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The Shell-Nodal Structure of the Atoms

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http://shpenkov.com/pdf/talk2017Berlin.pdf

Common point of view

on the structure of atoms was fully formed,

following the Standard Model,

in the framework of the theories of atomic and nuclear physics,
and quantum mechanics (QM)

It is based on two main concepts:

1) Atoms have tiny superdense nuclei in their centers.

This concept originates from the Rutherford hypothesis. Practically the whole mass of the atom (the mass of protons and neutrons, except of electrons) is concentrated in this diminutive (radius $\sim 10^{-13}$ cm) nucleus.

Dimensions of the atom (radius $\sim 10^{-8}$ cm) and its nucleus differ about a hundred thousand times ($\sim 10^{5}$). Consequently, the density of the "nucleus" is fantastically enormous, of the order of 10^{14} g/cm^3, and the atom, in fact, is an empty space.

2) Electrons in atoms are localized and move within the so-called atomic orbitals.

This concept arose when three-dimensional images of certain polar functions (the polar component of the solutions of the general wave equation) and spatial figures, formed at the rotation of their sections, and combinations thereof, became consider (arbitrary, unfoundedly by the creators of QM) as the regions (called atomic orbitals) of the location and motion of electrons in an atom.

The modern concept of an atom

is not perceived by common sense

The size of the hydrogen atom is defined by the first Bohr orbit whose radius is equal to $r_0 = 0.52917721067 \times 10^{-8} cm$. The radius of its nucleus, proton, (as believe) is equal to $r_p = 0.8751 \times 10^{-13}\ cm$, i. e., ~100,000 times less than r_0.

Imagine the physical image of such an atom, believing that it has a spherical shape. To do this, let's increase its radius (~10^{-8} cm) by 10^{10} times. We will obtain a sphere with a diameter of 2 m, which can fit in a small room, occupying an area of 3.14 m^2.

Even with such a huge increase, we will not be able to see in the center of the atom (sphere, occupying completely the room) the nucleus whose size on this scale will be only ~10 microns. Thus, we see that really the atom (according to modern ideas) is, in fact, an empty space.

On the other hand, from the Dynamic Model (developed by us [1]) it follows that $r_p = 0.528421703 \times 10^{-8} cm$, i.e., proton and hydrogen atom are practically equal in size. It is consistent with common sense and corresponds to reality: the hydrogen atom H and its ion H^+ (proton) are indistinguishable visually and practically look identical.

The wavelength of x-rays has the same order of magnitude (~10^{-8} cm), which allowed using them in the structural analysis of substances…

(Details in http://shpenkov.com/pdf/talkBrussels2017.pdf)

From our point of view

all arguments allegedly confirming the reality of an existence of atomic nuclei and atomic orbitals, as physical formations, are unconvincing.

Therefore, the adequacy of the common view on the structure of atoms

always caused our reasonable doubts

These doubts really turned out to be fair.

To date we have more than enough arguments revealing the fallibility of basic concepts, underlying the Standard Model, which led to the creation of inadequate theories that currently dominate physics.

We have in mind, in particular, QM (and, hence, quantum chemistry).

The validity of the above conclusion
(to which we came in the course of a comprehensive analysis)
fully confirmed.

To be sure in this, see, for example,
the following compelling documents:

L. Kreidik and G. Shpenkov, **"*Important Results of Analyzing Foundations of Quantum Mechanics*"**, Galilean Electrodynamics & QED-East, Special Issues 2, 13, 23-30, (2002); http://shpenkov.com/pdf/QM-Analysis.pdf

G. Shpenkov and L. Kreidik, **"*Schrodinger's Errors of Principle*"**, Galilean Electrodynamics, 3, 16, 51-56, (2005); http://shpenkov.com/pdf/Blunders.pdf

G. P. Shpenkov, **"*Conceptual Unfoundedness of Hybridization and the Nature of the Spherical Harmonics"***, Hadronic Journal, Vol. 29. No. 4, p. 455, (2006); http://shpenkov.com/pdf/hybridizationshpenkov.pdf

G. P. Shpenkov, **"*Some Words about Fundamental Problems of Physics: Constructive Analysis"***, LAMBERT Academic Publishing, pages116 (2012); http://shpenkov.com/978-3-659-23750-8_eng.JPG ; http://shpenkov.com/pdf/Book-2011-Eng.pdf
Part 1. ***Electron "orbitals"***, pages 4-7; http://shpenkov.com/pdf/electronorbitals-Eng.pdf

The actual situation in theoretical physics is so hopeless that there is an exceptional need in alternative theories that could take it out of stagnation. The present book offers the first real alternative to the bankrupt Standard Model. Basing on his long experience, the author has come to the conclusion that the current theoretical physics paradigm is erroneous and, therefore, must be changed. He has developed the Wave Model, physical, as an alternative to the abstract-mathematical Standard Model. The book differs by novel ideas. Along with the fair criticism, for all issues addressed in the book, clear solutions are presented. They were obtained on the basis of a new physics paradigm adequate to reality. In the literature on physics there is not a constructive analysis of fundamental problems of physics presented with such a manner as it is done in this book. Distinguishing features of the book are the breadth of issues covered by the analysis, its complexity and comprehensiveness, brevity and the use of simple and straightforward language. For this reason, the book will useful for all physicists, theorists and experimentalists, specialized in different branches of physics.

George Shpenkov

Comprehensive analysis of basic concepts of modern theoretical physics is presented in this book written in a concise and clear form. It is shown that the abstract-mathematical method dominated in theories of the Standard Model is erroneous and, therefore, dead-ended. The author proposes the real way to out of this situation.

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Dialectical physics paradigm

George Shpenkov

Some words about fundamental problems of physics

Constructive analysis

LAP LAMBERT Academic Publishing

Shpenkov

Thus, we have every reason to assert that all theories, including QM, which adhere to the SM, are inadequate to reality

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This is why modern physics

can not cope with the main key problems:

what is the charge,
what is the nature of the origin of the mass,
what is the nature of gravity, what is
the nature of origin and the structure of all atomic isotopes,
what is the physical meaning of the speed "c" in Eq. $E_0 = m_0 c^2$
what is the nature of the fine structure constant, "α", …;

is unable

to derive

neutron magnetic moment,
proton magnetic moment, …;

to build

a unified field theory, …;

erroneously interprets:

polar-azimuthal functions in the Schrödinger equation,
the nature of cosmic microwave background radiation,
a phenomenon called the Lamb shift, …; etc.

As an alternative to the Standard Model (SM)
we were developing (for many years of research) a new

General physics theory,

which would be more adequate to reality and for this reason
could solve the problems unsolvable in principle within the SM.

As a result, we created such a theory and called it the

Wave Model

(WM)

The WM includes two theories (models):
Dynamic Model of elementary particles
and
Shell-Nodal atomic model

All of the listed above problems were resolved within the framework of the WM !

New concepts, on which the WM is based,
vary greatly from the relevant concepts underlying the SM:

The Wave Model*

is based on

1. ***Dialectical philosophy and dialectical logic (dialectics)***

(in contrast to the formal logic accepted in modern physics)

and on

2. ***The axiom about the wave nature of all phenomena and objects in the Universe***

(It is the only axiom underlying the WM, and no postulates are used in the WM!)

Whilst an unlimited number of abstract-mathematical (fictional) postulates are the basis of the modern physics theories

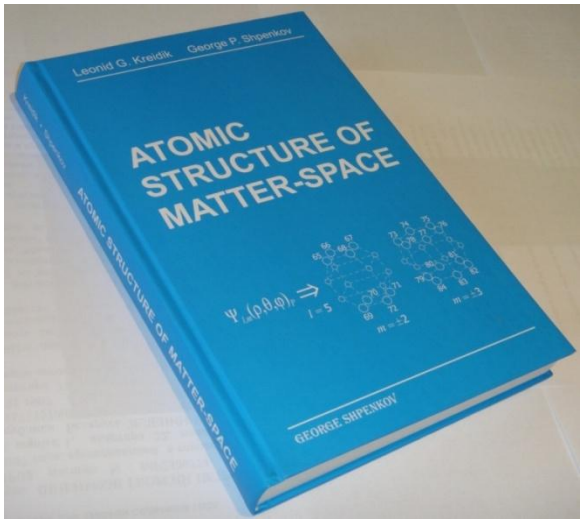
that is one of the main reasons of all problems faced them.

*[L. G. Kreidik and G. P. Shpenkov, Atomic Structure of Matter-Space, Geo. S., Bydgoszcz, 2001, 584 p.; http://shpenkov.com/atom.html]

The Wave Model

is described in detail in

the book



[L. G. Kreidik and G. P. Shpenkov, ***Atomic Structure of Matter-Space***, Geo. S., Bydgoszcz, 2001, 584 p.]
http://shpenkov.com/atom.html

and

the lectures:

[G. P. Shpenkov, ***Dialectical View of the World. The Wave Model*** (Selected Lectures); Volumes 1-6]

http://shpenkov.com/pdf/Vol.1.Dialectics.pdf
... /Vol.2.DynamicModel-1.pdf
... /Vol.3.DynamicModel-2.pdf
... /Vol.4.PhysicalUnits.pdf
... /Vol.5.Shell-NodalAtomicStructure.pdf
... /Vol.6.TopicalIssues.pdf

Discoveries of the WM, collected together,

can be found, in particular, in the "Conclusion" in the book:

[G. P. Shpenkov, "***Some Words about Fundamental Problems of Physics: Constructive Analysis***", LAMBERT Academic Publishing (2012), pages 70-78]
http://shpenkov.com/pdf/Conclusion-Eng.pdf

From the WM it follows that

1. **Atoms are elementary molecules of hydrogen atoms** !

(to which we refer the proton (p), neutron (n) and protium (${}_{1}^{1}H$))

2. **There are no superdense nuclei in their centers** !

As a consequence of these key discoveries,
we came to a whole series of other discoveries.
In particular, we revealed that a carbon two-dimensional hexagonal lattice of

Graphene is anisotropic !

and has two-fold rotational symmetry, but not six-fold as is commonly believed.

Basic steps

on the way to the above-mentioned discoveries

We took for granted

that the structure of atoms, having (in accordance with the basic axiom of the WM) the wave nature, should be described by well-developed methods of the physics of waves and, in particular, by the general ("classical") wave equation

$$\Delta\hat{\Psi} - \frac{1}{c^2}\frac{\partial^2\hat{\Psi}}{\partial t^2} = 0 \qquad (1)$$

This equation admits a particular solution of the form

$$\hat{\Psi}(\rho,\theta,\varphi;t) = \hat{\psi}(\rho,\theta,\varphi)e^{\pm i\omega t} \qquad (2)$$

which describes the standing waves in a spherical space.

The spatial component in (2)

$$\hat{\psi}(\rho,\theta,\varphi) = A\hat{R}_l(\rho)\Theta_{l,m}(\theta)\hat{\Phi}_m(\varphi) \qquad (3)$$

is a particular solution of the time-independent form of Eq. (1) (Helmholtz equation):

$$\Delta\hat{\psi} + k^2\hat{\psi} = 0 \qquad (4)$$

The solution (3) defines

the shell-nodal structure of standing waves in a spherical space.

We revealed that it is identical to the

Shell-Nodal structure of "atoms" !

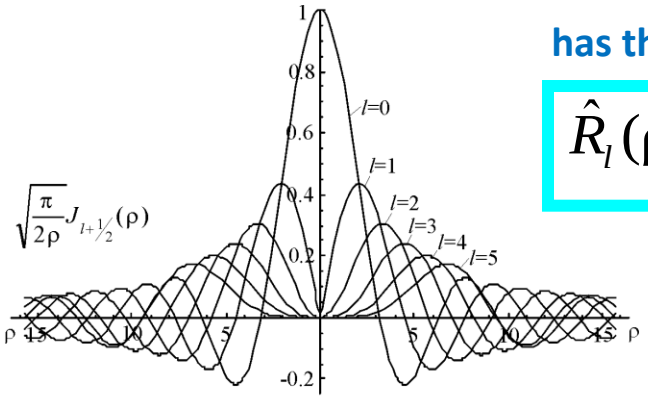
(we mean the "atoms" that contain two or more nucleons, Z ≥ 2); i. e.,

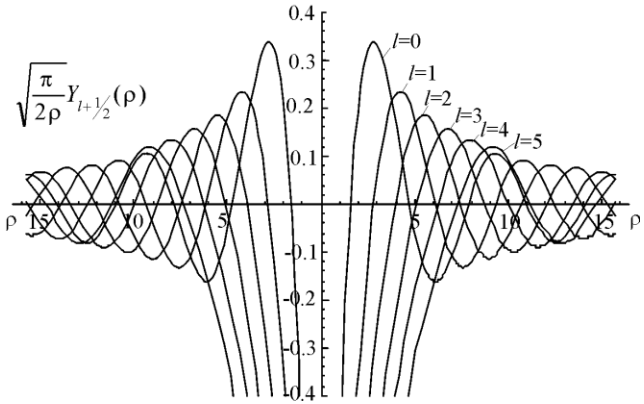
Eq. (3) defines the structure of

Elementary Molecules of hydrogen atoms!

The wave vector $k = \omega_e / c$ is the constant, $\omega_e = 1.869162559 \times 10^{18}\ s^{-1}$ is the fundamental frequency of the atomic and subatomic levels; $\rho = kr$

Radial component $\hat{R}_l(\rho)$ of the solution $\hat{\psi} = A\hat{R}_l(\rho)\Theta_{l,m}(\theta)\hat{\Phi}_m(\varphi)$





has the form:

$$\hat{R}_l(\rho) = A\sqrt{\pi/2\rho}\left(J_{l+1/2}(\rho) \pm iY_{l+1/2}(\rho)\right) \qquad (5)$$

A **is a constant factor;**

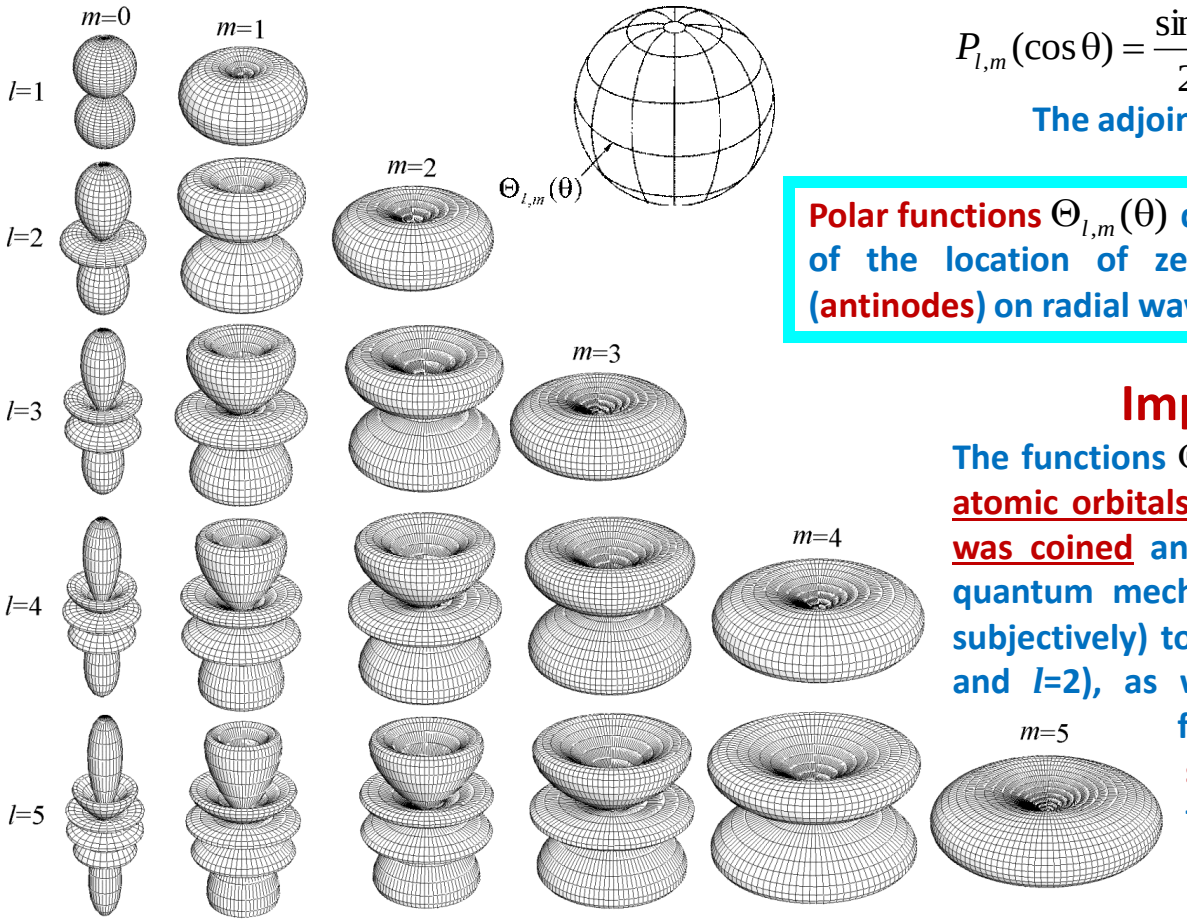
$l = 0,1,2,\ldots; \qquad m = 0,\pm 1,\pm 2,\ldots,\pm l$

