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Discovery
of the wave nature
of
GRAVITATION

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I keep talking about

key discoveries

that we have made in the framework of the theories of

the Wave Model (WM)

The WM is unique. We developed it relying on
dialectics (dialectical philosophy and its logic).

All of the discoveries, including the discovery of the wave nature of gravity, were obtained mainly when analyzing solutions of

(a) **the classical wave equation,**

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

(b) **the previously unknown equation,**

$$\hat{F}_s = \frac{4\pi r^3 \varepsilon_0 \varepsilon_r}{1 + k^2 r^2}(1 - ikr)\hat{\upsilon} i\omega \qquad (2)$$

(we first obtained), describing the **behavior** of elementary particles, **considered** in the **WM** as **pulsating wave** formations [1, 2].

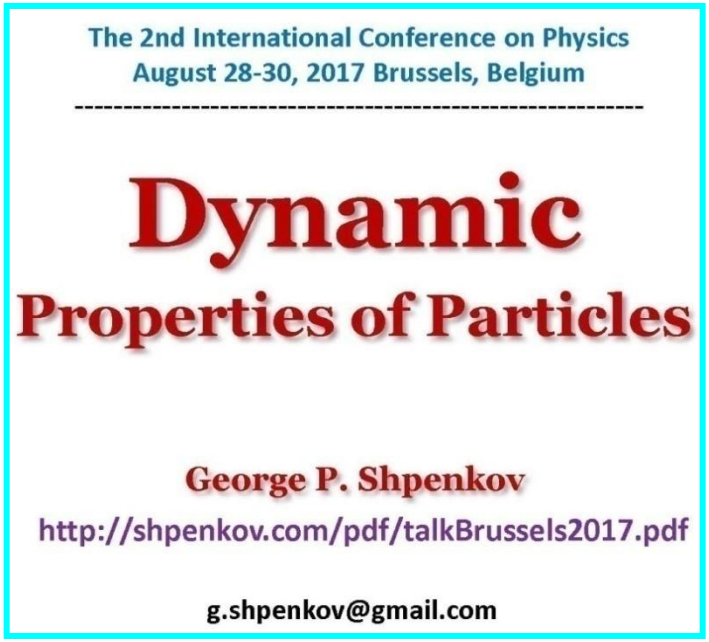
About the discovery

of the **wave nature** of **gravity** and
the **fundamental frequency** of the **wave gravitational field**
(made in 1996 [3]),

I have repeatedly reported, in particular, in 2017 at the Conference in Brussels (*keynote speech on the* ***Dynamic Model*** [2], which is a **part** of the **WM**):

shpenkov.com/pdf/talkBrussels2017.pdf

youtube.com/watch?v=jzIixlsFDuY



Yet earlier, in 2010, the material devoted to the discovery was **presented** at the 19th International Conference on the **General Theory** of **Relativity** and **Gravity** in Mexico City [4].

Generally, our **first publications** on this topic began to appear **since 1996** [3].

From 2016, I started posting videos about WM discoveries on YouTube:

youtube.com/channel/UCMc6igBG0cEYh2YCZiyVXPA/videos

In accordance with
the Dynamic Model (DM):

Elementary particles

are **finite-infinite formations** of the wave field-space of the Universe, **having** micro (**subatomic**) and mega (**gravitational**) spherical **wave** shells, **pulsating**, respectively, at the **fundamental frequencies**:

$$\omega_e = 1.869162505 \times 10^{18}\ s^{-1} \quad \text{and} \quad \omega_g = 9.158082264 \times 10^{-4}\ s^{-1}$$

inherent in the particles.

And the gravitational interaction of bodies

is **the result of resonant wave exchange (interaction) of all elementary particles, which make up the bodies, occurring at the frequency** ω_g.

In modern physics

Gravitational interaction

is described, partially, by the **Newton theory** of gravitation, and, in a general case, by the **general theory** of gravitation, and, in the so-called quantum limit, by unfinished yet the **quantum theory** of gravitation [5, 6].

However, the **above theories**, starting with Newton's theory,

unable to explain

the **nature** of gravity. They all **focus on the description** of experimental facts related to gravity.

Newton, in his commentary (General Scholium, 1713) to the 2nd edition of his Principia, wrote,

"*... I have not been able to discover the cause of those properties of gravity from phenomena, and I frame no hypotheses* [*hypotheses non fingo*]; ...».

For this reason:

All attempts of theoretical physics

to find the relationship between

gravitational interaction,

described by the **general theory** of **relativity** (GTR), and the other **two types** of fundamental interactions considering in modern physics, **strong** and **electromagnetic**, that is, to **create** a **unified field theory** (the "theory of everything", including the so-called "weak interaction"),

end in failure

despite the **great efforts** of theorists.

Gravity is still one of the most **incomprehensible phenomena** in natural science.

In-depth analysis conducted by us showed that the **gap** in understanding the phenomenon of gravitation is due to an **inadequacy** of **basic concepts** of the **Standard Model** (SM) and theories that adhere SM to **reality** (**general relativity** relates to such theories**)** [5].

Everything in Nature
is in natural harmony
and interconnected.

Therefore, if the theories are **correct**, the indicated **harmony** and **interconnection must necessarily be present** in the description of various interactions.

The description **should be unit**, universal **for all types** of **interactions**.

Judging by the **results** of research that we **first started** publishing in 1996
(a book "*Alternative Picture of the World*" in three volumes [3]),

the Wave Model

that we are developing **fully meets** the above **requirements**.

Therefore, it is not surprising that it **has already solved a number of problems, which are unsolvable in principle (like the problem of gravity) by existing basic theories of physics.**

The Wave Model,

relying on dialectics,

includes two theories (models):

1) The Dynamic Model of elementary particles and

2) The Shell-Nodal Model of atoms.

