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Discovery of the wave nature of GRAVITATION

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http://shpenkov.com/pdf/GravityWaveNature.pdf

This slide presentation is an English translation (interpretation) of the material presented earlier (14.03.2017) in Russian on YouTube, "*The Nature of Gravitation*" (*Discovery of the Wave Model*):

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https://www.youtube.com/watch?v=V2LeEmSaz1Q
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We **continue** the **consideration** of the **discoveries** that were made within the framework of the two theories of the **Wave Model** developed by us [1, 2].

These discoveries were obtained in analyzing solutions of:

(а) the **classical wave equation,** $\Delta\hat{\Psi} - \frac{1}{c^2}\frac{\partial^2\hat{\Psi}}{\partial t^2} = 0$, with taking into account **mathematics** of **dialectical logic**, and

(б) the **previously unknown equation,** obtained for the **first time** by us, $\hat{F}_s = \frac{4\pi r^3 \varepsilon_0 \varepsilon_r}{1 + k^2 r^2}(1 - ikr)\hat{\upsilon} i\omega$, which describes **behavior** of elementary particles regarded as **pulsating wave** formations [2].

In particular, here we will discuss discoveries related to the field of gravity:

* the discoveries of the **wave nature** of gravitation and the **fundamental frequency** and **fundamental wave radius** of the wave gravitational field, and

* the discovery of the **gravitational spectrum** of equilibrium **wave spherical shells**, which determine the **radii** of **orbits** of planets and their satellites in the Solar System.

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 [3, 4].

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

can't explain

the **nature** of gravity, they all **focus on the description** of the 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 still **remains** for natural science one of a series of **incomprehensible phenomena**.

In-deep analysis conducted by us [3] shows that the **reason** for the **failure** in understanding a phenomenon of gravitation is the **inadequacy** of the **reality** of **basic concepts** of the **Standard Model** (SM) and theories adhering SM, in particular, the **general theory of relativity** (the theory of gravity).

Everything in Nature is

interconnected

and is

in a natural harmony

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

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

Judging by the **results** of research that we **first began** to publish in 1996 (a book "*Alternative Picture of the World*" in three volumes [5]), the **Wave Model** (WM) we are developing **fully meets** the above **requirements**.

The **WM includes** two theories (models):

1) Dynamic Model of elementary particles and

2) Shell-Nodal Model of atoms.

The Wave Model
solved some of the problems accumulated in physics, including the problem of gravity.

The **radically new view** on the structure of elementary particles, proposed and **implemented** in the **Wave Model** [2, 4], led to the **discovery** of basic parameters, **previously unknown** in physics, characterizing the wave structure and behaviour of the particles.

By now, we have **obtained** enough **unique data** to say, without **exaggeration**, that **new physical concepts** laying in the base of the WM are **closer adequate** to **reality** than that ones which form the basis of relevant theories **adhering** to the Standard Model.

Key discoveries

of the **Wave Model**, along with other discoveries, derivatives from the key ones, **stimulated** the **revision** of established **dogmas** in the explanation and description of phenomena and the **rejection** of **inadequate** theoretical constructs.

Thus, with the **development** of the theories of the **WM**, the **process began** of **replacing** ideas, based on **abstract-mathematical postulates,** with concepts **adequate** to reality.

Discoveries began to **appear** as from the **horn** of **plenty**. Two years ago, I decided reporting on some of them in the materials of videos, posting their on YouTube:

