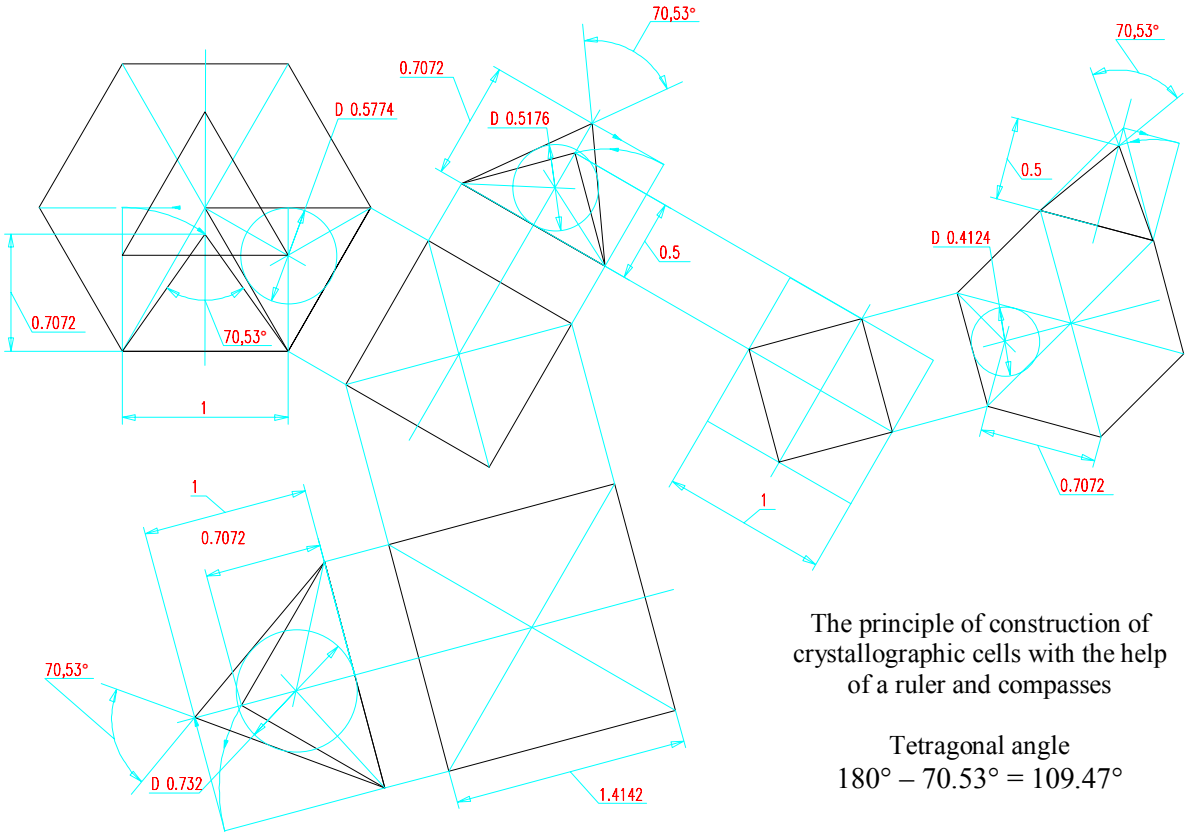
In the base development of the polytronic theory on the basis of experimental data it has been shown, that axial polytrones can be in two energy states – normal and anomalous. Relative amplitude of an anomalous axial polytron approximately twice more than relative amplitude of a normal axial polytrone. At the same time, the frequency of oscillations of anomalous axial polytron at mechanical resonance was by 5-7% lower than the frequency of normal polytron. Hence, internal energy of atoms, in structure of which there are anomalous axial polytrones should be much more, than internal energy of normal atoms.
With the purpose of detailed research of this feature of axial polytrones we shall carry out the comparison of spectral characteristics of hydrogen and heavy hydrogen. In the table 3, the observable lengths of waves λ_H and λ_D are resulted, and relative intensities j_H and j_D for the first series of the ionized hydrogen H^+ and for the ionized heavy hydrogen D^+.