By now, we have obtained enough unique data to say, without exaggeration, that

the WM, based on new physical concepts consistent with dialectics,

describes reality more correctly

than **modern theories based on abstract-mathematical (fictional) postulates, formal logic and adhering to the Standard Model**.

I will show this with an example of solving the problem of gravity, which we are considering here.

Recall

Two basic laws of physics,

а) **Newton's law** of gravitation (1686) and

б) **Coulomb's law** of interaction of point electric charges (1785-1788):

$$(3) \qquad F = G\frac{m_1 m_2}{r^2} \qquad \text{and} \qquad F = k\frac{q_1 q_2}{r^2} \qquad (4)$$

Both of the above laws refer to

Opposite worlds: megaworld and microworld

They **apply** to **phenomena** occurring at different levels of the Universe.

Being **similar** in **form**, they have the **same functional dependence**: both for interacting giant **masses** and for tiny elementary **charges**.

However, **since** their **discovery,** these laws are considered **different**, **completely unrelated**.

This is due to the fact that **the nature** of the **interactions** described by the laws is still **not understood properly** by modern physics because of

unknowing, above all, the nature of

***mass* (*m*)** [7] **and *electric charge* (*q*)**.

Thus,

Modern physics, which relies on the **Standard Model**, has so far ***not been able*** to ***uncover*** the ***nature*** of the **key** physical **parameters** included in both laws: ***mass*** m and ***charge*** q.

The *great mystery* is also what parameters determine the *proportionality factors* G and k.

The **factor** entering **Newton's law**, called the ***gravitational constant***, $G = 6.67384(80) \times 10^{-8}\ cm^3 g^{-1} s^{-2}$, is a parameter whose **magnitude** and **dimensionality** have been determined **experimentally**.

The **magnitude** and **dimensionality** of the **coefficient** of proportionality k in the **Coulomb law** are **unknown**:

> In the **objective** system of units **CGS** (cm, g, s), k **was taken** as a **dimensionless unit**, $k = 1$. This led to the **absurd dimensionality** of charge q, expressed by **fractional powers** at units of length and masses, $[q] = g^{1/2} cm^{3/2} s^{-1}$.
>
> In the **international SI system**, the situation with the **dimensionality** is **similar**. It is convincingly shown, for example, in [8, 9].

Recognizing
the wave nature of all objects,

harmony and interrelation of all processes and phenomena in the Universe,

we came to the **conclusion**, following the elementary logic, that **both laws,** (3) and (4), are **particular cases** of the **unified law** of Nature determining **wave interactions**, to which all objects of different levels of the Universe obey.

Indeed, **as we expected**, a study within the WM led us to the **discovery** of the

Universal Law of Exchange!
(interaction)

How we have come to this Law?

The Wave Model

is based on the fundamental concept

according to which

all objects, processes and phenomena in the Universe have the wave nature.

This naturally means that

the Newton and **Coulomb laws,** $F = k\frac{q_1 q_2}{r^2}$ and $F = G\frac{m_1 m_2}{r^2}$, are **laws**

describing

wave interactions (!)

of the

wave objects

that ***behave like wave formations***, characterized, respectively, by such fundamental parameters as ***mass*** and ***charge***.

To find out the form of the

Universal Law of Exchange (interaction),

obviously, it was **necessary** to **understand** the **nature** of the **four** physical **parameters**, included in both laws, and **their interrelation**. Namely, we had to find out:

1) **what** is **mass** m, what is **its nature**;
2) **what** is **charge** q, what is **its nature** and, therefore, the **true dimensionality** (expressed by integer powers of the objective units of the CGS system);
3) **on which** parameters the **gravitational constant** G **depends**;
4) **on which** parameters the proportionality **coefficient** k in the Coulomb law **depends**, **what** is its **magnitude** and **dimensionality**;
5) the **relation between** the physical **parameters** m and q;
6) the **relation between** the proportionality **coefficients** G and k.

Modern physics based on the **Standard Model** is **not able** to **deal with** these problems. In the framework of modern theories of physics, **these problems** are **unsolvable in principle** and, therefore, **remain** a **white spot** holding back the development of physics.

Below are solutions

to the above problems that we have obtained within the framework of the WM:

The nature of basic parameters

in the laws of Newton and Coulomb, revealed thanks to the Wave Model:

1) The **mass** of particles m is **associated**, has a **dynamic wave character** (see [2]). The **rest mass** of the particles **does not exist**.

2) **Electric** q_e , **magnetic** q_m and **gravitational** q_g **charges** are **exchange charges**; they **determine** the **rate** of the corresponding **wave exchange** (interaction). Their **dimensionality** is $g \times s^{-1}$.

3) **Gravitational constant** G is a quantity **depending on** the **fundamental frequency** of elementary particles at the **mega level** ω_g (the latter determines gravitational exchange, interaction, of particles):

$$\boxed{G = \omega_g^2 / 4\pi\varepsilon_0} \quad ! \qquad (5)$$

The **constant** G is **known** from experiment, $G = 6.67384 \times 10^{-8}\ cm^3 g^{-1} s^{-2}$; ε_0 in the WM is the **absolute unit** of **density**, $\varepsilon_0 = 1\ g \times cm^{-3}$. Hence, the frequency ω_g is equal to

$$\boxed{\omega_g = \sqrt{4\pi\varepsilon_0 G} = 9.158082264 \times 10^{-4}\ s^{-1}} \quad ! \qquad (6)$$

4) The **coefficient** of proportionality in the **Coulomb law** is equal to $1/4\pi\varepsilon_0$; its **dimensionality** is **inverse** to the dimensionality of **density**:

$$\boxed{k = \frac{1}{4\pi\varepsilon_0}\ cm^3 \times g^{-1}} \quad ! \qquad (7)$$