https://www.youtube.com/channel/UCMc6igBG0cEYh2YCZiyVXPA/videos

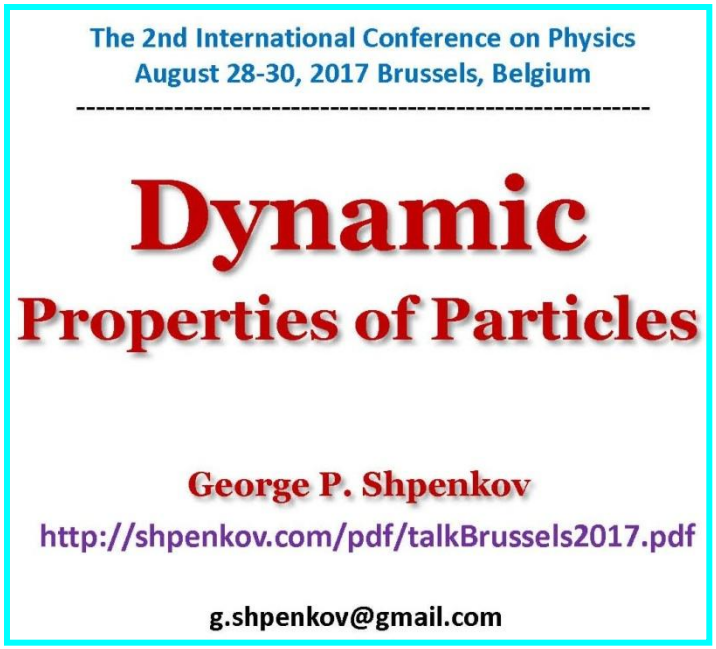
The adequate paradigm of physics, laid in the foundation of the Wave Model, provided a breakthrough in solving problems accumulated in physics, including the problem of gravity!

About discovery

of the **wave nature** of **gravity** and the **fundamental frequency** of the gravitational field, made in 1996 [5], was reported, in particular, in the keynote speech on the **Dynamic Model** at the conference in Brussels (2017) [2]:

http://shpenkov.com/pdf/talkBrussels2017.pdf

https://www.youtube.com/watch?v=jzIixlsFDuY



The relevant material, devoted to the discovery, was **presented** earlier at the 19th International Conference on the **General Theory** of **Relativity** and **Gravity** in Mexico City (2010 [5]).

The **first publications** on this topic began to appear **since 1996** (see, for example, [7]).

At the **beginning** of this presentation, in **continuation** of the **topic** of gravity, I will **remind** the **main** points of the **discovery**, and then present **additional data**.

In accordance with the Dynamic Model (DM):

Elementary particles

are **finite-infinite formations** of the wave field-space of the Universe, **limited by** micro (**subatomic**) and mega (**gravitational**) spherical **wave shells**, pulsating, respectively, at frequencies inherent in these shells:

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

And the gravitational interaction of bodies

is the **result** of the total resonant **wave exchange** (interaction) of **all** elementary **particles**, that **make up** the **body**, realized on the extremely low own **fundamental frequency** ω_g intrinsic to each particle [6].

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):

$$F = G\frac{m_1 m_2}{r^2} \quad \text{and} \quad F = k\frac{q_1 q_2}{r^2} \qquad (1)$$

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 official physics because of **unknowing**, above all, the **nature** of interacting **masses** and **charges**.

The **Higgs** hypothesis on some particle with the “integer spin value" ("**boson**"), supposedly **responsible** for the **inertial mass** of all particles, **does not hold water** [8]. And **what** is the **charge**? Physics also **does not know** the answer.

In this way,

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*, as well as the proportionality **coefficients** *G* and *k*.

The **coefficient** 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** were obtained **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**, which is convincingly shown, for example, in [9, 10].

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** (1) are **particular cases** of a **Unified Law** in Nature describing wave interactions, to which wave objects of different levels of the Universe obey.

Indeed, as we expected, research within the WM led us to the discovery of the

Universal Law of Exchange (interaction)!

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 means that **Newton's law** $F = G\frac{m_1 m_2}{r^2}$ and **Coulomb's law** $F = k\frac{q_1 q_2}{r^2}$ (1) are the laws that **describe wave interactions**, respectively, of **masses** and **charges**, which, like all objects in the Universe, **have** the **wave origin** and, therefore, **behave like wave formations**.