Solutions of $\hat{R}_l(\rho)$ **are roots** $z_{\nu,q}$ **(zeros and extremal values) of Bessel functions *J* and *Y*, where** $\nu = l + 1/2$ **is the order of the functions , *q* is number of the zero or extremum.**

$\hat{R}_l(\rho)$ **defines the radii *r* of characteristic wave shells, potential and kinetic, on which are nodes and antinodes, respectively :** $\rho_{\nu,q} = z_{\nu,q} = kr_{\nu,q}$, $k = \omega_e / c$

Graphs of the polar functions

$$\left|\Theta_{l,m}(\theta)\right| = C_{l,m} \cdot P_{l,m}(\cos\theta) \qquad (6)$$



$$P_{l,m}(\cos\theta) = \frac{\sin^{m}\theta}{2^{l}\,l!}\,\frac{d^{\,l+m}}{d(\cos\theta)^{\,l+m}}\left(\cos^{2}\theta - 1\right)^{l}$$

The adjoined Legendre functions

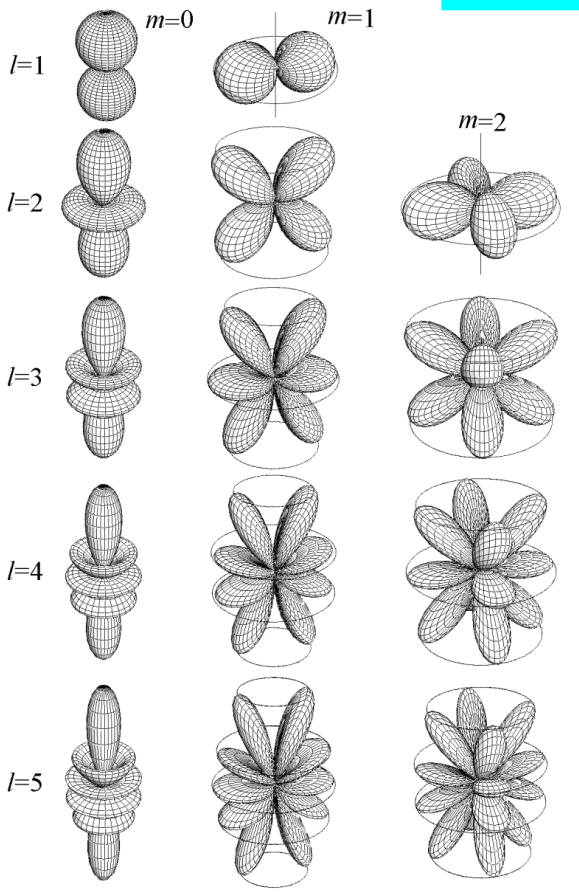
Polar functions $\Theta_{l,m}(\theta)$ define characteristic parallels of the location of zeros (nodes) and extremes (antinodes) on radial wave spherical shells.

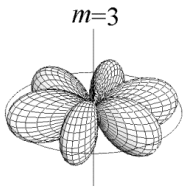
Important notice!

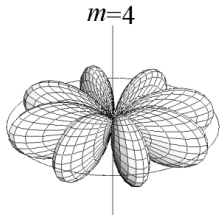
The functions $\Theta_{l,m}(\theta)$ have nothing to do with atomic orbitals. The notion of atomic orbitals was coined and ascribed by the founders of quantum mechanics arbitrarily (unfoundedly, subjectively) to some of the functions (at *l*=1 and *l*=2), as well as to the spatial figures formed at the rotation of their sections, and combinations thereof.

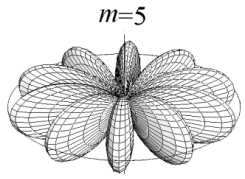
Graphs of the polar-azimuthal functions

$$Y_{l,m}(\theta,\varphi)_p = \left|\Theta_{l,m}(\theta)Cosm\varphi\right| \quad \text{(the potential constituent)} \quad (7)$$

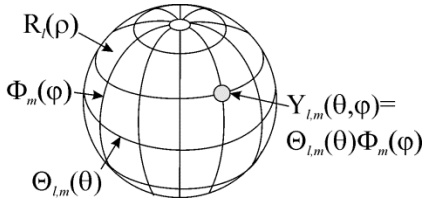








Functions $Y_{l,m}(\theta,\varphi)_p$ define the spatial angular coordinates of the nodes of standing spherical waves (and toroidal vortices-rings) on the corresponding radial wave shells.



The shell-nodal structure of standing waves in a spherical space

The particular solution ψ_p of the wave equation (1):

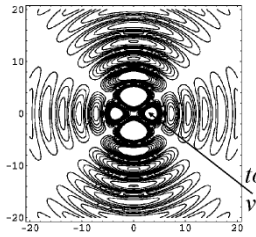
ψ_p is the potential component of $\hat{\psi}$

α is an initial phase of the azimuth state

$l = 0,1,2,\ldots \quad m = 0,\pm 1,\pm 2,\ldots,\pm l$

$$\psi_p = A\sqrt{\frac{\pi}{2\rho}}J_{l+1/2}(\rho)\Theta_{l,m}(\theta)Cos(m\varphi+\alpha) \qquad (8)$$

The solution for $l = 2,\ m = 0$ (section $x = 0$)

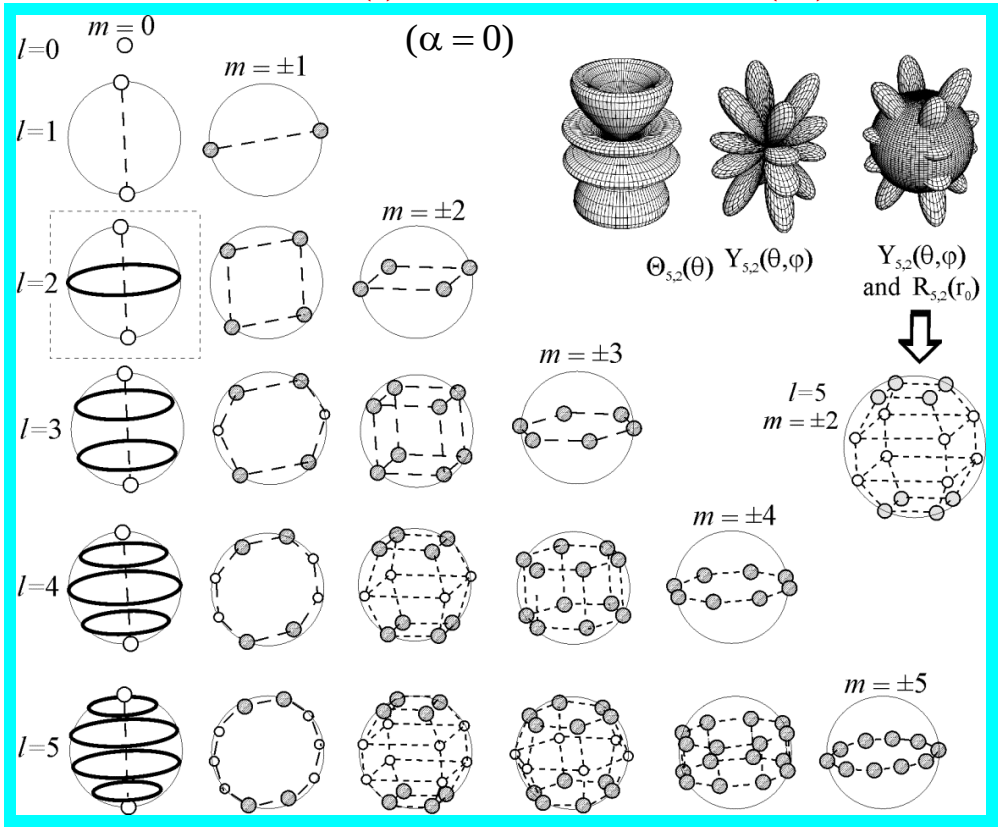


The schematic representation of the solution (8), shown here (that we first made in 1990th) became key.

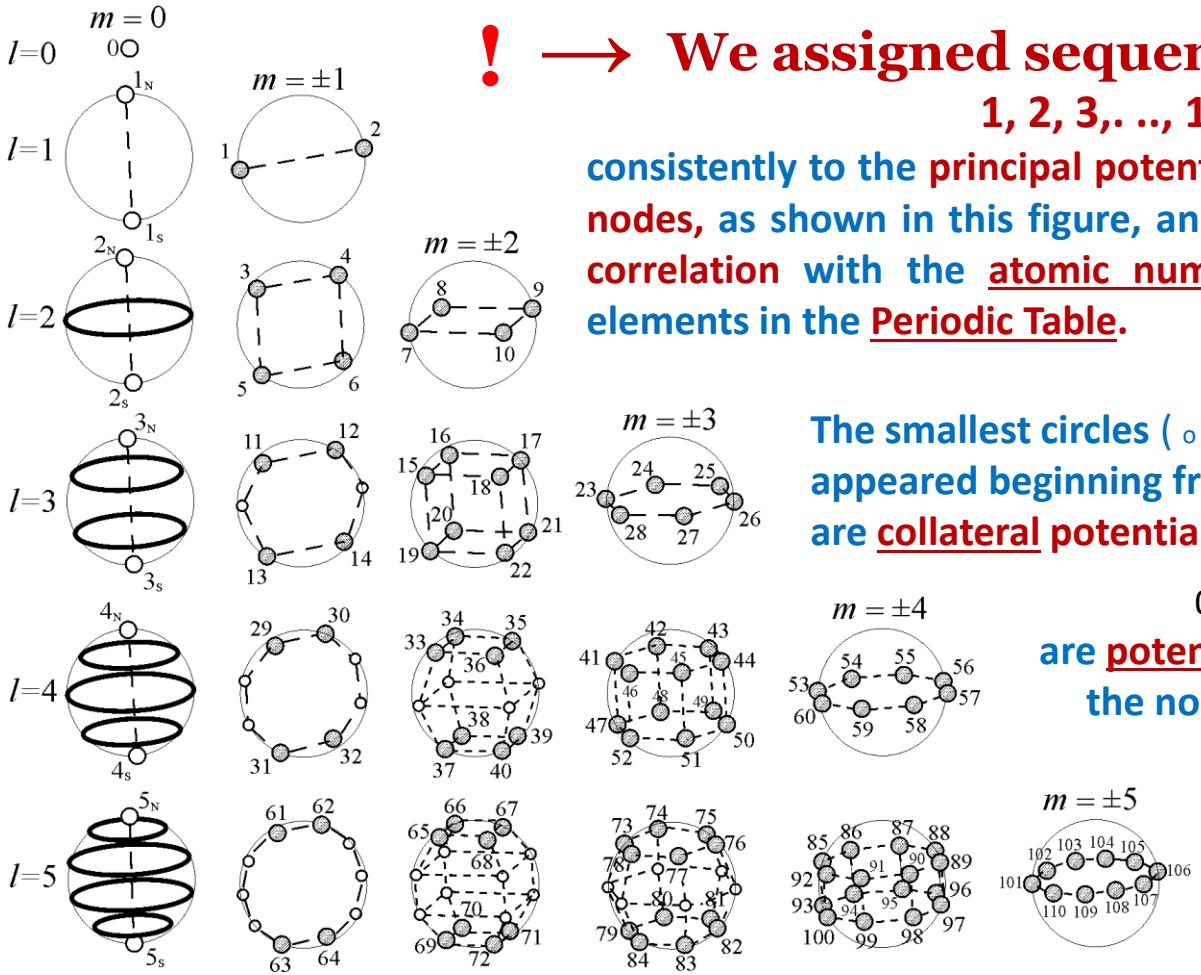
It led us, during comprehensive long-term studies (whose results were first published in 1996 [1]), to the key discovery that this solution defines the true structure of the "atoms", which, being the wave formations, are in fact the

Elementary Molecules of hydrogen atoms.

Shells (l) and subshells (m)



How we unraveled this mystery?



! → We assigned sequential numbers

1, 2, 3,. .., 110

consistently to the principal potential polar-azimuthal wave nodes, as shown in this figure, and found their astounding correlation with the atomic numbers Z assigned to the elements in the Periodic Table.

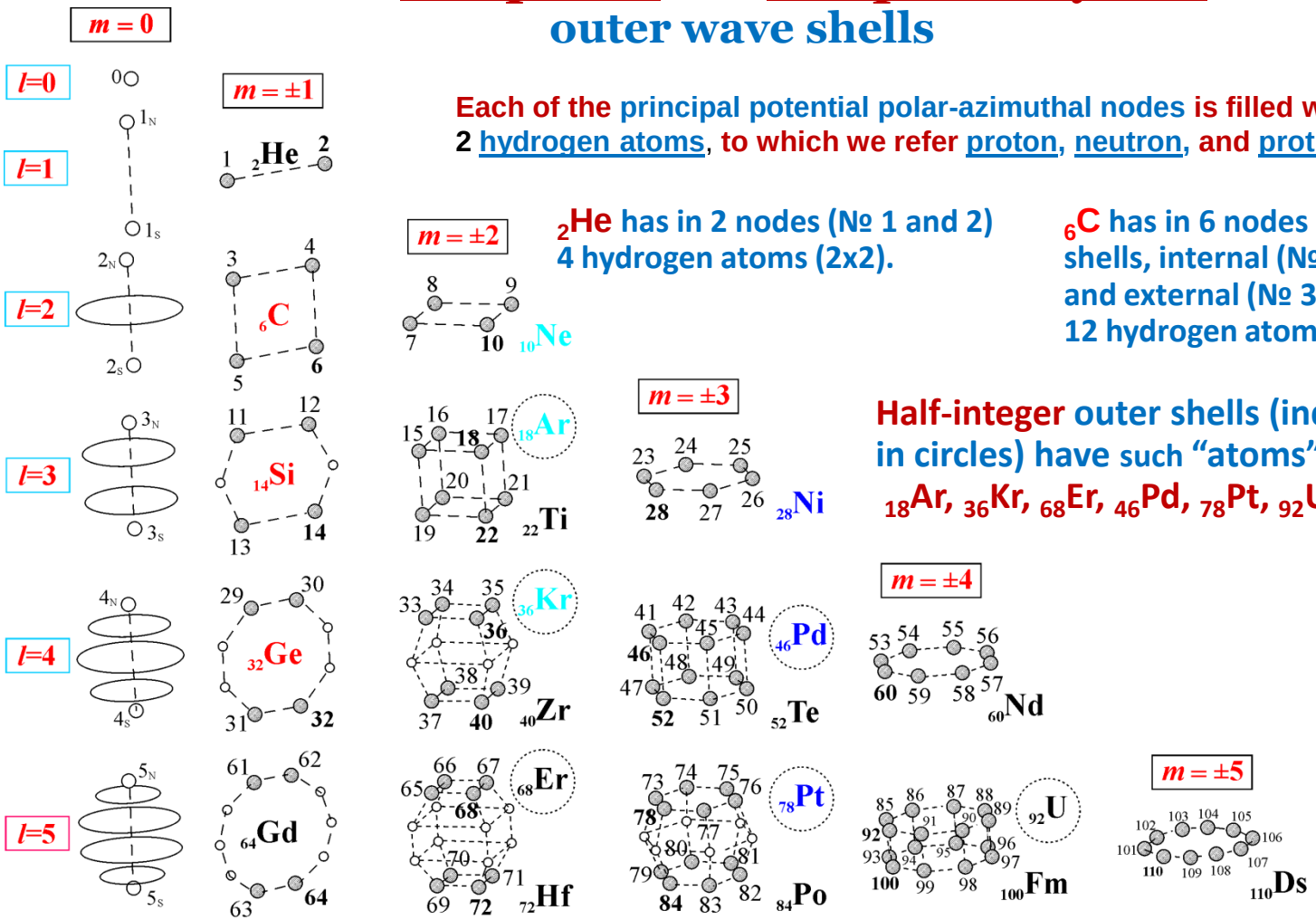
The smallest circles (ₒ) (empty, unnumbered) appeared beginning from $l = 3$, $m = \pm 1$, are collateral potential polar-azimuthal nodes.