5) The **parameters** *m* and *q* in the **laws** of **Newton** and **Coulomb**, (3) and (4), are **related** as follows:

а) at the **gravitational level** by the relation

$$q_g = m\omega_g \tag{8}$$

б) at the **atomic** and **subatomic levels** in a similar way

$$q_e = m\omega_e \tag{9}$$

where

$$\omega_e = e / m_e = 1.869162559 \times 10^{18}\ s^{-1} \tag{10}$$

is the **fundamental frequency** of atomic and subatomic levels. The **parameter** *e* in (10),

$$\boxed{e = m_e \omega_e = 1.702691627 \times 10^{-9}\ \ g \cdot s^{-1}} \tag{11}$$

is the elementary quantum of the rate of mass exchange (interaction),

"**electron charge**", and m_e – associated **electron mass**.

6) The **parameters** G and *k*, as can be seen from (5) and (7), **are interconnected** by the relation

$$\boxed{G = k\omega_g^2} \tag{12}$$

Thus, as can be seen,

A radically new concept

on the structure of elementary particles, underlying the Wave Model,

led to the discovery

of

basic parameters of the particles

(previously unknown in physics)

and the relationship of these parameters.

Such parameters are characteristic namely for particles that have a wave nature and behave *like wave formations* [2, 6].

Having revealed, following the Wave Model, the physical meaning of the enumerated above fundamental parameters, we have come to the discovery of the

Universal Law of Exchange,

which describes **three types** of **fundamental** interactions,

strong, ***electromagnetic*** and ***gravitational***:

$$\boxed{\langle F \rangle = \omega_f^2 \frac{m_1 m_2}{4\pi\varepsilon_0 r^2}} \qquad (13)$$

($\langle F \rangle$ - averaged value, for the inphase and antiphase ($\Delta\varphi$ = o; π) cases, modulo)

m_1 and m_2 are **associated masses** of interacting objects,

$\varepsilon_0 = 1\ g \times cm^{-3}$ is the **absolute unit** of **density**,

ω_f is one of the two **fundamental** frequencies, ω_e or ω_g.

For $\Delta\varphi$ = o:

$$\boxed{\langle F \rangle = -\omega_f^2 \frac{m_1 m_2}{4\pi\varepsilon_0 r^2}} \qquad (13a)$$

Coulomb's *and* Newton's laws

are particular cases of

the Universal Law of Exchange (13) [5, 6, 10, 11]**:**

Coulomb's law **Newton's law**

(14) $$\boxed{\langle F_e \rangle = \omega_e^2 \frac{(zm_e)(Zm_e)}{4\pi\varepsilon_0 r^2}}$$ *and* $$\boxed{\langle F_g \rangle = \omega_g^2 \frac{(zm_n)(Zm_n)}{4\pi\varepsilon_0 r^2}}$$ (15)

Eq. (14) describes the ***exchange interaction*** *at the level of the wave* ***"electric" field*** *of elementary quanta of exchange, having the* ***associated mass*** m_e *and the* ***exchange*** *("****electric****")* ***charge***

$$q_{el} = e = m_e \omega_e \qquad (16)$$

Eq. (15) describes the ***exchange interaction*** *at the level of the wave* ***gravitational field*** *of gravitons-nucleons having the* ***associated mass*** m_n *and the* ***exchange*** *(****gravitational****)* ***charge***

$$q_{gr} = m_n \omega_g \qquad (17)$$

In the case *of describing the "nuclear" (****strong) interaction*** *(exchange),*

$$q_{str} = m_n \omega_e, \qquad (18)$$

and

$$\boxed{F_{strong} = \omega_e^2 \frac{(zm_n)(Zm_n)}{4\pi\varepsilon_0 r^2}} \qquad (19)$$

Strong interaction

Fundamental gravitational frequency (6)

$$\boxed{\omega_g = \sqrt{4\pi\varepsilon_0 G} = 9.158\times10^{-4}\ s^{-1}}$$

of particles ***follows from the Universal Law of exchange*** *(13)* , $\langle F \rangle = \omega_f^2 \dfrac{m_1 m_2}{4\pi\varepsilon_0 r^2}$, ***when comparing*** *it with Newton's law of gravitation (3)* , $F = G\dfrac{m_1 m_2}{r^2}$.

$G = 6.67408\times10^{-11}\ m^3 kg^{-1} s^{-2}$ *is the Newtonian constant of gravitation (experimental);*

$\varepsilon_0 = 1\ g\cdot cm^{-3}$ *is the absolute unit of density.*

ω_g *is the* ***proper frequency*** *of elementary particles, responsible for their* ***gravitational exchange*** *(interaction) at the* ***<u>mega level</u>*** *of the Universe.*

Gravitational
wave radius
of elementary particles,

(*elementary radial gravitational wave*)

corresponding to the fundamental frequency ω_g ***, is***

$$\boxed{\lambda\!\!\!^{-}_{g} = \frac{\lambda_g}{2\pi} = \frac{c}{\omega_g} = 3.2736 \times 10^{13}\ cm} \qquad (20)$$

Thus

Gravitation,

like everything else in the Universe, has the wave nature!

The nature of gravitation:

(Definition, in accordance with the WM)

Gravitational interaction of bodies is the result of resonant wave exchange (interaction) of all elementary particles, which make up the bodies, occurring at the extremely low proper fundamental frequency ω_g **, inherent in each particle.**

In accordance with the Dynamic Model,

particles pulsate

simultaneously at two fundamental frequencies.

The wave **exchange interaction** (gravitational, electromagnetic and strong) of the particles with the environment (the field and other particles) is **realized** at **these frequencies**, following the Universal Law of Exchange (13).