The data are taken from Kelly Atomic Line Database.

Table 3

The Element (ion)	$m_o \rightarrow m$	λ_H, pm (in vacuum)	j_H	λ_D, pm (in vacuum)	j_D
H^+ and D^+ First series	$2 \rightarrow 4$	121566.8	670	121534.3	670
	$2 \rightarrow 6$	102572.2	300	102544.3	300
	$2 \rightarrow 8$	97253.7	130	97227.2	140
	$2 \rightarrow 10$	94974.3	70	94948.5	70
	$2 \rightarrow 12$	93780.3	40	93754.8	40
	$2 \rightarrow 14$	93074.8	30	93049.5	-
	$2 \rightarrow 16$	92622.6	20	925.974	-
	$2 \rightarrow 18$	92315.0	10	92289.9	-
	$2 \rightarrow 20$	92096.3	9	92071.2	-
	$2 \rightarrow 22$	91935.1	7	-	-
	$2 \rightarrow 24$	91812.9	5	-	-
	$2 \rightarrow 26$	91718.1	4	-	-
	$2 \rightarrow 28$	91642.9	3	-	-
	$2 \rightarrow 30$	91582.4	3	-	-
	$2 \rightarrow 32$	91532.9	2	-	-

Experimental data in table 3 speak, that the amount of energy in atoms of hydrogen and heavy hydrogen insignificantly influences on the spectrum of radiation-absorption of various isotopes of hydrogen. Hence, radial polytrones in that and in other isotopes are the same. The difference of energies of radiation in hydrogen and heavy hydrogen does not exceed 0.0037eV, and, probably, is caused by distinction of temperatures in that and in other experiment.
Dissociation energy of molecule of hydrogen is equal 4.478 eV/molecule, dissociation energy of molecule of heavy hydrogen 4.557 eV/molecule. Distinction in energies less than 2%.
The geometrical form of molecule of heavy hydrogen is similar to the geometrical form of molecule of hydrogen. Experimentally observable sizes of crystal cells of hydrogen and heavy hydrogen differ from each other approximately by 5%. This small distinction can be caused by many reasons, and so we cannot assert, that hydrogen and heavy hydrogen polytrones have various diameters.
Taking into account the fact, that amplitude of anomalous axial polytron in isotopes of hydrogen twice more than normal amplitude, hence, the maximal internal energy of anomalous isotope of hydrogen can be four times more than internal energy of normal atom of hydrogen.
Hence, hydrogen should have an isotope with relative mass equal 4.
The reduced data confirm one of substantive provisions of the polytronic theory, that axial polytrones are accumulators of energy, and they can influence on observed energetic characteristics of atoms only indirectly – by pumping energy into radial polytrones.
The basic part of energy of axial polytrones can be in a kind inaccessible for observation.
Apparently from fig. 3, concept of a crystal cell is rather conditional. Parameters of a crystal lattice of that or other element can specify the well-ordered arrangement of identical active points in atoms of the given element. But these parameters cannot characterize the geometrical form of separate atom.
Since, as a result of nuclear reactions one element can turn into others it is necessary to assume, that there is quite concrete law of transformation of one geometrical form into others geometrical forms. In fig.6 the sequence of transformation tetragonal, hexagonal and cubic cells without application of trigonometrical functions and the algebraic equations is shown. All these transformations are executed with the help of a ruler and compasses.



The principle of construction of crystallographic cells with the help of a ruler and compasses

Tetragonal angle
180° – 70.53° = 109.47°

Fig.6
Various crystal cells are constructed by the principle "one from another"

As a result of consecutive geometrical constructions the number of the sizes, including a number of polytronic diameters, which correspond to the certain chemical elements can be received. Parameters of one element, for example of hydrogen, can be set as base. For finding of parameters of other elements two numbers are used only: $2^{1/2}$=1.41421… (a diagonal of a square) and $3^{1/2}$=1.73205…. (a diagonal of a cube).
Apparently, ancient Egyptians used this mathematics at construction of the pyramids.