0, 1_N, 1_S, …, 5_N, 5_S are potential-kinetic polar nodes – the nodes of rest and motion simultaneously.

Analyzing characteristic features of the solutions, presented in this way (with the numbered nodes), we made sure, ultimately, that they really give us information about the shell-nodal (molecule-like) structure of the "atoms" [1, 2].

Elementary molecules of hydrogen atoms

(the "atoms" with Z ≥ 2), having completed and completed by half outer wave shells



Each of the principal potential polar-azimuthal nodes is filled with 2 hydrogen atoms, to which we refer proton, neutron, and protium.

$_2$He has in 2 nodes (№ 1 and 2) 4 hydrogen atoms (2x2).

$_6$C has in 6 nodes on 2 its shells, internal (№ 1, 2) and external (№ 3, 4, 5, 6), 12 hydrogen atoms (6x2).

Half-integer outer shells (indicated in circles) have such "atoms" as:
$_{18}$Ar, $_{36}$Kr, $_{68}$Er, $_{46}$Pd, $_{78}$Pt, $_{92}$U

Noninteger solutions

$$l = m = s/2, \quad s \in \mathbf{N},$$

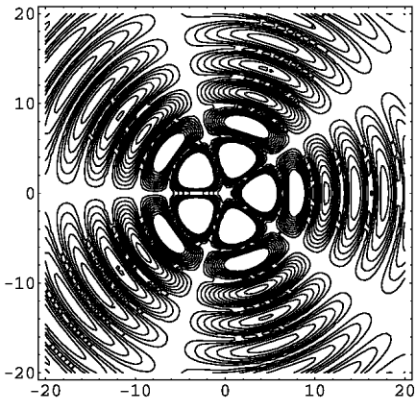
correspond to intermediate states. They define uncompleted external shells and subshells: half-filled (shown above) and partially filled, such as the shells of $_3$Li, $_4$Be, $_5$B or $_7$N, $_8$O, $_9$F, etc.

$$\hat{\psi} = A\sqrt{\frac{\pi}{2\rho}}\left(J_{\frac{s}{2}+\frac{1}{2}}(\rho) \pm iY_{\frac{s}{2}+\frac{1}{2}}(\rho) \right) \sin^{\frac{s}{2}}\theta\left(\cos\frac{s}{2}\varphi \pm i\sin\frac{s}{2}\varphi\right)$$

Zeros and extremes of the noninteger solutions (nodes and antinodes) are in the equatorial plane (z=0); they have any-fold symmetry, including forbidden by mathematical laws of crystallography. Here are two examples.

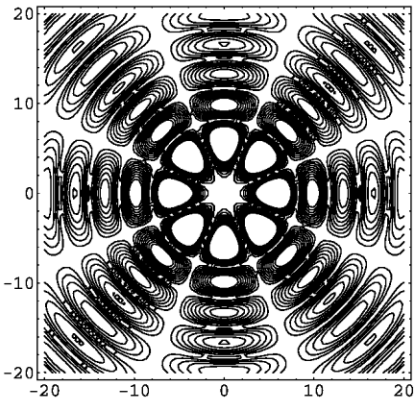
Contour plots of the sections for the potential component of the solutions, determined by the function:

$$\frac{J_{s/2+1/2}(\rho)}{\sqrt{\rho}} \sin^{s/2}\theta\cos\left(\tfrac{s}{2}\varphi\right)$$



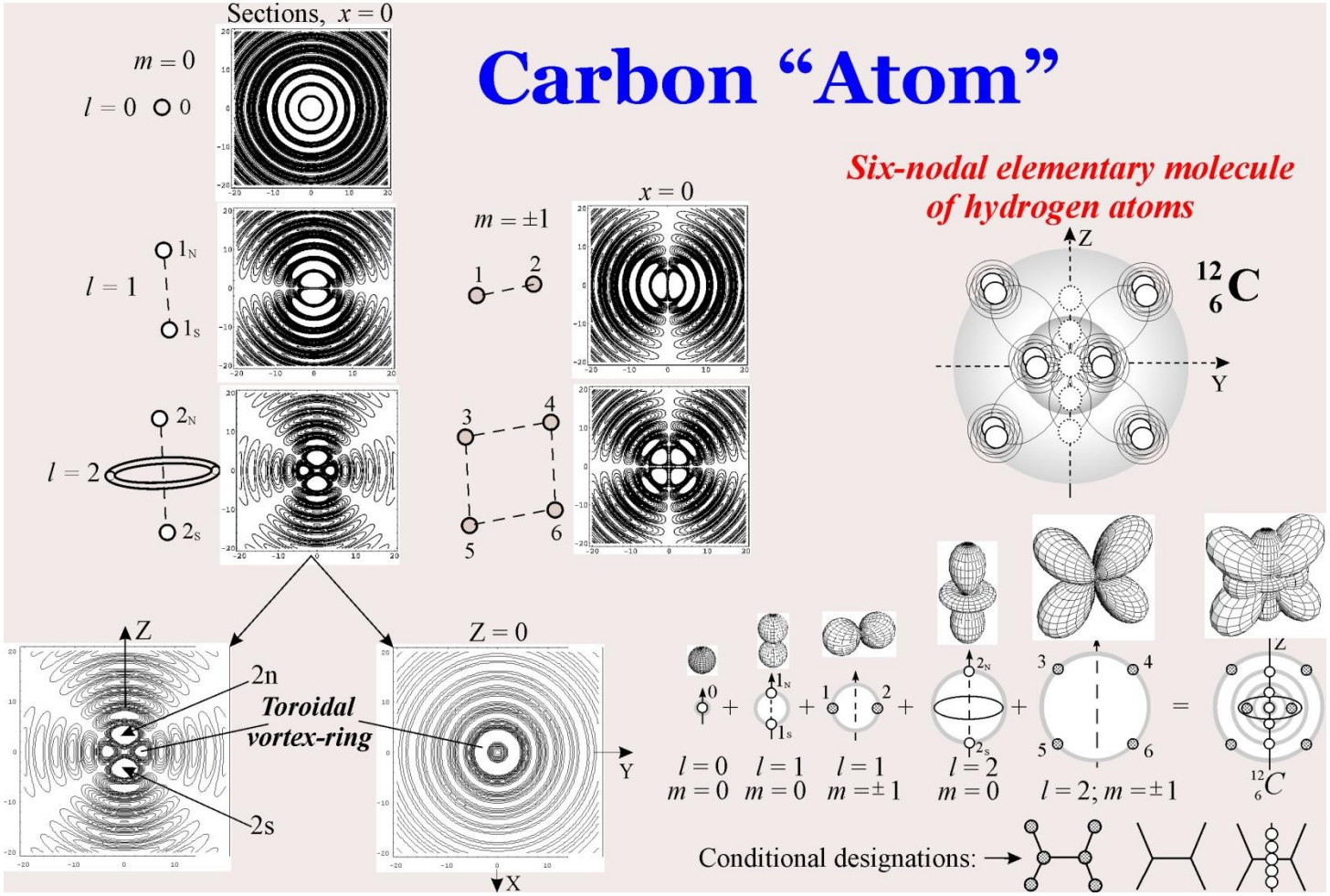
S=5

S=8

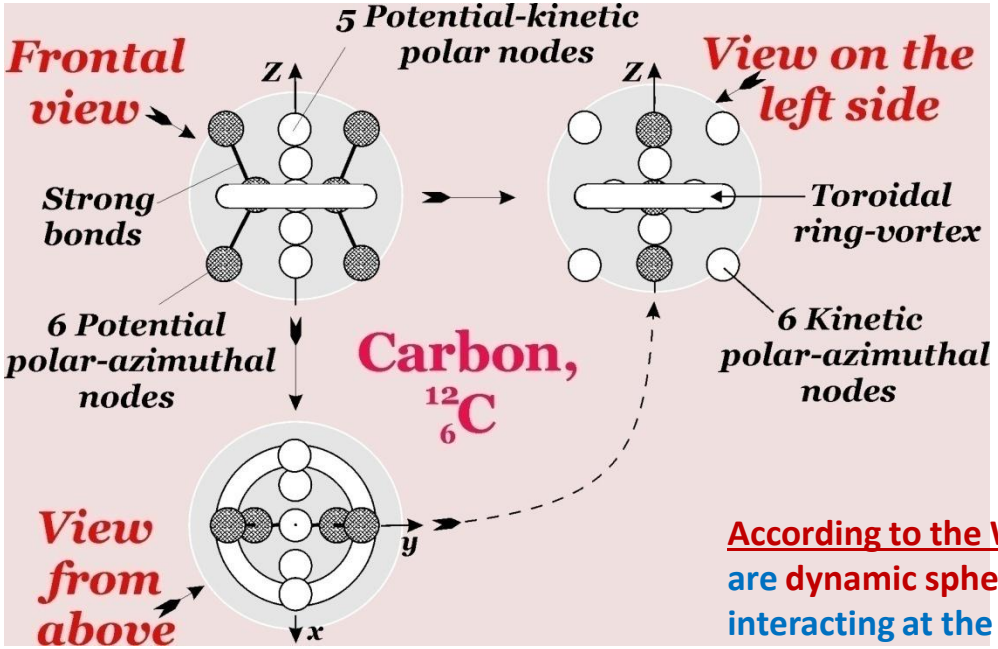


Equatorial distribution of the nodes of the five- and eight-fold symmetries

Shell-nodal structure of the six-nodal elementary molecule of hydrogen atoms, $^{12}_{6}C$



The six-nodal elementary molecule of hydrogen atoms (carbon "atom"), $^{12}_{6}C$



Potential and **kinetic** polar-azimuthal nodes dislocated relative to each other in the radial direction, and are in planes differing in phase by $\varphi=\pi/2$

Fundamental frequency and the fundamental wave radius of the atomic and subatomic levels:

$$\omega_e = 1.869162559\times10^{18}\ s^{-1}$$

$$\lambda\!\!\!^{-}_e = \frac{c}{\omega_e} = 1.603886492\times10^{-8}\ cm$$

According to the WM, all elementary particles and atoms are dynamic spherical formations pulsating and interacting at the frequency ω_e (discovered in the WM, along with ω_g and E_B).

Binding energy of the nodes in $^{12}_{6}C^{-4}$, calculated by the formula is $E_{C,ion} = 92.349...\text{MeV}$

$$E_B = \omega_e^2 \frac{m_1 m_2}{8\pi\varepsilon_0 r}$$

$\omega_e m_2 = q_1$ and $\omega_e m_1 = q_1$ are exchange charges of interacting nucleons; $\varepsilon_0 = 1g\cdot cm^{-3}$ is the absolute unit density.

Fundamental frequency and the fundamental wave radius of the gravitational level:

$$\omega_g = 9.158082264\times10^{-4}\ s^{-1}$$

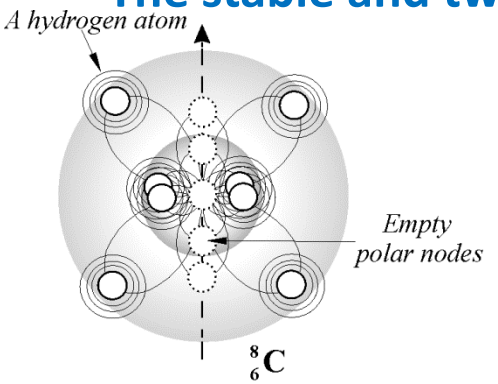
$$\lambda\!\!\!^{-}_g = \frac{c}{\omega_g} = 327.4\times10^{6}\ km$$

Thanks to the WM, the next mystery,

The nature of origin and the structure of all "atomic" isotopes,

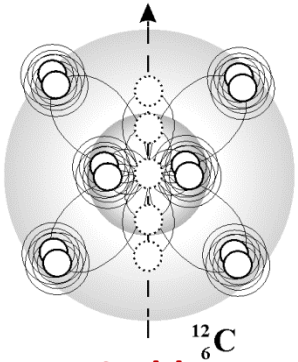
was, at last unravelled by us.

The stable and two limit short-lived isotopes of carbon *

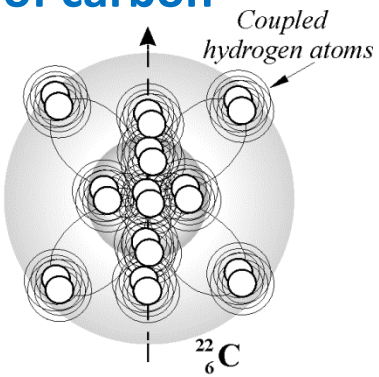


Lightest

(The least stable isotope, a half-life of 2.0×10^{-21} s)



Stable



Heaviest

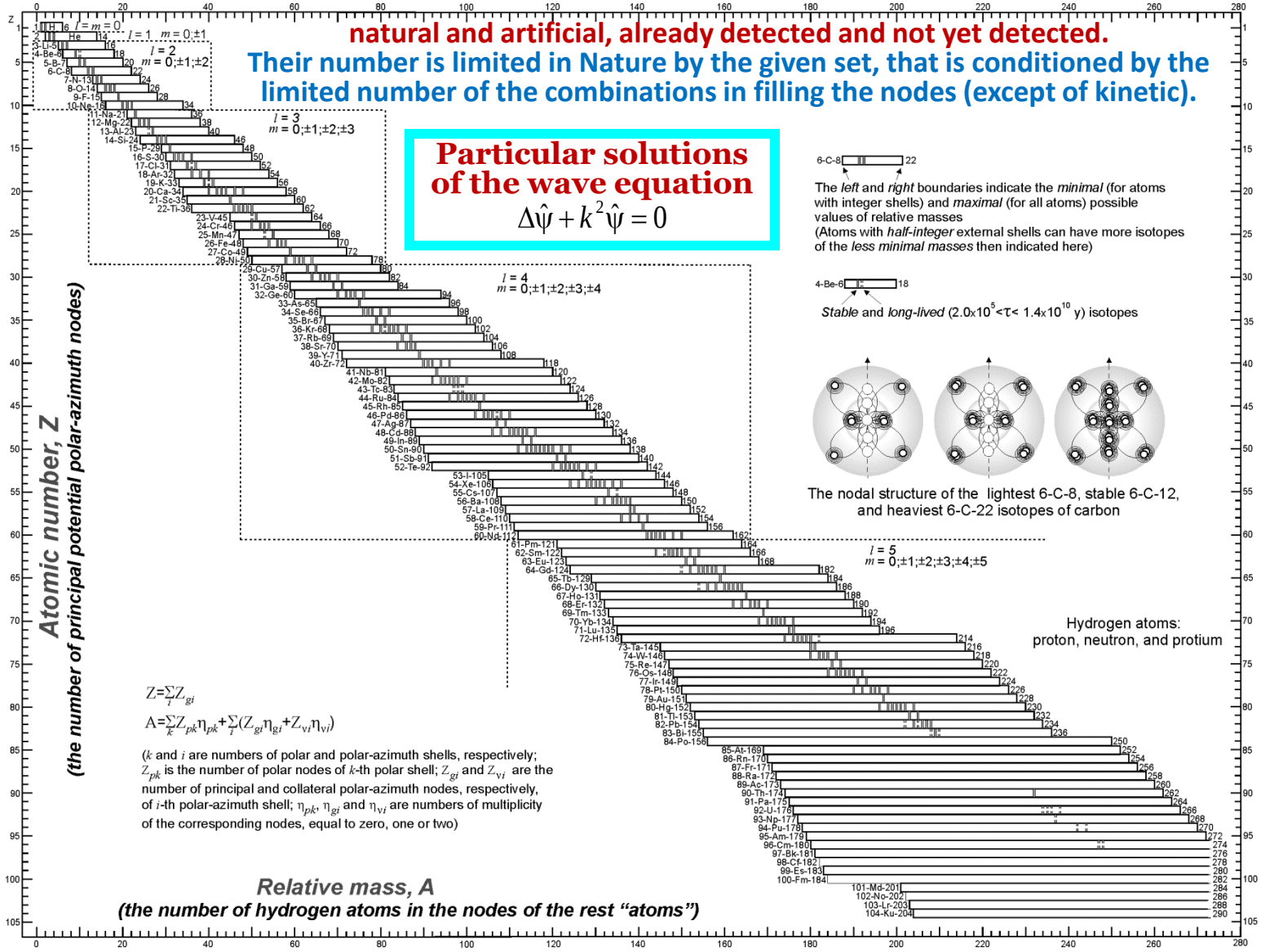
(A half-life of 6.2×10^{-3} s)

*[G. P. Shpenkov, *Physics and Chemistry of Carbon in the Light of Shell-Nodal Atomic Model*, Chapter 12 in "*Quantum Frontiers of Atoms and Molecules*", edited by Putz M. V., NOVA SCIENCE PUBLISHERS, NY, 277-323, 2011]

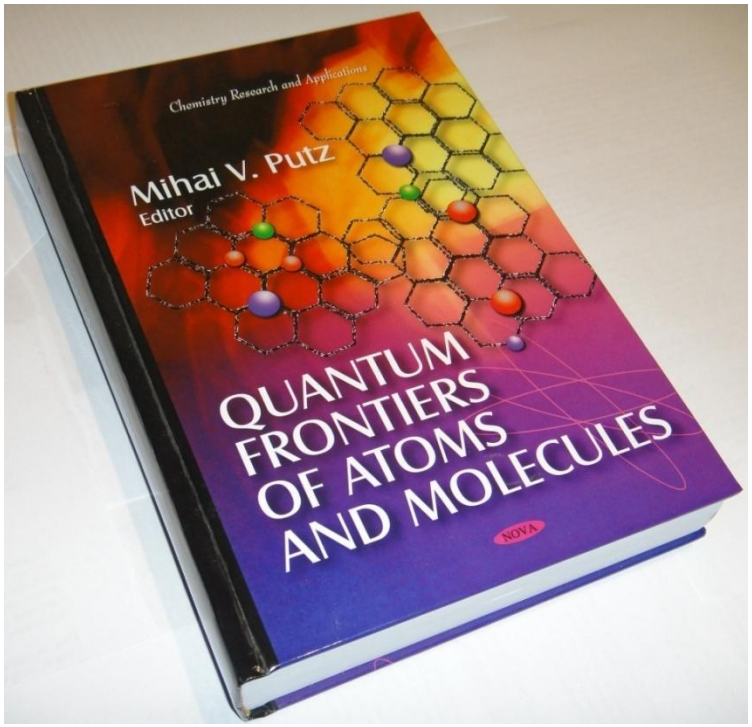
It is another in a series of the discoveries following from the fundamental discovery (the shell-nodal structure of the "atoms") and, thereby, directly confirming reality of the latter.