The first,

extremely high fundamental **frequency** $\omega_e = 1.869162559 \times 10^{18}\ s^{-1}$ of particle pulsations, is responsible for **electromagnetic** and **strong interactions**.

This frequency **determines**, in particular, the **ordering** in the **arrangement** of interacting **atoms** (which are wave formations in accordance with DM) in crystals with an **average step** (inter-nodal distance, lattice parameter) of the order $3.2 \times 10^{-8}\,cm$ exactly **equal** to **twice** the wave radius $2\lambda\!\!\!^{-}_e$, where

$$\boxed{\lambda\!\!\!^{-}_e = \frac{c}{\omega_e} = 1.603886492 \times 10^{-8}\ cm} \qquad (21)$$

The second,

extremely low fundamental frequency of particle pulsations (6)

$$\omega_g = 9.158082264 \times 10^{-4} \ \ s^{-1}$$

is **responsible** for their **gravitational interaction**.

Confirmation of the **reality** of particle **pulsations** with frequency ω_g, and their **interaction** at this frequency, is the **coincidence** of **theoretical calculations** of the **average radii** of the **orbits** of the **planets** and their **satellites** with **astronomical data** [10, 12] (the formula of the spectrum of the orbits and other details will be shown below).

The **correlation** between the **results** of the **calculation** and the **data** of **astronomical observations** turned out to be **quite satisfactory**.

At a **distance** from the Sun, **equal** to the average **gravitational wave radius** (20),

$$\lambda\!\!\!^{-}_g = \frac{c}{\omega_g} = 3.274 \times 10^{13} \ cm = 327.4 \times 10^{6} \ \ km \ ,$$

is the **ring** of **asteroids**. The **gravitational radius** is the **boundary separating** the **vibrational** and **wave zones** of the **particle**. Therefore, the **neighbourhood** of this **boundary** is a spatial **region-sphere** of **intensive movement**.

Thus

The wave shell of the gravitational wave radius $\lambda\!\!\!^{-}_g$ (20) of a particle in star systems

(**which in turn are spherical objects of mega space - atoms of megaworld**)

separates

the vibrational region

of the spherical field-space of a star

and its wave region.

We on Earth and in near-Earth space are inside a giant gravitational wave, $\lambda\!\!\!^{-}_g = 327.4 \times 10^6 \ km$ ***, and, therefore, perceive the gravitational field not as a wave field, but as stationary.***

The **power** of **gravitational exchange** ("force" of gravity) for **individual particles**, as follows from the Universal Law of Exchange [6, 11], is an **insignificant** value.

But a **huge number** of particles (the Sun consists of approximately 10^{57} nucleons) **compensates** for this **negligibly small** value and, in **sum**, at the **mega level**, leads to a very **significant effect** – gravitational attraction.

One of the proofs of the validity of the WM concept about the wave nature of gravity is the discovery of the gravitational spectrum of the orbits of the planets and their satellites.

Consider this.

The nature

of the existing order in the arrangement of the

orbits of the planets

at strictly certain average distances from the Sun, and the

orbits of their satellites,

is still

an insoluble problem for modern physics and astrophysics,

one of the unsolved mysteries.

How does official physics, for all that,
explain this fact?

Newton's law and **Kepler's** laws allow us to find the **relationship of** the **size** of the **orbits** of the planets **with** their **periods** of **revolution.**

However, it is impossible to calculate the radii of the orbits by these laws.

The Standard Model is also helpless here, as in many other cases.

Therefore, **until now**, the **distance** of planets from the **Sun** (average radii of orbits) is **calculated** using a simple **empirical formula** proposed by J. D. Titius **250 years ago**, in 1766, and further popularized by J. E. Bode in his works in 1772.

This **formula** is named in their honour by the **Rule of Titius-Bode** (or Bode's Law).

In one version of the writing of Bode's law,

The average radius of orbits

(in astronomical units) **obeys** the formula

$$R_i = \frac{D_i + 4}{10} \qquad (22)$$

where $D_{-1} = 0, \quad D_i = 3 \times 2^i, \; i \geq 0.$

The **calculated** values **correlate** in a **certain range** of variation of the **values** with **astronomical data**, but not for all planets.

For example, in a **calculated orbit** for i = 3, instead of a planet, **there is** an **asteroid belt**. Why? Unknown. The orbits of **Neptune** and **Pluto** also fall out of the calculations performed by this empirical formula.

And **most importantly**, the **empirical rule** of **Titius-Bode**

has no theoretical substantiation.

Conceptual basis for analytical derivation of the formula (22) is missing.

There is only a **trivial verbal explanation** (essentially, a **statement** of a **fact taken for granted**) according to which at the stage of **formation** of the **Solar System** a **regular structure** was **formed** from **alternating areas** in which **stable orbits** could or could not exist according to the so-called **rule** of **orbital resonances** (a certain ratio of the radii of neighbouring orbits).

Having solved the problem of orbits, we came to the discovery of the

Spectrum of equilibrium wave gravitational shells of particles

$$r_{\nu,q} = \lambda\!\!\!^{-}_{g} z_{\nu,q} = 327.4 \cdot 10^{6} \cdot z_{\nu,q} \quad km \qquad (23)$$

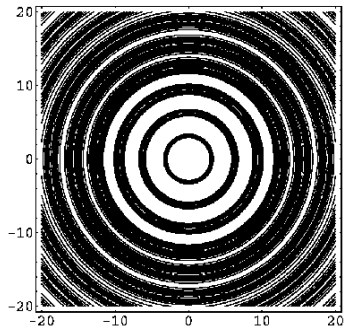
!