The complete set of “atomic” isotopes

Isotopes of elementary molecules of hydrogen atoms



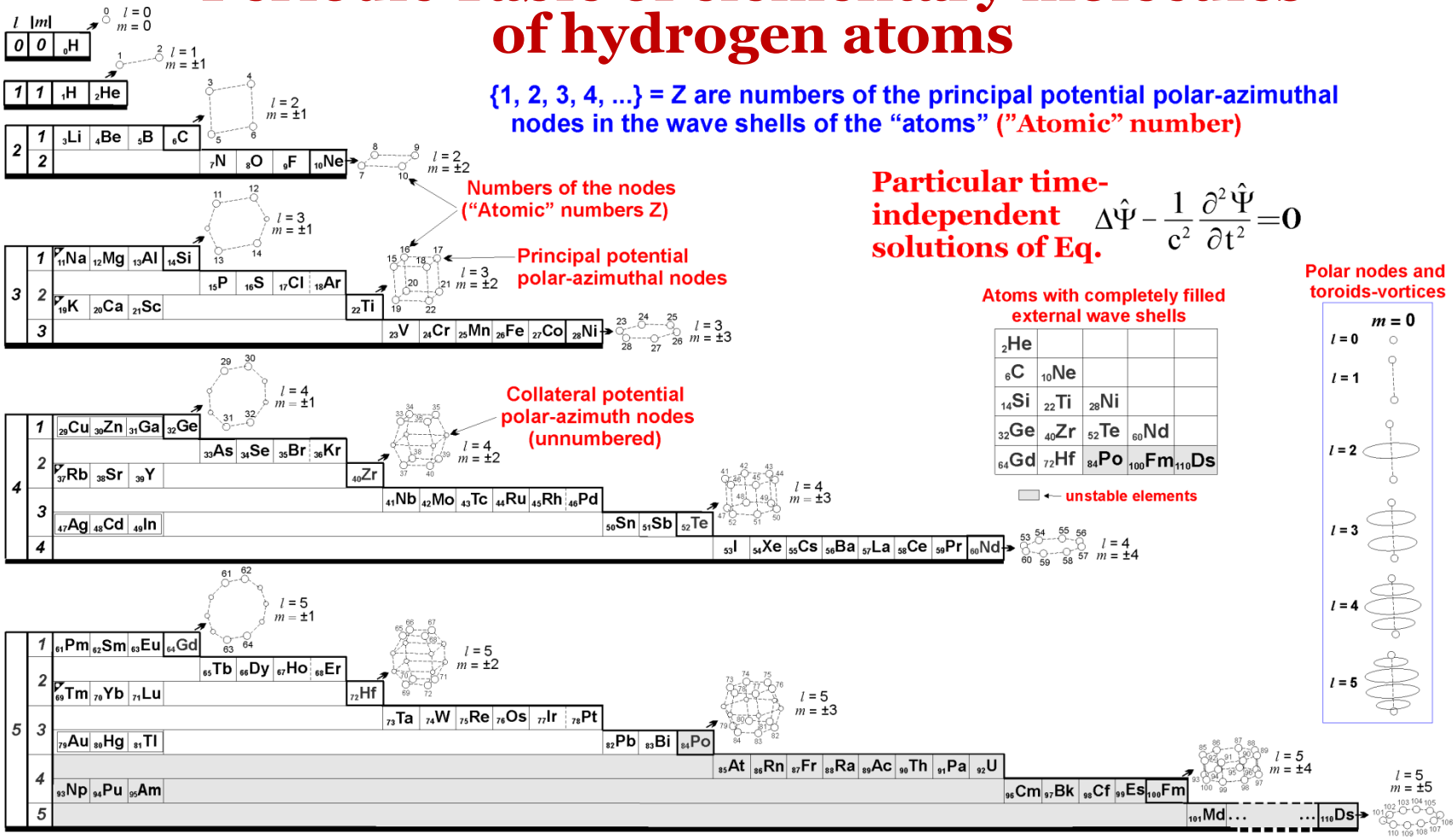
[G. P. Shpenkov, *Physics and Chemistry of Carbon in the Light of Shell-Nodal Atomic Model*, Chapter 12 in "*Quantum Frontiers of Atoms and Molecules*", edited by Putz M. V., NOVA SCIENCE PUBLISHERS, NY, 277-323, 2011]



A colour variant of the Table of Isotopes of 2001
is available online at http://shpenkov.com/pdf/isotopes.pdf

Thanks to the solutions (8), it was also revealed by us the main true cause of the observed similarity in the physical and chemical properties of elements that was first generalized and formulated by D. I. Mendeleev as the Law of Periodicity.

Periodic Table of elementary molecules of hydrogen atoms



{1, 2, 3, 4, ...} = Z are numbers of the principal potential polar-azimuthal nodes in the wave shells of the "atoms" ("Atomic" number)

Numbers of the nodes ("Atomic" numbers Z)

Principal potential polar-azimuthal nodes

Collateral potential polar-azimuth nodes (unnumbered)

Particular time-independent solutions of Eq. $\Delta\hat{\Psi} - \frac{1}{c^2}\frac{\partial^2\hat{\Psi}}{\partial t^2} = 0$

Atoms with completely filled external wave shells

2He				
6C	10Ne			
14Si	22Ti	28Ni		
32Ge	40Zr	52Te	60Nd	
64Gd	72Hf	84Po	100Fm	110Ds

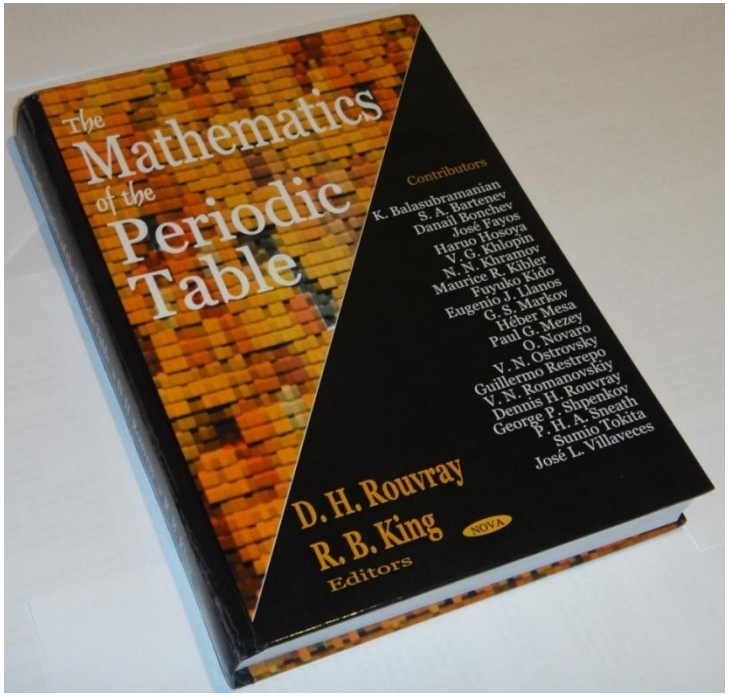
unstable elements

Polar nodes and toroids-vortices

* The hydrogen atoms: *proton*, *neutron*, and *protium*

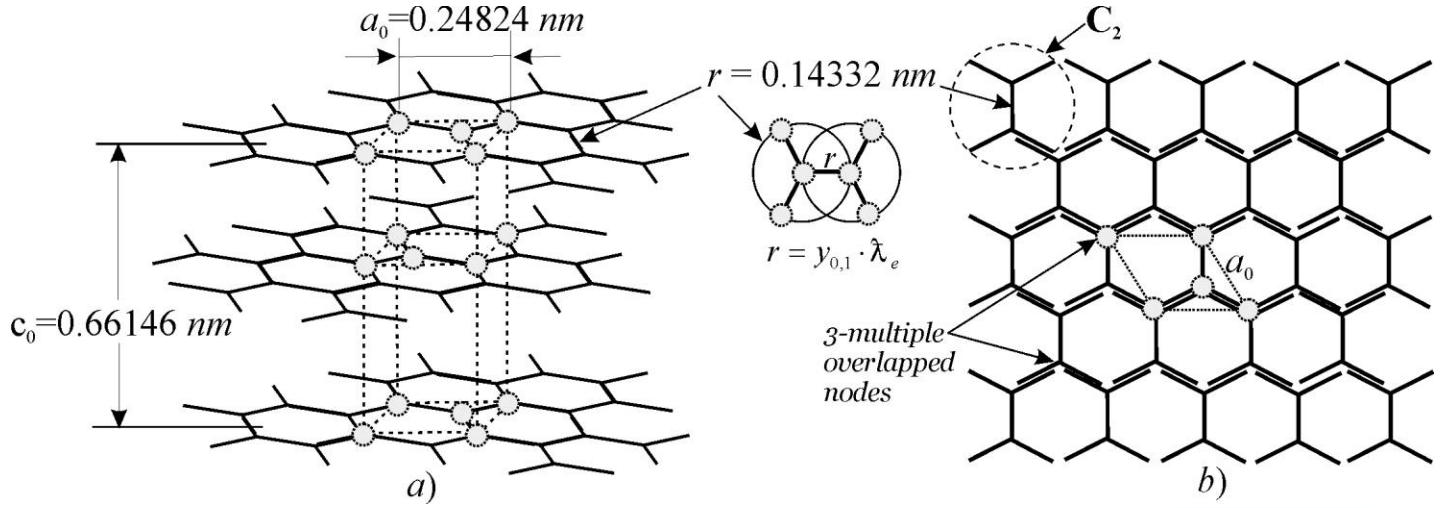
[1] *Alternative Picture of the World*, V. 1-3, (1996); [2] *Foundations of Physics*, (1998);
[3] *Atomic Structure of Matter-Space*, (2001); Geo. S., Bydgoszcz
by L. Kreidik and G. Shpenkov.
The Shell Structure of Matter Spaces, **http://shpenkov.janmax.com/ShellStr.pdf**

[G. P. Shpenkov, *An Elucidation of the Nature of the Periodic Law*, Chapter 7 in "*The Mathematics of the Periodic Table*", edited by Rouvray D. H. and King R. B., NOVA SCIENCE PUBLISHERS, NY, 119-160, 2006]



A colour variant of the Periodic Table of 2001
is available online at http://shpenkov.com/pdf/placard.pdf

A unit cell and the structure of graphite and its single atomic layer – graphene



According to WM, the length of bonds in graphite is determined by the product $r = y_{0,1} \cdot \lambda\!\!\!^{-}_e$, where $y_{0,1}$ is the root of Bessel functions [3] ($y_{0,1}$= 0.89357697) and $\lambda\!\!\!^{-}_e = \omega_e / c = 1.603886538 \cdot 10^{-8}\ cm$

$$n = (1\tfrac{1}{6} \times 2 + 1\tfrac{2}{3}) = 4\ nodes\ per\ unit\ cell,\ V = n \cdot 12.0107 \cdot m_u / \rho = 35.29953318 \cdot 10^{-24}\ cm^3,$$
$$m_u = 1.660539040 \cdot 10^{-24} g,\ \rho = 2.26\ g \cdot cm^{-3},\ a_0 = \sqrt{3} r,\ c_0 = V \cdot 2 / a_0^2 \sqrt{3} = 6.614634572 \cdot 10^{-8}\ cm$$

Lattice constants a_0 and c_0, calculated as shown here, are close to the lattice constants of graphite (at 300 K) known from the literature. The calculation data correspond to graphite consisting of carbon dimers C_2 having the shell-nodal structure.

Thus, we have come to the conclusion that the "building blocks" of graphite and, hence, graphene are carbon dimers C_2.

Accurate calculations of atomic positions and lengths of interatomic bonds

are based on the iterative method: by comparison and fitting the measured intensities of the reflected beam with calculated, taking into account Rutherford-Bohr's nuclear model of atoms, until an adequate match between the two sets of values will not be reached.

In accordance with the WM, we should take into account, at the iteration, the shell-nodal (molecule-like) "atomic" model.

Under this condition, the results of calculating the lattice constants for graphite practically coincide with the known data, within the error limits, if only we will take the dimer of the 6-nodal elementary molecule of hydrogen atoms (C_2) as an elementary "building block" of graphite, but not the carbon "atom" (C).

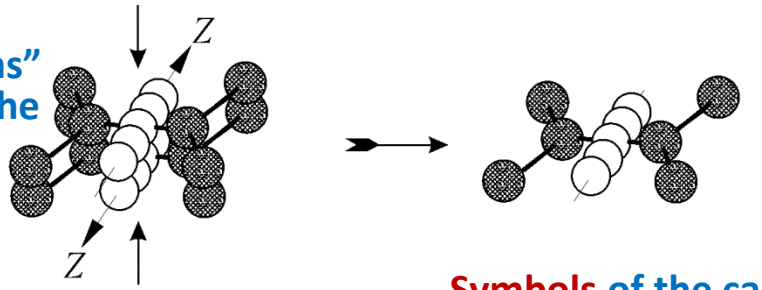
This conclusion relates also to various other carbon compounds.

(In the course of further discussion, we will adhere to this)

Schematic representation of the formation of the molecule C_2

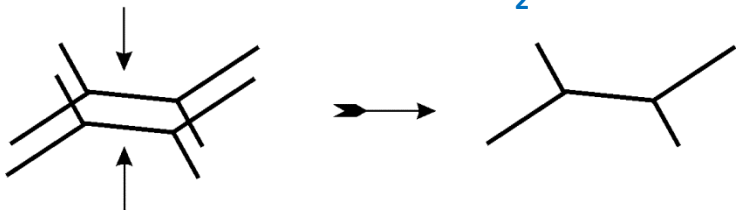
C_2 is formed by overlapping, "merging", all approaching nodes (and toroidal rings-vortices, not shown here) of two 6-nodal elementary molecules of hydrogen atoms (two carbon "atoms") into a single whole.

Like magnets, two carbon "atoms" are attracted to each other by the opposite directed fields of their internal internodal bonds



$C + C \longrightarrow C_2$

Symbols of the carbon "atom" C and the molecule C_2 are the same



In [H. C. Shih, et al., *Diamond and Related Materials*, 2, 531 (1993)],

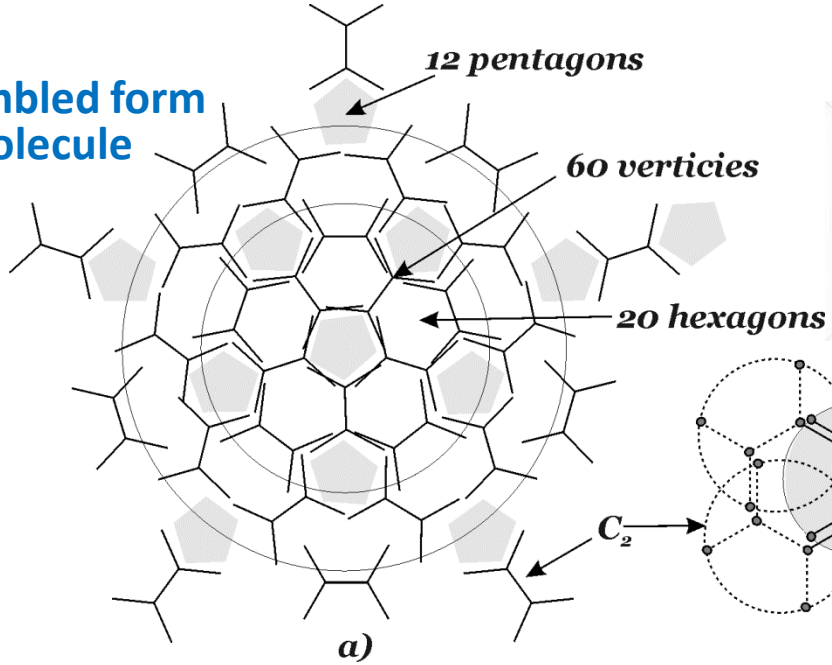
"...the C_2 radical was considered to be responsible for the formation of graphite"

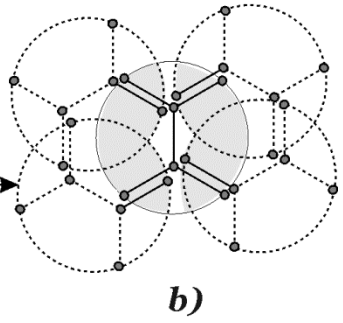
Buckminsterfullerene (C_{60}),

in accordance with the WM,

is formed from 30 carbon dimers, C_2 :

The disassembled form of the molecule





Scheme of binding and overlapping of nodes

Thus, according to WM, the formula of the molecule is $(C_2)_{30}$

"Carbon Dimer (C_2) is in fact the major observable product of C_{60} fragmentation. Being a very effective growth species, it can rapidly incorporate into the diamond lattice leading to high-film growth rates"*.

*[D. M. Gruen, et al., *Turning Soot Into Diamonds With Microwaves*, Proceedings of the 29th Microwave Power Symposium, Chicago, Illinois, July 25-27, 1994]

A diagram showing

The formation of chemical ("covalent") C–C bonds

in hydrocarbon compounds

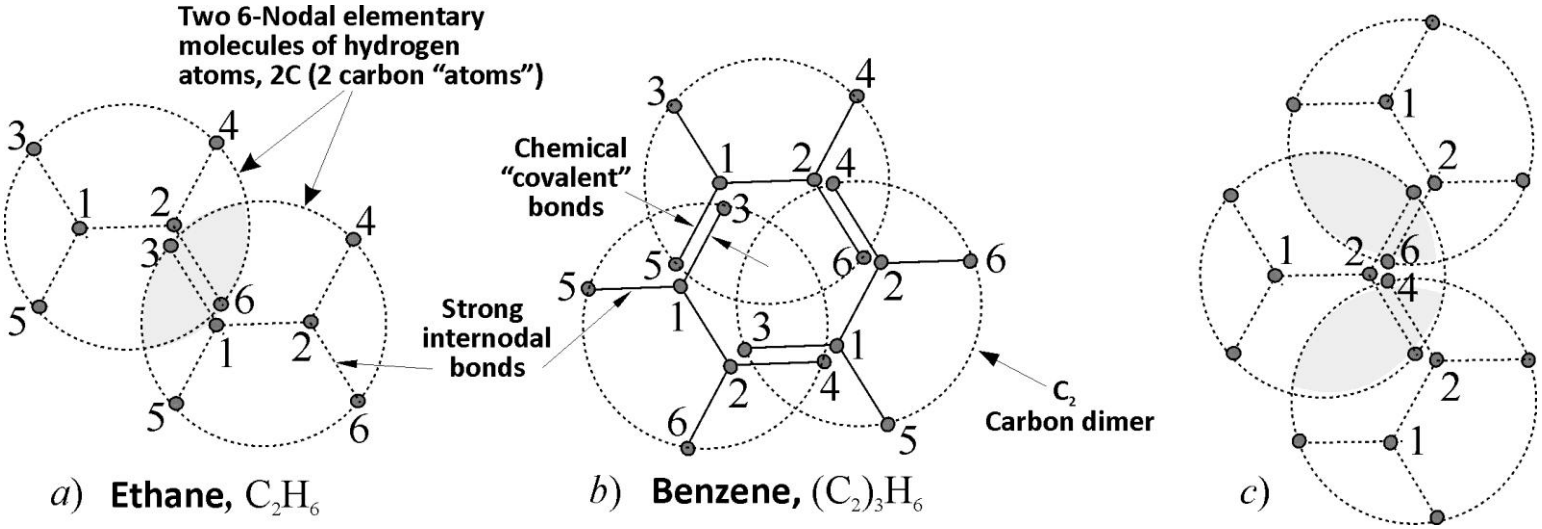
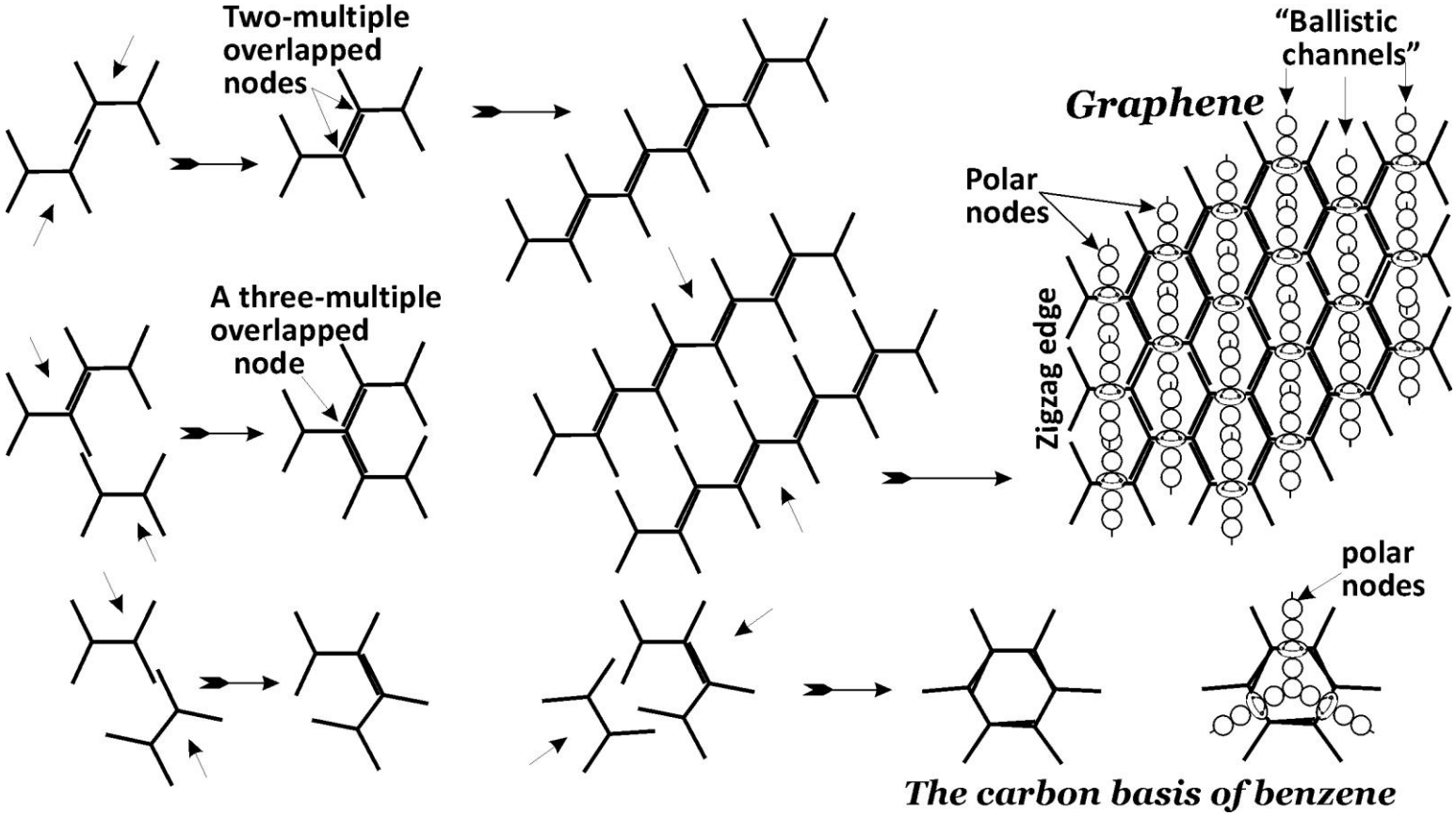


Fig. Two-multiple (a, b) and three-multiple (c) overlapping of external and internal polar-azimuthal nodes, belonging to the joined carbon nucleon molecules (single, C, or dimmers, C_2).

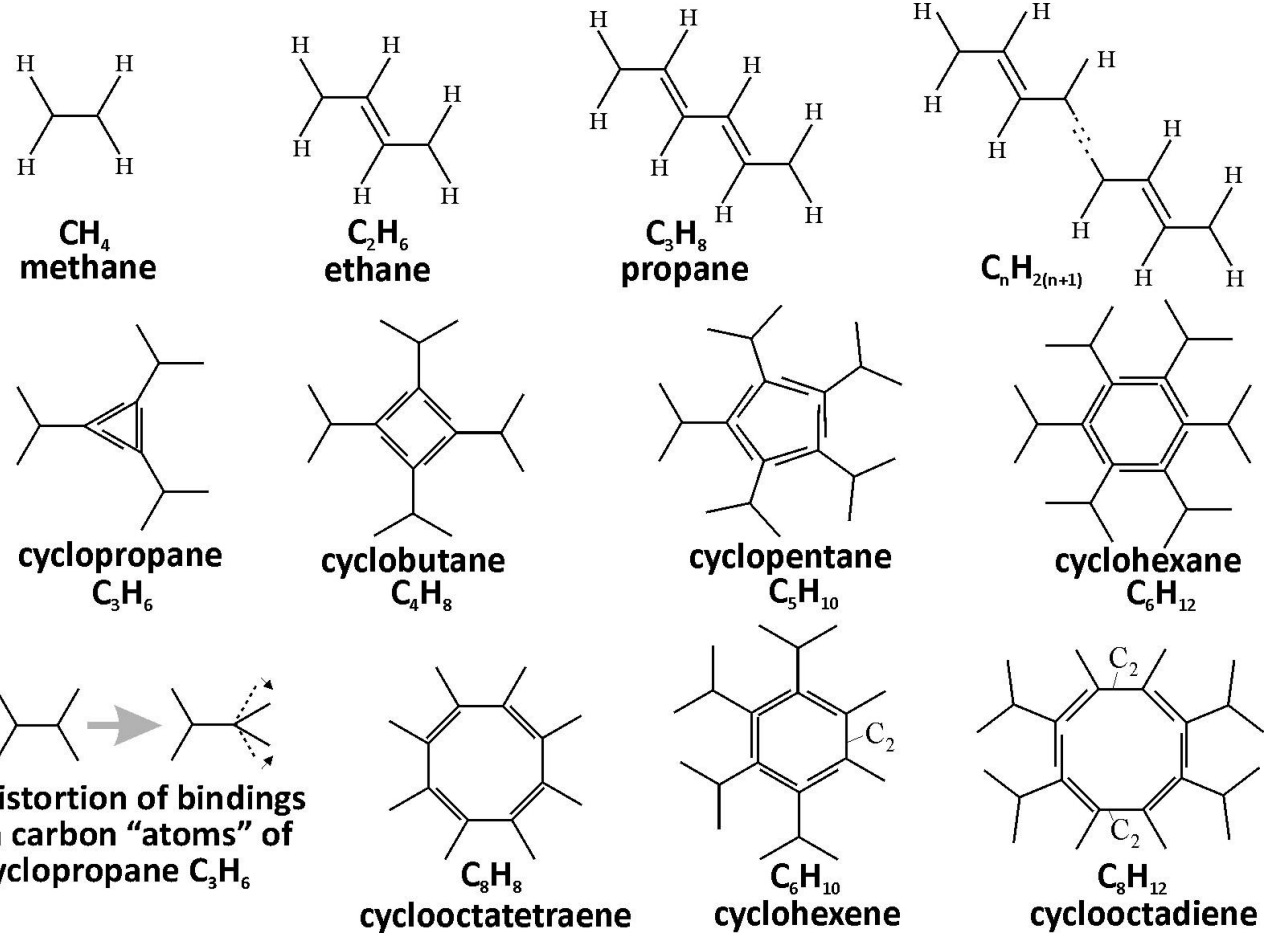
Chemical "covalent" bonds are realized along the lines of strong internodal bindings (existing between external and internal nodes) each of the joined "atoms" (a) or dimers (b). Electrons play the secondary role, they define only the strength of the bonds.

Schematic representation of self-bindings (assembling) of two-dimensional carbon compounds



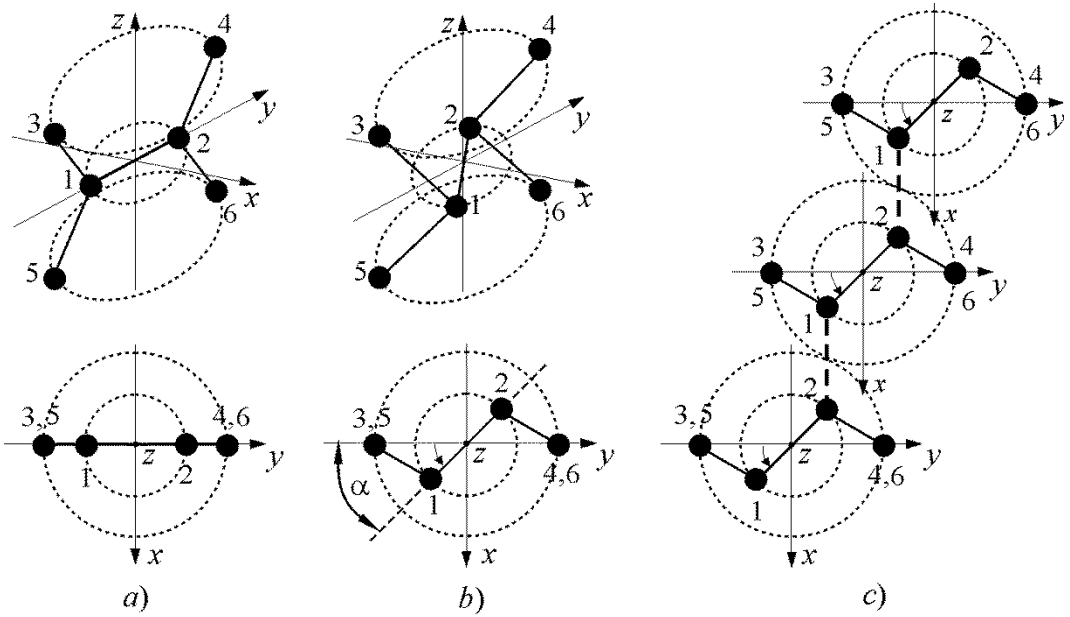
The structure of C-C bonds

in typical hydrocarbon compounds*



*[G. P. Shpenkov, The Role of Electrons in Chemical Bonds Formations (In the Light of Shell-Nodal Atomic Model), Molecular Physics Reports 41, 89-103, (2005)]