where $\lambda\!\!\!^{-}_{g} = c/\omega_g = 1/k_g$ is the **gravitational wave radius** of particles (20), corresponding to the **fundamental frequency** of the gravitational wave field, ω_g , determined from the **solutions** of the **equation** for the **central exchange** (2) that we **first obtained** (см. [2, 7]):

$$\hat{F}_s = \frac{4\pi r^3 \varepsilon_0 \varepsilon_r}{1 + k^2 r^2}(1 - ikr)\hat{\upsilon} i\omega$$

where $z_{\nu,q}$ are **roots** (zeros) of Bessel functions [13] – **solutions** of the **radial component** of the wave equation (1),

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



$l = 0$

$m = 0$

General solution

$$\boxed{\hat{\psi} = \hat{R}_l(\rho)\Theta_{l,m}(\theta)\hat{\Phi}_m(\varphi)} \qquad (24)$$

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

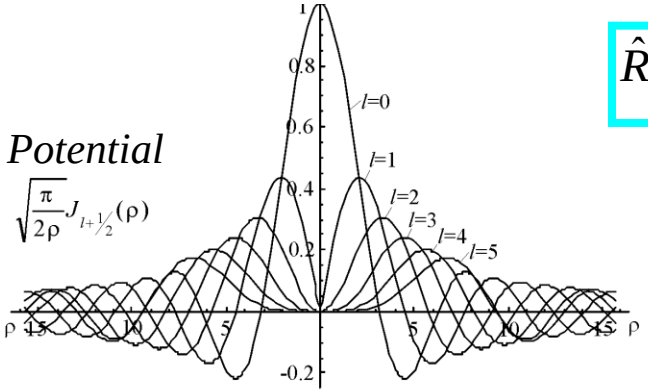
Radial solutions:

$$\boxed{\hat{R}_l(\rho)/A = \sqrt{\pi/2\rho}\,(J_{l+1/2}(\rho) \pm iY_{l+1/2}(\rho))} \qquad (25)$$

$l = 0,1,2,...; \quad m = 0, \pm 1, \pm 2, ..., \pm l$

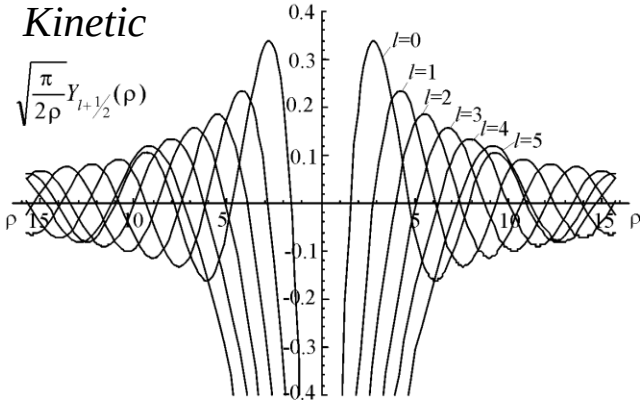
Potential

$\sqrt{\frac{\pi}{2\rho}}J_{l+1/2}(\rho)$



Kinetic

$\sqrt{\frac{\pi}{2\rho}}Y_{l+1/2}(\rho)$



$\rho = kr = r/\lambda\!\!\!^{-}$ – **relative radius** of wave **characteristic shells**, determined by **roots** $z_{\nu,q}$ (**zeros** and **extreme** values) of the **Bessel functions**:

$$\boxed{z_{\nu,q} = \rho = kr_{\nu,q}} \qquad (26)$$

$\nu = l + 1/2$ is the **order** of the functions,
q is the **number** of **zero** or **extremum**; $k = \omega/c$

$k = k_e = \omega_e/c = 1/\lambda\!\!\!^{-}_e$ (for **subatomic** and **atomic** levels)

$k = k_g = \omega_g/c = 1/\lambda\!\!\!^{-}_g$ (for the **gravitational** level)

Hence, $\boxed{r_{\nu,q} = \lambda\!\!\!^{-}_g z_{\nu,q}}$ (see. (23))

Thus, as follows from the WM,

Equilibrium orbits of planets of stellar systems and their satellites

are determined by simple, in form, equality (23):

$$\boxed{r_{\nu,q} = \lambda\!\!\!^{-}_{g} z_{\nu,q}}$$

This expression **contains** only **two** parameters: **one** of them is the **wave gravitational radius** of elementary particles $\lambda\!\!\!^{-}_{g}$, **corresponding** to the characteristic **extremely low** frequency of their **pulsations** ω_g ; the **second** parameter is the **solution** of the **radial** component of the **wave equation** – **roots** $z_{m,n}$ of **Bessel functions**.

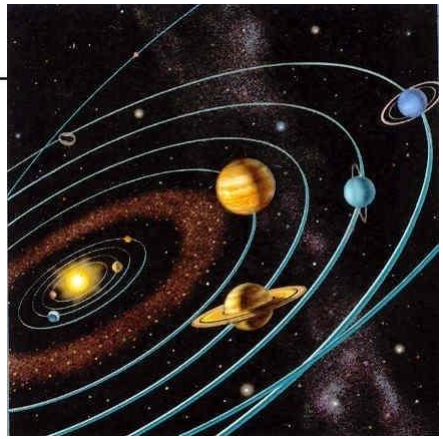
The solution (23) is **implemented** in the **first approximation** in the **spectrum** of **Kepler's shells-orbits**, if we **assume** that these **shells** are **spherical** and, therefore, **orbits** are **circular** (see Table 1).

Naturally, **under conditions** of interplanetary gravitational **interaction** (causing **disturbances**), the planets **do not move** along **ideal** circular orbits, to which they constantly strive, since **circular orbits** are **equilibrium**. Mutual **perturbation** eventually **turned** the **circular orbits** into **elliptical**, and since the **eccentricity** is **insignificant**, the orbits of the planets can be considered in the **first approximation** (in the analysis) as **circular**.

Table 1

Gravitational spectrum of *H*-atomic wave spherical shells.

s	$z_{m,n} = j_{0,s}$	$r,\ Mkm$	Planets*	
1	2.4048	787.3	Jupiter	(778.57)
2	5.5201	1807.3	Saturn	(1433.45)
3	8.6537	2833.2	Uranus	(2876.68)
4	11.7915	3860.5		
5	14.9309	4888.4	Neptune	(4503.4)
6	18.0711	5916.5	Pluto	(5906.5)



*) Planets located in relative proximity to the spherical shells.
In parentheses are the semi-major axes of the elliptical orbits of the planets.

The following relation, **important** in a **practical sense**, comes from (23):

$$\boxed{r_s = r_1 \frac{z_{m,s}}{z_{m,1}}} \quad ! \qquad (27)$$

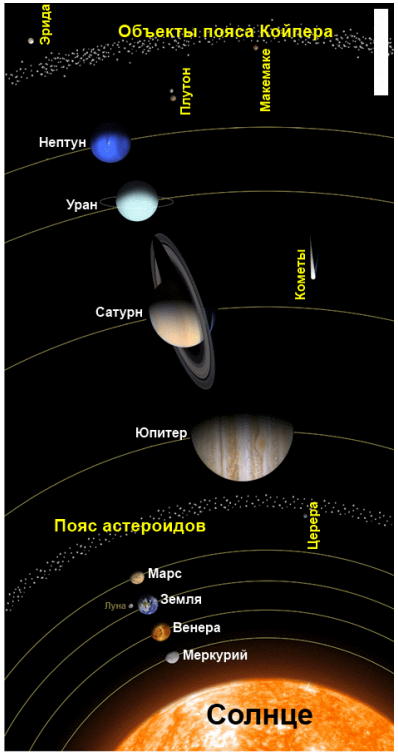
If we take as a **basis the** gravitational **wave shell** $r_1 = 57.91\,Mkm$ of the **Sun**, where the **orbit** of the **planet Mercury** is **located**, then we **arrive** at the following **gravitational spectrum** corresponding to the **solutions** of the **first-order** Bessel functions (Table 2).

Table 2

Gravitational spectrum of spherical wave shells of particles.

s	$z_{m,n} = j_{1,s}$	r_s, *Mkm*	Planets
1	3.831706	57.91	Mercury
2	7.015587	106.03 (108.2)	Venus
3	10.17347	153.76 (149.6)	Earth
4	13.32369	201.36 (204.5)	Toro
5	16.47063	248.93 (227.9)	Mars
9	29.04683	438.96	413.77 (Ceres)
16	51.04354	771.44 (778.57)	Jupiter
30	95.02923	1436.2 (1433.45)	Saturn

In parentheses are the semi-major axes of the elliptical orbits of the planets.
For a small planet Toro in brackets indicates the average distance from the Sun.



The **transition region** between the **vibrational** and **wave** regions, **separated** by a **wave gravitational radius** $\lambda\!\!\!^{-}_g = 327.4\ Mkm$, is **represented** by an **asteroid belt** around the Sun (on average, the radius of the asteroid belt is within 329.12 - 538.56 *Mkm*).

Among the **asteroids** in the center of the **region** is the only dwarf planet **Ceres**. Large planets are absent there, because in the process of the formation of the solar system, the **transition region** was the site of the most **intensive motion**.

In addition, Tables 3, 4, and 5 show the **spectra** $r_s(j_{1,s})$ and $r_s(y_{1,s})$ of **wave gravitational shells** of **Jupiter**, **Saturn** and **Uranus**, resulting from the following relations derived from (27):

$$\boxed{r_s(j_{1,s}) = r_1 \frac{j_{1,s}}{j_{1,1}}} \quad \text{and} \quad \boxed{r_s(y_{1,s}) = r_1 \frac{y_{1,s}}{j_{1,1}}} \qquad (28)$$

where $j_{1,s}$ and $y_{1,s}$ - **roots** of **Bessel functions** [13]; $<r_s>$ are the **major semiaxes** (α) of the **orbits** of **satellites** of planets, known from astronomical observations.

Table 3

Spectrum of Jupiter's wave gravity shells; r_s *kkm*.

s	$r_s(j_{1,s})$	$r_s(y_{1,s})$	$<r_s>$ (experiment); semimajor axis
1	71.492		
2	130.9	101.3	129,0 (Adrastea), 128 (Metis)
3	189.8	160.38	181.4 (Amalthea)
4	248.6	219.2	221.9 (Thebe)
7	424.7	395.3	421.8 (Jo)
11	659.2	629.9	671.1 (Europa)
18	1069.6	1040.3	1070.4 (Ganymede)
32	1890.29	1860.98	1882.7 (Callisto)

r_1=71.492 *kkm* - equatorial radius of the planet Jupiter

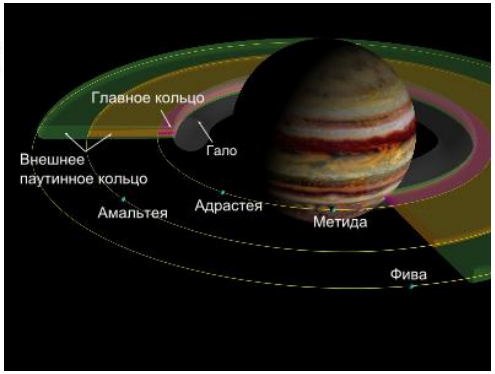
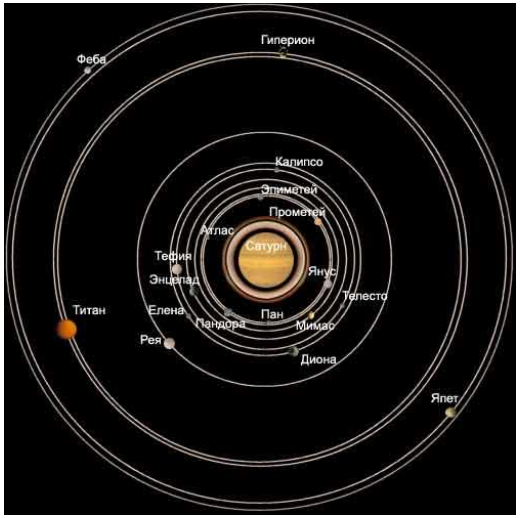