The formation of internodal bonds in diamond



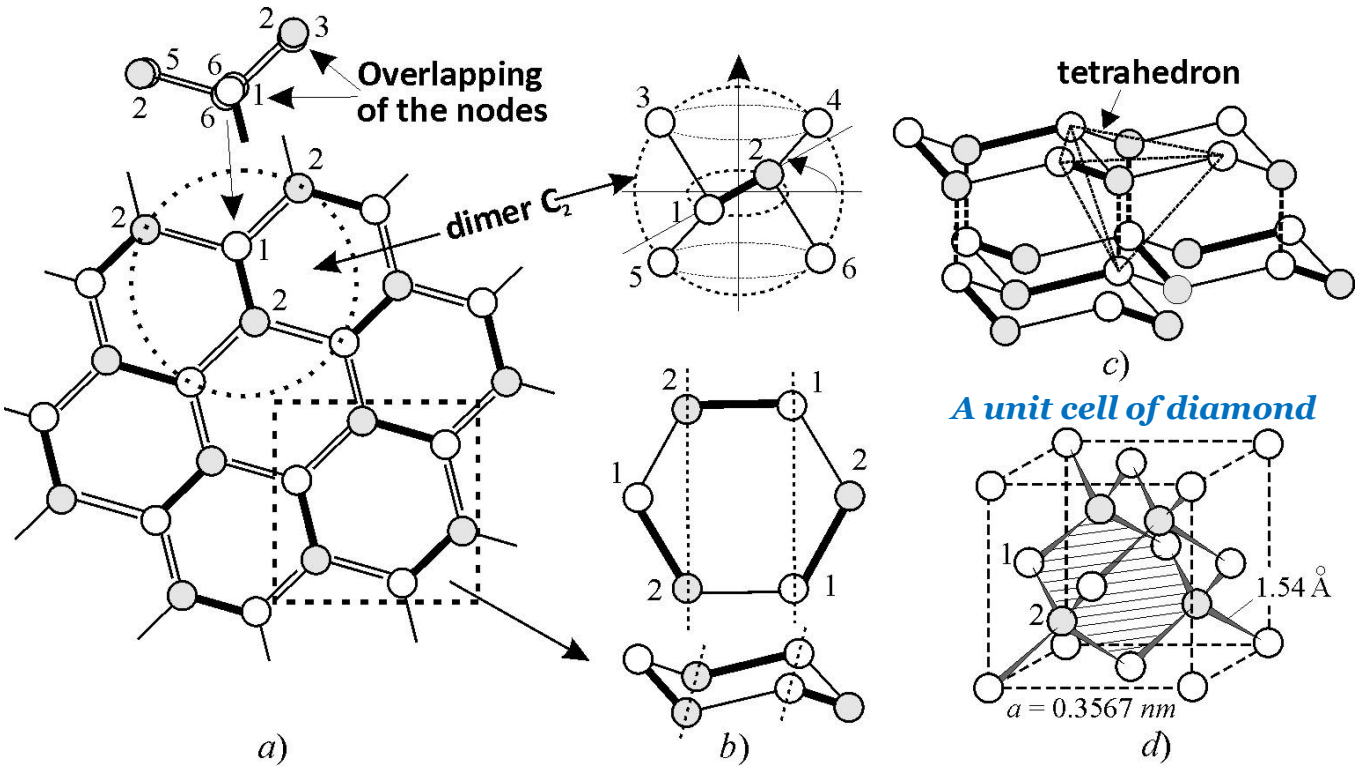
(*a*) The planar structure of carbon dimer C_2 (and carbon "atom" C).

(*b*) Azimuth state of nodes 1 and 2 of the inner shell, rotated by a phase angle $\alpha = \pi/4$, in relation to the outer shell, allowed by the solution for φ, since $\Phi_p(\varphi) = \Phi_m \cos(m\varphi + \alpha)$.

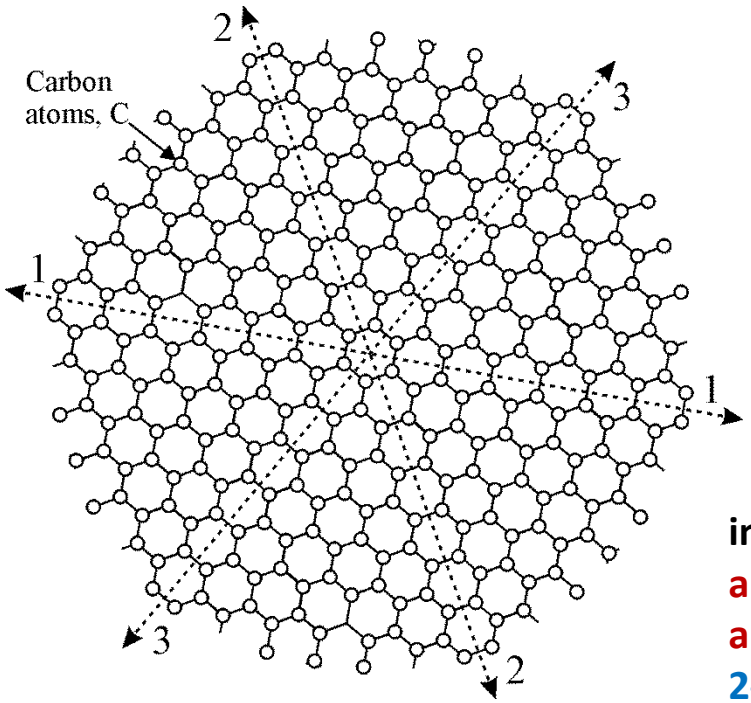
(*c*) Formation of bonds (dashed lines) between rotated internal nodes, 1 and 2, adjacent dimmers of carbon , which results in a face-centered cubic structure of diamond.

The face-centered cubic lattice of diamond

(made of carbon dimers C_2)



Traditional view on the basic properties of graphene



* [Robert E. Newnham, Properties of Materials: Anisotropy, Symmetry, Structure; Oxford University Press, 2005]

Graphene is an allotrope of carbon in the form of a two-dimensional hexagonal lattice.

Point group D6h, space group P6/mmm

- One atom forms each node of the lattice.
- sp^2 hybridized orbitals are responsible for the bond of carbon atoms in the lattice.
- The lattice has 6-Fold rotational symmetry.

Hence,

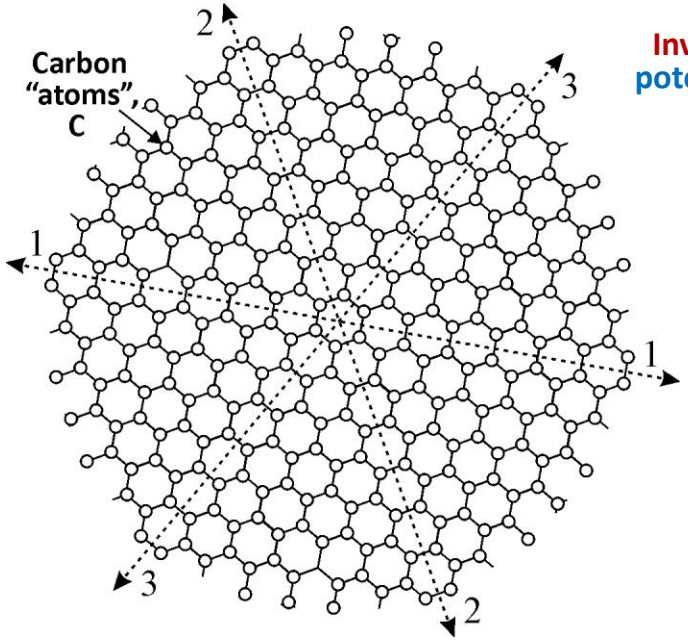
in full agreement with the basic symmetry theory*, all properties, including electronic conductivity, along the crystallographically identical directions 1-1, 2-2, 3-3 (indicated here) must be equal.

However, our studies show that it is not true

The structure of graphene

Conventional view:

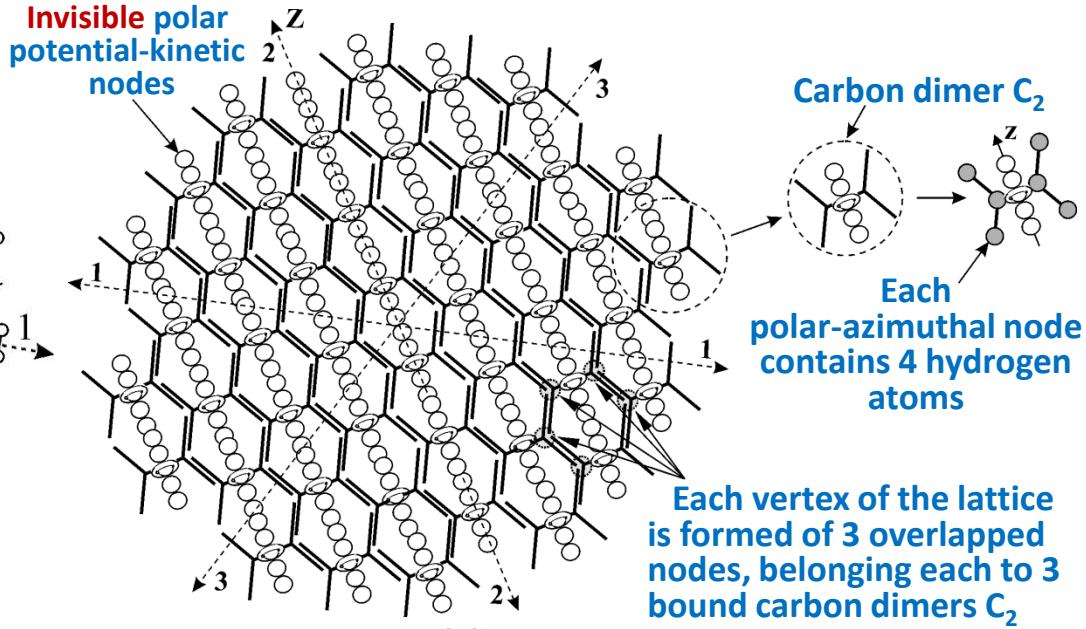
Hexagonal lattice is formed of carbon "atoms", C



6-Fold
rotational symmetry

According to WM:

Hexagonal lattice is formed of carbon dimers, C_2



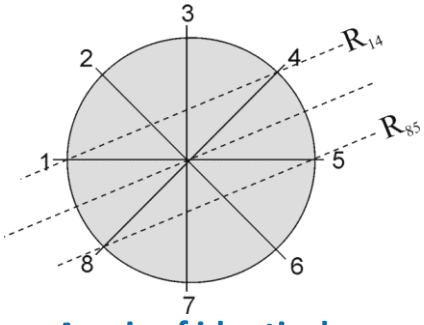
2-Fold
rotational symmetry

An ordered "covalent" bond of carbon dimers C_2 is realized in graphene along strong internodal bonds in such a way that a continuous chain of empty polar nodes forms hollow channels inside the crystal, through which charge carriers can move without obstacles not being scattered, like it occurs at the ballistic motion.

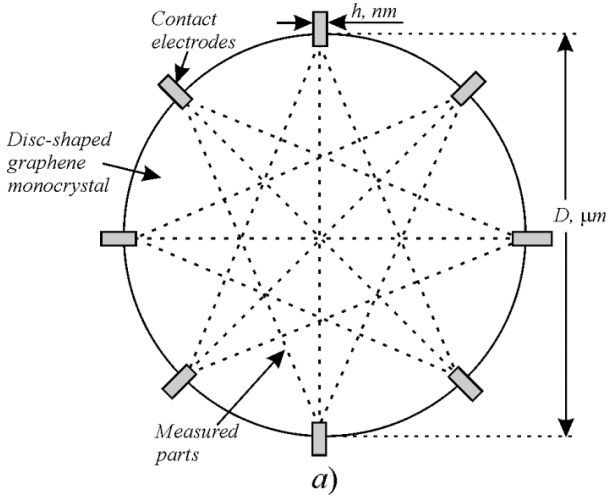
The truthfulness of the shell-nodal structure of “atoms”
was experimentally verified also by us
by direct detection of the consequences caused by this structure

Yes or No anisotropy of conductivity in graphene?

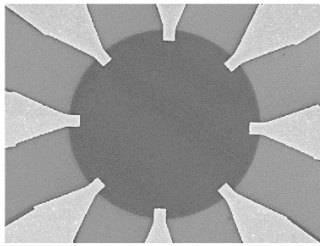
Scheme of measurement (*a*)
and SEM image (*b*) of graphene round sheets during their testing (2010):



A pair of identical
conductive sections



a)



b)

Both resistances between parallel pairs of contacts (for example, such as R_{14} and R_{85}), embracing **identical conductive areas** (i.e., having the same geometrical configuration), **should be equal** in magnitude (within the permissible error).

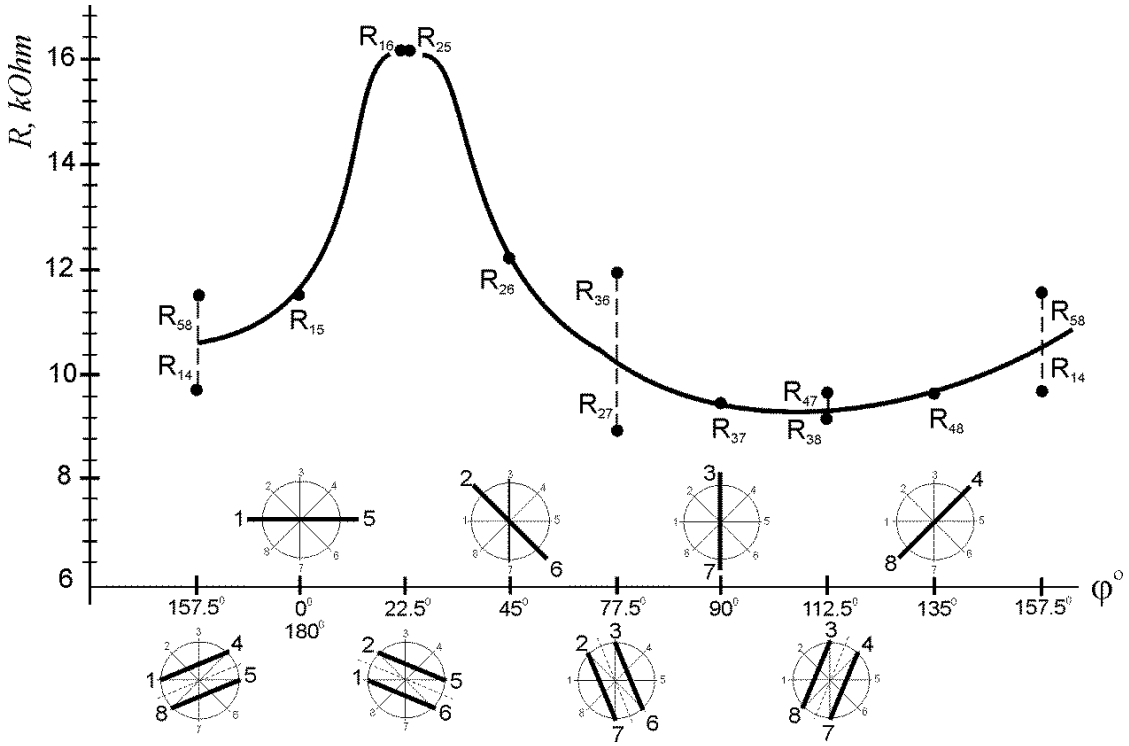
This allows to **instantly monitor** the **perfection** of electric contacts with disc-shaped graphene plates, directly in the process of measuring resistance.

Therefore, the given scheme **can be used** to test the **effectiveness** of various **technological methods** developing for creating improved electric contacts with graphene.