Table 4

Spectrum of wave gravitational shells of Saturn; r_s *kkm*.

s	$r_s\,(j_{1,s})$	$r_s\,(y_{1,s})$	<r_s> (experiment); semimajor axis, α
1	60.268		
2	110.346	85.40	74.5-92.0 (Ring C)
			92.0-117.5 (Ring B)
3	160.0	135.20	137.67 (Atlas), 139.38 (Prometheus)
			133.58 (Pan), 136.5 (Daphnis)
			122.2-136.8 (Ring A)
			140.210 (Ring F)
			165.8-173.8 (Ring G)
4	209.56	184.8	185.539 (Minas)
5	259.06	234.3	238.037 (Enceladus)
6	308.53	283.8	294.67 (Tethys)
			294,71 (Telesto, Calypso)
7	357.99	333.26	180.0-480.0 (Ring E)
8	407.43	382.71	377.42 (Dione, Helene)
			377.2 (Polydeuces)
...	...	...	...
11	555.73	531.02	527.04 (Rhea)
25	1247,61	1222.9	1221.865 (Titan)
30	1494.69	1469.98	1500.934 (Hyperion)

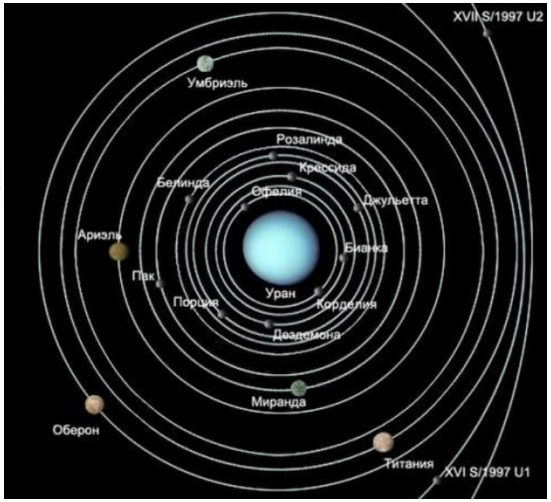


r_1=60.268 *kkm* – equatorial radius of the planet Saturn. For rings, there are indicated the distances to the center of Saturn.

Table 5

Spectrum of wave gravity shells of Uranus; r_s *kkm.*

s	$r_s\,(j_{1,s})$	$r_s\,(y_{1,s})$	$\langle r_s \rangle$ (experiment); semimajor axis α
1	25.559		
2	46.8	36.2	49.8 (Cardelia)
3	67.85	57.34	59.2 (Bianka), 66.1 (Portia)
			69.9 (Rosalind)
4	88.87	78.37	86.0 (Puck), 76.42 (Perdita)
			74.39 (Cupid)
5	109.86	99.36	97.736 (Mab)
6	130.84	120.36	129.9 (Miranda)
9	193.75	183.27	190.9 (Ariel)
13	277.6	267.12	266.0 (Umbriel)
21	445.27	434.79	436.3 (Titania)
28	591.97	581.5	583.5 (Oberon)



r_1=25.559 *kkm* – equatorial radius of the planet Uranus

The correlation between

* the **results** of the **calculation** by the formulas (23, 27, 28) of the **wave gravitational shells** of the **Sun** as well as the wave gravitational shells of **its planets** and

* the **values** of the **major semiaxes** of elliptical orbits of the **planets** of the solar system and the orbits of the **satellites** of these planets, **estimated** from **astronomical observations**, is quite **satisfactory**.

Thus

The mystery

of the **existing order** in the **arrangement** of the **orbits** of the **planets** at strictly defined average distances from the Sun and the **order** in the **arrangement** of the **orbits** of the **satellites** of these planets **was** at last **unravelled**.

Planets and their **satellites** move in space **along orbits** formed in **discrete regions** of the **spectrum** (23) of the **gravitational wave spherical shells** of the **particles** that make up the Sun and the planets of the Solar system.

Theoretical foundations

of the discovery

of the **gravitational wave spectrum** of **particles** (23)

$$r_{\nu,q} = \lambda\!\!\!^{-}_{g} z_{\nu,q}$$

are:

a*)** ***Solutions of equation (2) of the **Dynamic Model** of elementary particles, resulted in the ***discovery*** of the characteristic ***fundamental frequency*** (6),

$$\omega_g = 9.158082264 \times 10^{-4}\ s^{-1}$$

of the **gravitational field** of **particles**, and, hence, the fundamental ***gravitational wave radius*** of particles (20), corresponding to this frequency:

$$\lambda\!\!\!^{-}_{g} = c / \omega_g = 327.4 \times 10^{6}\ km$$

and also

b*)** ***Radial solutions of the universal (classical) ***wave equation*** (1):

roots of Bessel functions, $z_{\nu,q}$

It should also be noted the following found fundamental feaures:

(I) The similarity of the spectra of the two wave shells of particles:

(*a*) **The spectrum** ➡ $$r_{\nu,q} = \lambda\!\!\!^{-}_{g} z_{\nu,q} \qquad (23)$$

of the ***gravitational*** **wave shells** of particles (and, respectively, of the **orbits** of the **planets**), of the wave gravitational field of the **frequency** ω_g, and

(*b*) **The spectrum** ➡ $$r_{\nu,q} = \lambda\!\!\!^{-}_{e} z_{\nu,q} \qquad (29)$$

of the ***atomic*** **wave shells** of particles corresponding to the **relatively high fundamental frequency** ω_e , characteristic for **atomic** and **subatomic levels**.

Particles, being **extremely small** and **infinitely large** at the same time, in full accordance with the DM, are described at both levels by the **same wave equation** (1),

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

Therefore, its **solutions** for both the **atomic** (29) and **gravitational** (23) levels are **similar**. The **difference** in **frequencies** and, accordingly, the **wave radii**: in (23), the wave radius is $\lambda\!\!\!^{-}_{g}$, and in (29) – $\lambda\!\!\!^{-}_{e}$.

(II) The similarity of the laws of exchange (interaction)

The laws of exchange interaction of particles at the **different levels** of the Universe: ***subatomic***, ***atomic*** and ***gravitational***, to which they **belong simultaneously** being finite-infinite in size [2], are ***similar*** both in ***form*** and ***content*** (difference in frequencies and masses):

Electromagnetic

(14) $$F_{elec} = \omega_e^2 \frac{(Z_1 m_e)(Z_2 m_e)}{4\pi\varepsilon_0 r^2}$$

Gravitational

$$F_{grav} = \omega_g^2 \frac{(Z_1 m_n)(Z_2 m_n)}{4\pi\varepsilon_0 r^2}$$ (15)

Strong ("nuclear")

$$F_{strong} = \omega_e^2 \frac{(Z_1 m_n)(Z_2 m_n)}{4\pi\varepsilon_0 r^2}$$ (19)

All the above laws are particular cases of ***the Universal Law of Exchange***:

$$\langle F \rangle = \omega_f^2 \frac{m_1 m_2}{4\pi\varepsilon_0 r^2}$$ (13)

An additional proof of the validity of the discovery

of the wave nature of gravity and numerical value of its fundamental frequency:

The **gravitational frequency** ω_g (6) determines the **radial time wave-period**,

$$T_g = 2\pi / \omega_g = 0.686080898 \times 10^4 \ s \qquad (30)$$

In an **orbit** with one node, only one **half-wave** of the **fundamental tone** is **placed** (see, for example, [14]). Therefore, the following

Azimuthal time wave

of the fundamental tone,

$$\boxed{T_{azimuth} = 4\pi T_g = 8.621546841 \times 10^4 \ s} \quad ! \qquad (31)$$

corresponds to the **radial wave period** (30). The value (31) practically **coincides** with the **Solar Day**

$$T_{orb,Earth} = 23 \ hours \ 56 \ min \ 4 \ s = 8.6164 \times 10^4 \ s$$

The azimuthal **time wave** $T_{azimuth}$ **repeats** the structure of a **spatial wave** of the **fundamental tone** in the Bohr orbit of a hydrogen atom, $\lambda = 4\pi r_0$.

The relationships above show

that the **Earth** is in **harmonic resonance coupling** with the **fundamental frequency** of the **gravitational field** ω_g.

Similarly, an **electron** in the Bohr orbit in a hydrogen atom is in **harmonic resonance coupling** with the **fundamental frequency** of the **atomic** and **subatomic** levels ω_e.

The words of the text on the

Emerald Tablet

found in the tomb of Hermes Trismegistus

(Tabula Smaragdina Hermetis)

are fully confirmed:

Verum est sine mendacio, certum et verissimum:	*This true without lying, certain & most true.*
Quod est inferius est sicut id quod est superius.	*That which is below is like that which is above &*
Et quod est superius est sicut id quod est inferius, ad perpetranda (praeparanda, penetranda) miracula rei unius.	*that which is above is like that which is below, to do the miracles of one only thing…*

[Chrysogonus Polydorus. De Alchimia. Nuremberg, 1541]
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Conclusion

The following key discoveries related to the *problem of gravity* were made in the framework of the Wave Model:

1) The origin of mass m.

2) The wave nature of gravity. The source of origin of gravity waves are pulsating spherical wave gravitational shells of elementary particles which are dynamic (wave) formations.

3) The fundamental frequency ω_g and the fundamental wave radius $\lambda\!\!\!^{-}_g$ of the gravitational wave field.

4) The gravitational charge q_g of particles.

5) The dependence of gravitational constant G on the fundamental frequency ω_g of the gravitational wave field.

6) The relation of the gravitational constant G with the constant factor k in the Coulomb law.

7) The Universal Law of Exchange.

8) The true form of Newton's law and the meaning of all the physical parameters included in it.

9) Gravitational spectrum $r_{\nu,q}$ of equilibrium wave spherical shells of elementary particles, its coincidence with the spectrum of the orbital radii of planets and satellites of the planets in stellar systems.

The key discoveries

of the **WM**, along with other discoveries, derivative from key ones, **stimulate** the **revision** of established **dogmas** in the description of phenomena and **rejection** of **inadequate** theoretical constructs.

Thus, with the development of the WM,

the **process of updating began**, consisting in

replacing the subjective approach

adopted in physics, based on the use of **abstract-mathematical (fictional) postulates,** with concepts that are **adequate** to reality**.**

Adequate paradigm of physics,

laid down in the WM foundation, provided

a breakthrough

in solving the problems accumulated in physics!

Practical significance

Discoveries

of

the wave nature of gravitation,

the fundamental frequency

of the gravitation wave field, and

the Universal Law of Exchange

allow to make a fairy tale about the "carpet-plane" come true:

The problem
of controlling the direction and power of the gravitational interaction of bodies
becomes now solvable!

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Thank you
for your attention!