Angular dependence of electrical resistance $R = f(\varphi)$

in the plane of a graphene sheet of circular shape

(D=10 μm, h=580 nm, T=4.2 K, I=1 nA)



The obtained dependence is characteristic for anisotropic materials having two-fold symmetry

Anisotropic behavior of electrical conductivity in graphene

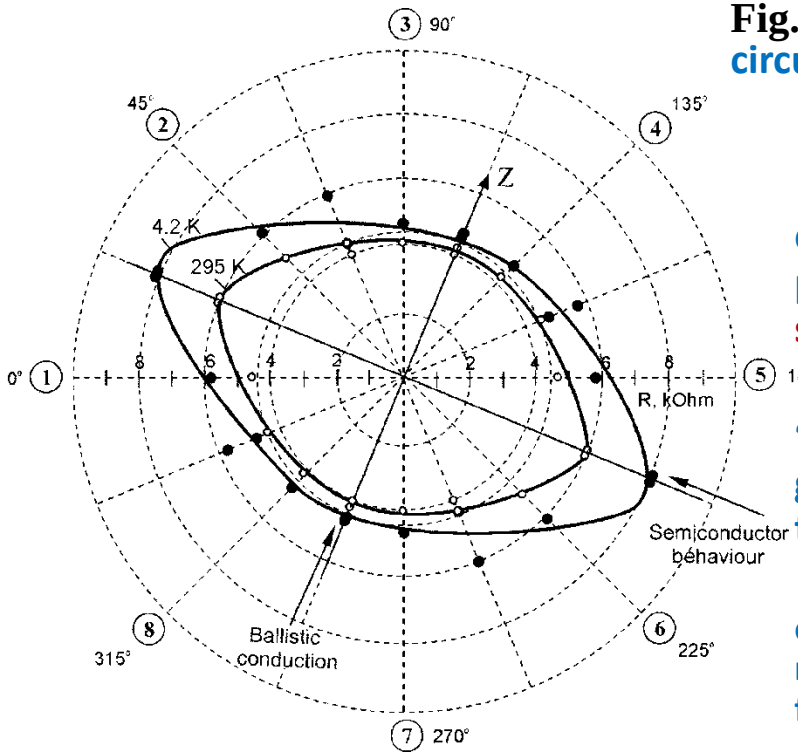


Fig. Polar diagram of resistance in the plane of a circular graphene sheet of monoatomic thickness:

(D=10 μm, h=580 nm, T=4.2 and 295 K)

Temperature dependence of graphene conductivity, along one of the directions in the plane, shows that graphene behaves like a semiconductor in this direction .

In the perpendicular direction, along the "ballistic channels" (z-axis), the resistance in graphene is practically independent of temperature; graphene behaves like metal.

(Comparison with metal refers only to the absence of a temperature dependence, because the conduction mechanisms in the metal and in graphene are fundamentally different)

The discovery of anisotropy of the hexagonal lattice of graphene, predicted by the author theoretically (2009), is the next in a series of the discoveries of the WM.

Together with discoveries of the nature of all possible "atomic" isotopes and the primary cause of the Periodic Law, it is a direct experimental confirmation of the reality of the shell-nodal structure of "atoms".

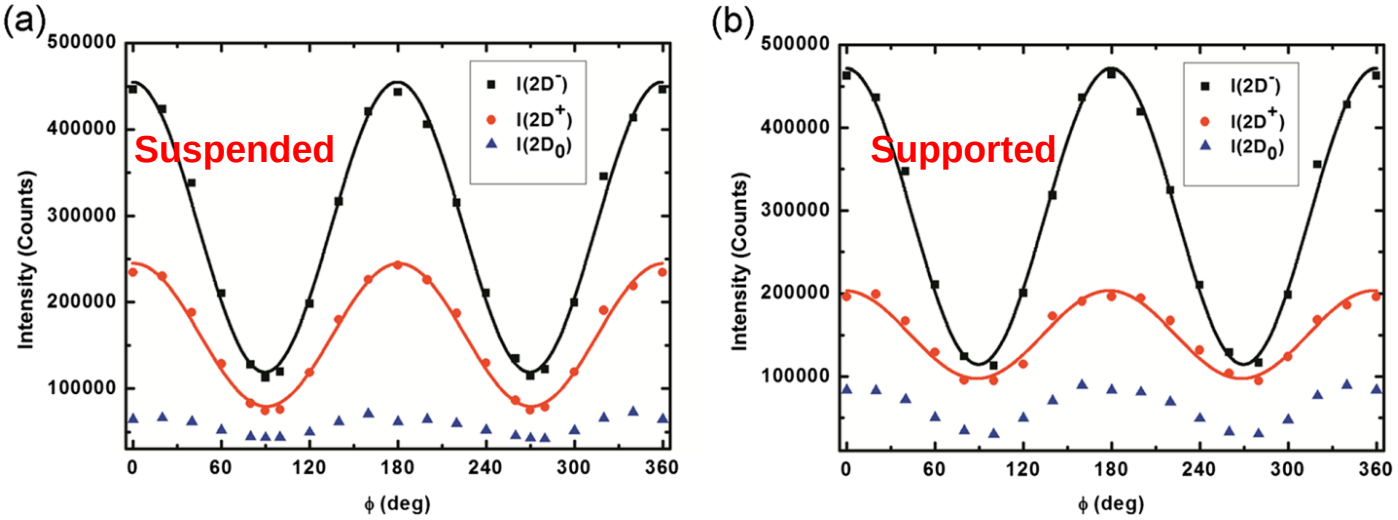
Anisotropy
of
unstrained graphene,
was subsequently
well confirmed by optical methods:

1) Microscopic Reflection Difference Spectroscopy
in the visible-frequency range
(2014 - 2015, Beijing Key Laboratory).

2) Polarized Raman spectroscopy
Also in absence of any external influences (unstrained from outside)
(2012, Taiwan), see below:

Strong sinusoidal intensity modulation*
with a period of 180°

The estimated peak positions: 2.647 and 2.660 (a), 2.647 and 2.660 cm^{-1} (b), respectively, for the $2D^+$ and $2D^-$ sub-bands.



"Figure 4. Analysis of intensity. (a) **Suspended** and (b) **supported** graphene. The plots of $I(2D^+)$, $I(2D^-)$, and $I(2D_0)$ as functions of Φ. The symbol 'I' denotes the intensity of the corresponding sub-peak obtained by fitting the related Raman spectrum with a triple-Lorentzian function. The obtained intensities are shown by the dots, which are fitted by the form of $A\cos^2(\Phi - \Phi_0)$ for $I(2D^+)$ and $I(2D^-)$, and of a constant of A, where A and Φ_0 are fitting parameters. The black and red lines display the fitting results"*.

*[Huang et al, "*Observation of strain effect on the suspended graphene by polarized Raman spectroscopy*", Nanoscale Research Letters 2012, 7:533]

By now we have the grounds to argue that

Raman spectra

(presented in various papers on the influence of strains)

largely reflect the natural anisotropy inherent in unstrained graphene.

For example, strains, caused by bending of the hexagonal lattice of graphene (as in the paper* of 29.05.2009 analyzed below), only slightly distort the characteristic Raman spectra conditioned by anisotropic structure of graphene, not changing their main form (see Fig. 6).

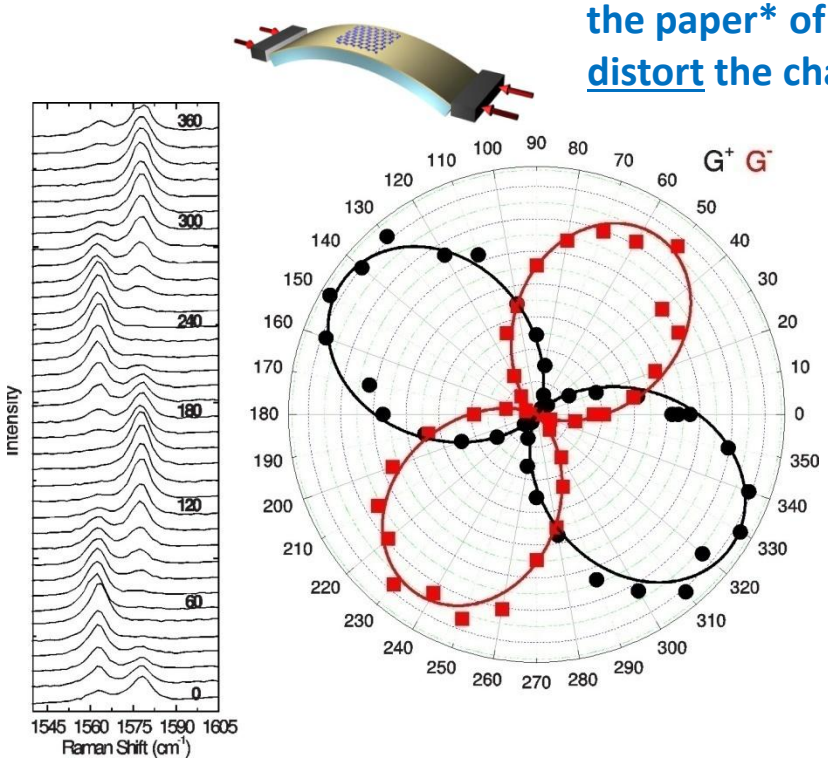


Figure 6: (Color online.) (Left) Raman spectra and (right) polar plot of the fitted G^+ and G^- peaks as a function of the angle between the incident light polarization and the strain axis θ_{in} measured with an analyzer selecting scattered polarization along the strain axis, $\theta_{out} = 0$. The polar data are fitted to $I_{G^-} \propto \sin^2(\theta_{in} + 34^\circ)$ and $I_{G^+} \propto \cos^2(\theta_{in} + 34^\circ)$, see text.

*[T. M. G. Mohiuddin at al, "*Uniaxial strain in graphene by Raman spectroscopy: G peak splitting, Grüneisen parameters, and sample orientation*", Phys. Rev. B 79, 205433 (29.05.2009)]

Comments:

It is fairly noted in the above article that

"…, the G peak is entirely due to the anisotropic terms in the electronic spectrum"

"…, in order to contribute to the G peak, electrons (interacting with phonons, G. Shp.) ***must "feel" the crystallographic directions***" (page 205433-7)

However, the difference between the spectra, obtained on strained and unstrained tested samples of graphene, is not indicated in this work.

Apparently, for this reason (and the reason stated above, in the previous slide) the degree of strain is not indicated in the description of images (Fig. 6).

Also for the above reasons: (citations)

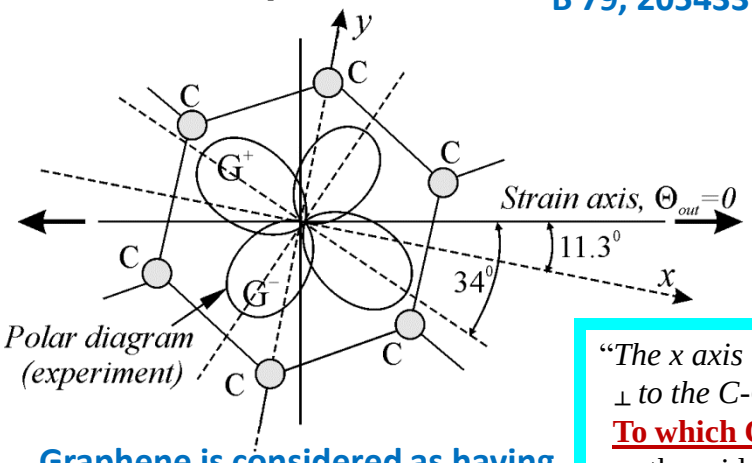
"…the inferred strains disagreed by a factor of 5 or more for similar Raman shifts[20,22-24]"

"…no significance difference was seen between the cases of uniaxial and biaxial strain[20,23,24], in contrast with theory" (page 205433-1). Etc.

Additional comments to the article*

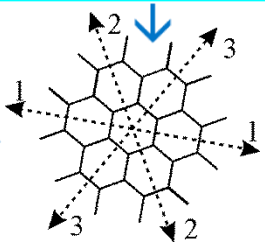
*[Uniaxial strain in graphene by Raman spectroscopy: G peak splitting, Grüneisen parameters, and sample orientation, Phys. Rev. B 79, 205433 (8 pages), 29.05.2009 by T. M. G. Mohiuddin at al.]

*According to the article**



Graphene is considered as having 6-fold rotational symmetry.

"*The x axis is chosen ⊥ to the C-C bond*". **To which C-C** of the three identical**?**



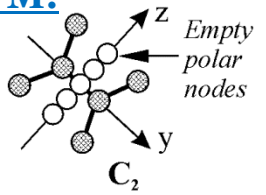
Because the orientation of the *x*-axis is ambiguous, the conclusion, "*We thus get the orientation of the graphene crystal with respect to the known strain axis*" (page 205433-6)**, is incorrect.**

and

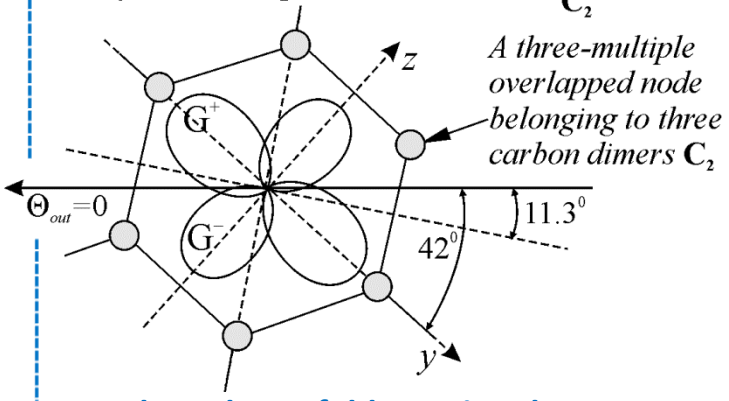
Nothing is said about the polar diagram of undeformed graphene. Hence, the conclusion about the influence of strains on the Raman spectra of graphene is incorrect.

According to the VM:

An expected result for unstrained graphene, in accordance with solutions of the wave equation



A three-multiple overlapped node belonging to three carbon dimers C_2



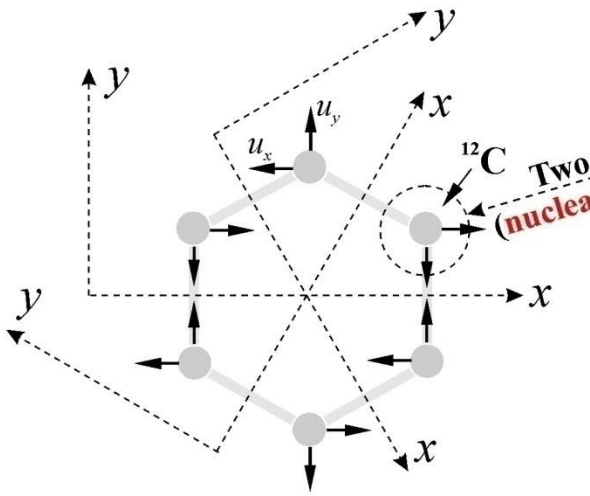
Graphene has 2-fold rotational symmetry

Supposed polar plot (above) of G^+ and G^- peaks as a function of the angle between the incident light polarization and the random crystallographic direction in graphene, as in the paper in question (11.3^0), if it will be measured with an analyzer selecting scattered polarization along this direction, $\Theta_{out} = 0$.

Two views on the structure of nodes in lattices

SM: **WM:**

[Phys. Rev. B 79, 205433 (29.05.2009)]



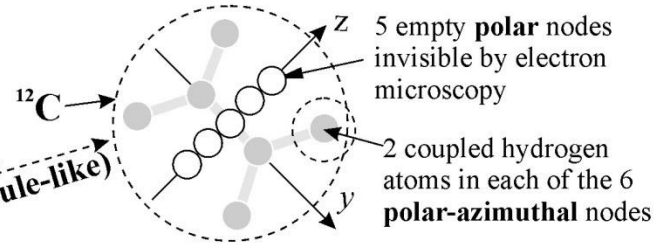
One atom ^{12}C forms each node of the lattice (conventional view)

Small arows indicate
"phonon displacements in the (x,y) basis"

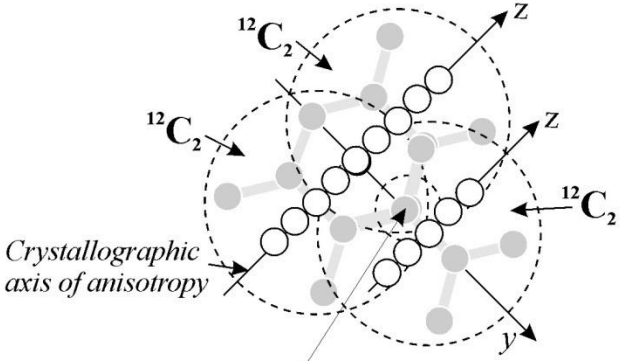
*"The x axis is chosen **perpendicular to** the C-C bond"*
(page 205433-6)

To which of 3 pairs of the identical C-C bonds?

Two different atomic models (nuclear and shell-nodal, molecule-like)

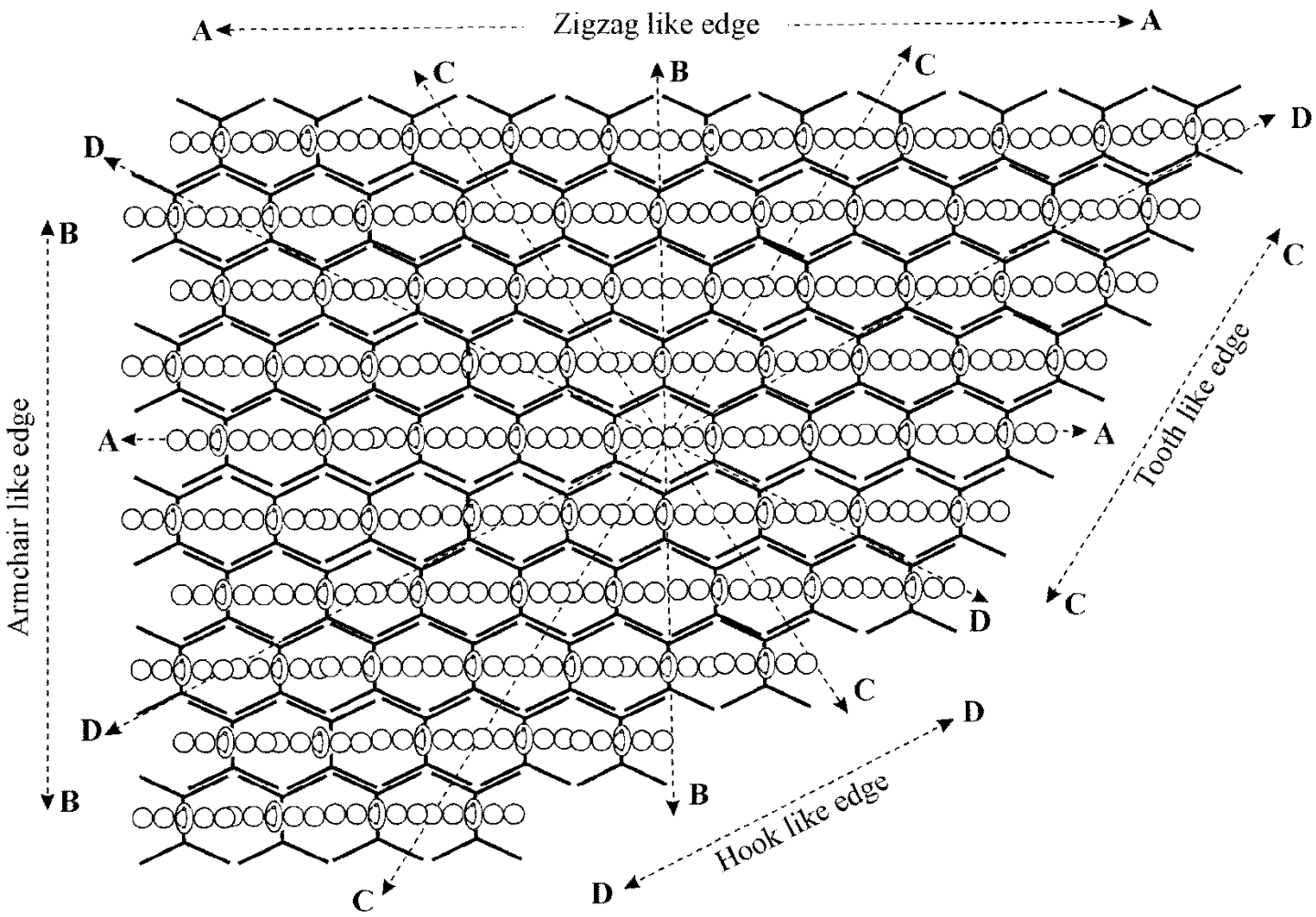


Six-nodal elementary molecule of hydrogen atoms (carbon "atom") ^{12}C
(according to the WM)

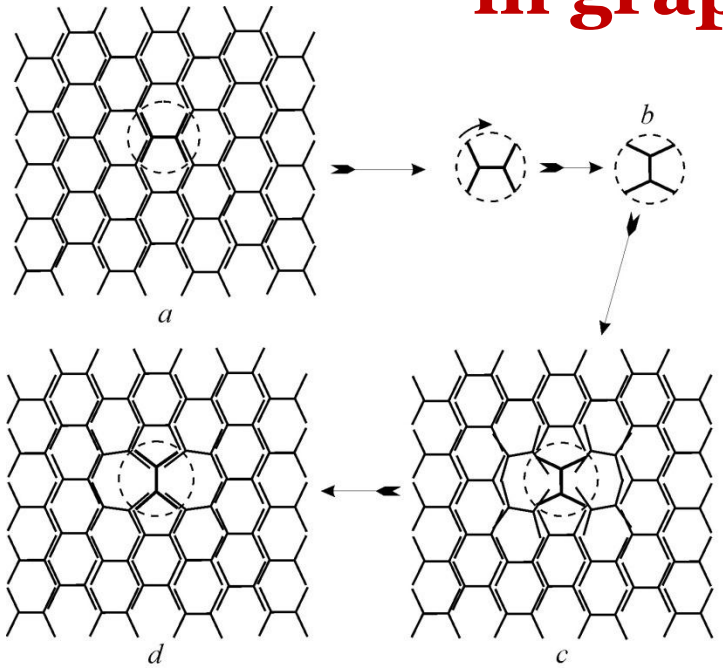


Three nodes, belonging to three carbon dimers $^{12}C_2$, form, being overlapped, each node of the lattice
(according to the WM)

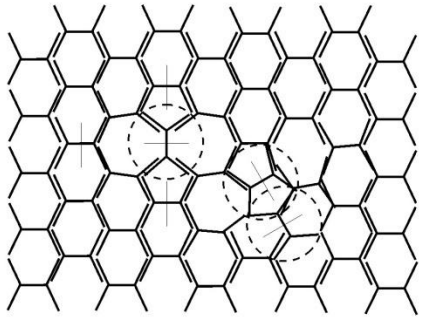
The shape of the edges in graphene



Topological defects in graphene



The formation of pentagon-heptagon defects (SW defects)

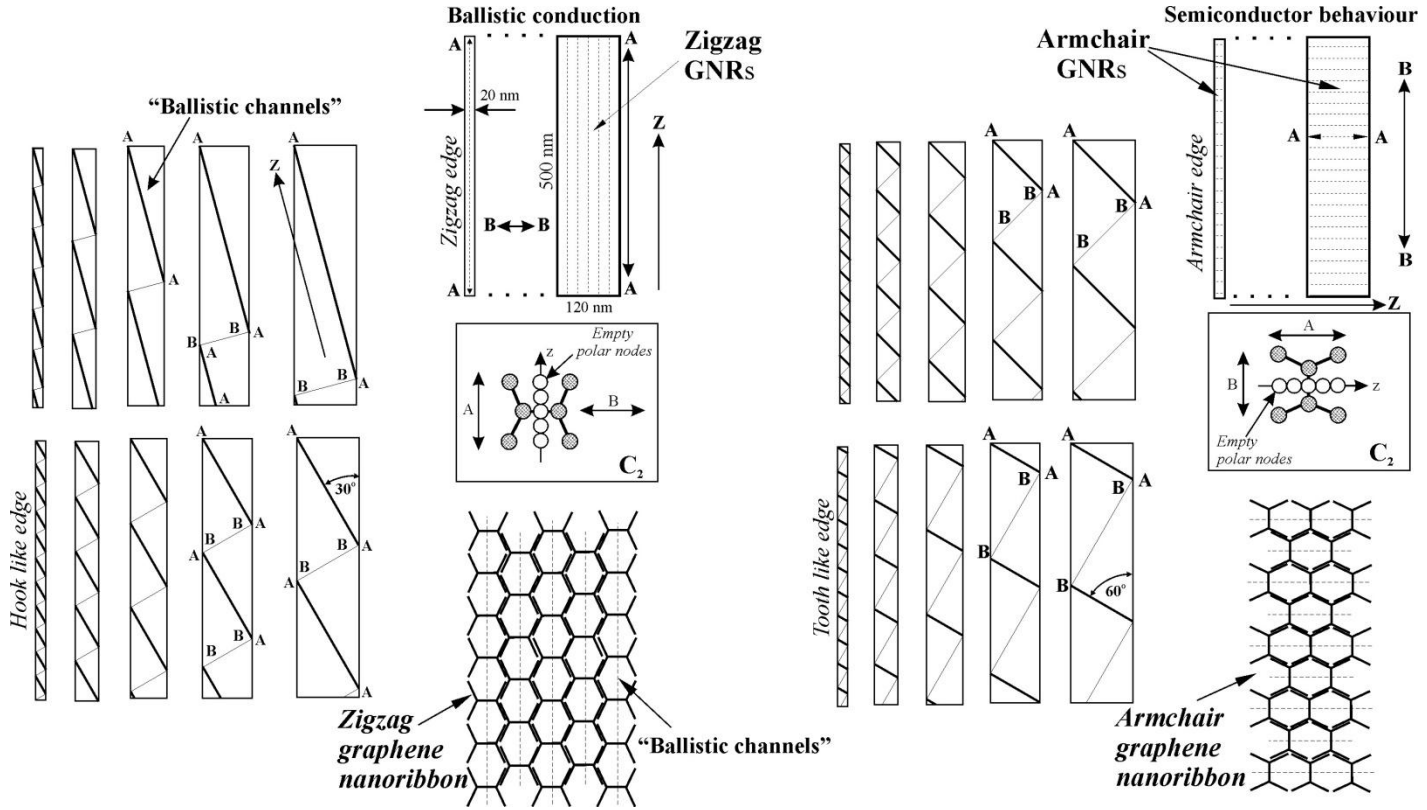


Scheme of binding in complex metastable defects

Topological defects, such as **pentagon-heptagon pairs,** appear due to arising, when heated, of the rotational modes (additionally to vibrational) that leads to a violation at some instant of equilibrium bonds and the formation of short-lived bonds with other nodes of the nearest carbon dimers, as indicated in this scheme.

When cooling, **self-assembly** takes place: the excited region of the lattice returns to the initial state of equilibrium, the defect disappears.

Graphene nanoribbons



The shape of the edges of graphene nanoribbons, different widths and lengths, depends on the orientation of the crystallographic axis z in relation to the orientation of the edges.

Just a certain orientation of the z axis, but not the shape of the edges (as is commonly believed), affects the properties of nanoribbons, for example, electrical resistance, because the chains of empty polar nodes, which are responsible for the "ballistic" motion of charge carriers, are parallel to this axis (A-A, in the drawings).

We should not confuse cause and effect.

Thus, independent experiments, carried out by various methods in different laboratories, confirmed our prediction that two-fold symmetry is a feature inherent in the hexagonal lattice of graphene.

Recall that this feature is a consequence of the shell-nodal structure of the carbon "atom" (which is the six-nodal elementary molecule of hydrogen atoms) and the specifically ordered binding of these "atoms" in the hexagonal lattice.

Additional confirmations, as we believe, will be obtained in the ongoing experiments studying the effect of the Second Harmonic Generation (SHG), and from other relevant works.

Practical significance of the discovery of graphene anisotropy

Theoretically predicted and confirmed experimentally, the anisotropy of graphene should be taken into account in the electronics industry of the future, which will be based on the use of graphene.

A strictly defined orientation of the crystallographic axis of all anisotropic monocrystals on substrates is an obligatory self-evident initial technological stage, which provides electronic devices, produced on such crystals, identical in parameters.

[G. Shpenkov, *Method for manufacturing nanoelectronic devices made from 2D carbon crystals like graphene and devices obtained with this method*", file EP2401764, priority date 29.02.2009]

https://register.epo.org/application?number=EP10707863

Particular Conclusion

1. **Graphene has two-fold rotational symmetry and is an anisotropic crystal.**
2. **Invisible polar nodes, being bound each other, take the form of parallel hollow channels that is favourable for the "ballistic" motion of electrons.**

Hence, it becomes understandable and explainable now:

Why ***"Graphene…is an interesting mix of a semiconductor…and a metal"***
Why ***"Electrons in graphene … have very long mean free paths"***

[A.H. Castro Neto, F. Guinea, N. M. R. Peres, K. S. Novoselov and A. K. Geim, *The electronic properties of graphene*, Rev. Mod. Phys. 81, 2009]

Why carbon "***Nanotubes can be metallic or semiconducting,...***"

[Tsuneya Ando, *The electronic properties of graphene and carbon nanotubes*, Review, NPG Asia Materials (2009) 1, 17–21; doi:10.1038/asiamat.2009.1]

Carbon nanotubes, rolled-up form of graphene, have either conductivity, metallic or semiconducting.

The rolling-up is realized mainly along two crystallographic directions: along the major axis of anisotropy and in perpendicular to it direction. They define the thermodynamically favourable minimum-energy states.

General Conclusion

We highlight here four breakthrough discoveries

of a series of others that we made within the WM,

which alter our conventional ideas regarding the structure of matter:

- **1. "Atoms" ($Z \geq 2$), being stable wave formations, have the shell-nodal structure and are elementary molecules of hydrogen atoms. Their nodes, filled with paired hydrogen atoms, are bound with each other by strong interaction.**

- **2. The main role at the formation of molecules and crystals plays a spatial arrangement of the nodes and internodal strong bonds in the "atoms". Electrons play the secondary role: they define only the strength of chemical bonds.**

  Chemical "covalent" bonds are realized directly along strong internodal bonds each of the joined "atoms" or their dimers.

- **3. All "atomic" isotopes (their structure and relative mass) are defined by the extent of filling all potential and potential-kinetic nodes of the "atoms" with hydrogen atoms (slide 23).**

- **4. The original cause of the observed periodicity in properties of chemical elements is the quasi-periodicity of the shell-nodal structure of the "atoms", generalized in the relevant Periodic Table (slide 25).**

Judging by the results, the WM can be considered as a real alternative to the Standard Model

Additional references

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The true structure of atoms
was the eternal problem of mankind and
remains a problem to this day.

The fundamental discovery
that we have made
has brought us closer to solving this
great puzzle.

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for your attention!

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Georgi P Shpenkov, J Laser Opt Photonics 2017, 4:3(Suppl)
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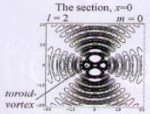
The shell-nodal structure of the atoms

Analyzing particular solutions of a three-dimensional (not Schrodinger's) wave equation in spherical polar coordinates, we have found that they contain information about the atomic structure. Considered as the wave formations, atoms have a quasi-spherical shell-nodal structure coincident with the nodal structure of standing waves in three-dimensional wave space-field. Their nodes, filled with paired hydrogen atoms, are bound by strong interaction. Each atom with $Z \geq 2$ represents a specific elementary molecule of hydrogen atoms, to which we refer proton, neutron and protium. The shell-nodal structure of the atoms was verified in different ways. All of them completely confirmed the trueness of the found structure. A unique opportunity for the direct verification of the discovery gave us graphene. According to the modern data, a two-dimensional hexagonal lattice of graphene has a six-fold axis of symmetry. Hence, in full agreement with a basic symmetry theory, physical properties of graphene must be isotropic in a plane perpendicular to this axis, in particular, electrical conductivity. However, our studies have shown that graphene actually has a two-fold axis of symmetry, due to the shell-nodal structure of carbon atoms, and is an anisotropic crystal. Along the main axis of anisotropy, there are empty potential-kinetic polar nodes (invisible for modern devices), which form a specific channel conducive to the "ballistic" motion of charges in it. In this direction, graphene behaves like a metal. In a perpendicular direction graphene exhibits semiconducting properties. Laboratory tests completely confirmed the predicted feature of graphene, following from particular solutions of the wave equation. Polar diagrams of conductivity of one-atom thickness graphene layers, measured along a plane in all directions, have a characteristic elliptical form for all test samples (they had a round shape) which are inherent in anisotropic materials. Experiments performed by polarized Raman spectroscopy also confirmed the above feature of graphene, found theoretically. Thus, "atoms" are the wave formations. Having the shell-nodal structure, they represent elementary molecules of hydrogen atoms.



$$\hat{\psi}_p = A\sqrt{\frac{\pi}{2\rho}}J_{l+\frac{1}{2}}(\rho)\Theta_{l,m}(\theta)e^{\pm im\varphi}$$

Figure: *A particular solution*

Biography

Georgi Shpenkov has completed his PhD in 1968 from Ioffe Physico-Technical Institute of RAS (Leningrad) and DrSc degree in 1991 (Tomsk, RAS). He is a retired Professor, an Honorary Member of the Russian Physical Society. He has published 9 books and more than 100 papers in different issues. His main achievements are the discoveries of the nature of mass and charge of elementary particles, the Shell-Nodal (molecule-like) structure of the atoms, the microwave background radiation of the hydrogen atom, the Dynamic Wave structure of the elementary particles, the fundamental period-quantum of the decimal code of the universe, the fundamental frequencies of the atomic, subatomic and gravitational levels, the true nature of the Lamb shift, etc.

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