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 formulas, and **their interrelation**. Namely, it was necessary to establish:

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 we show our solutions,
obtained within the framework of the WM, to the above problems:

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):

$$G = \omega_g^2 \,/\, 4\pi\varepsilon_0 \quad ! \qquad (2)$$

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

$$\omega_g = \sqrt{4\pi\varepsilon_0 G} = 9.158082264 \times 10^{-4}\ s^{-1} \quad ! \qquad (2a)$$

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**:

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

5) The **parameters** *m* and *q* in the **laws** of **Newton** and **Coulomb** (1) are **related** as follows:

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

$$q_g = m\omega_g \qquad (4)$$

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

$$q_e = m\omega_e \qquad (5)$$

where

$$\omega_e = e/m_e = 1.869162559\times10^{18}\ s^{-1} \qquad (6)$$

is the **fundamental frequency** of atomic and subatomic levels. The **parameter** *e* in (6),

$$e = m_e\omega_e = 1.702691627\times10^{-9}\ \ g\cdot s^{-1} \qquad (7)$$

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 (2) and (3), **are interconnected** by the relation

$$G = k\omega_g^2 \qquad (8)$$

With the disclosure of the physical meaning of the above fundamental parameters, the Wave Model led us to the discovery of the

Universal Law of Exchange,

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

strong, electromagnetic and gravitational:

$$F = \omega_x^2 \frac{(Z_1 m_x)(Z_2 m_x)}{4\pi\varepsilon_0 r^2} \qquad (9)$$

where Z_1 and Z_2 – **relative masses** of interacting objects,

m_x – **absolute mass** of **elementary exchange charges** (electron or nucleon, m_e or m_n),

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

ω_x – the **fundamental** frequency (ω_e or ω_g).

Coulomb's law and **Newton's** law are particular cases of the **Universal Law** of **Exchange** (9) [3, 4, 11, 12]:

Coulomb's law

$$(10) \qquad F_{elec} = \omega_e^2 \frac{(Z_1 m_e)(Z_2 m_e)}{4\pi\varepsilon_0 r^2}$$

Newton's law

$$F_{grav} = \omega_g^2 \frac{(Z_1 m_n)(Z_2 m_n)}{4\pi\varepsilon_0 r^2} \qquad (11)$$

Thus, thanks to the Wave Model, we have come to the

Unified theory

describing three types of fundamental interactions:

strong, electromagnetic and **gravitational**

(which is impossible in principle
in the framework of modern theories of physics based on the Standard Model).

Particular cases

of the Universal Law of Exchange (9), **Coulomb's law** (10) and **Newton's law** (11), **describe**, respectively, the **exchange** (interaction):

a) **at the level** of the wave "**electric**" **field** (10) (**interatomic** interaction) – on the basis on an **electron** having an associated mass m_e and exchange ("electric") charge $e = m_e\omega_e$, and

b) **at the level** of the wave **gravitational** field (11) – on the basis of a **graviton-nucleon** with an associated mass m_n and exchange gravitational charge $q_g = m_n\omega_g$.

In the case of describing the **strong interaction** (exchange) [13], the Universal Law of Exchange (9) takes the form

$$F_{strong} = \omega_e^2 \frac{(Z_1 m_n)(Z_2 m_n)}{4\pi\varepsilon_0 r^2} \qquad (12)$$

Thus

In accordance with the DM

particles pulsate at **two fundamental frequencies** simultaneously.

At these frequencies, following the Universal Law of Exchange (9), their **exchange interaction** (gravitational, electromagnetic and strong) with the environment, the field and other particles is **carried out**.

The **first**, **extremely high** fundamental **frequency** $\omega_e = 1.869162559 \times 10^{18}\ s^{-1}$ of particle pulsation, 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

$$\lambda\!\!\!^{-}_e = \frac{c}{\omega_e} = 1.603886492 \times 10^{-8}\ cm \qquad (13)$$

The **second**, **extremely low** fundamental frequency of pulsation of particles

$$\omega_g = 9.158082264 \times 10^{-4} \ \ s^{-1} \qquad (14)$$

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** [11, 14] (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**,

$$\lambda\!\!\!^{-}_g = \frac{c}{\omega_g} = 3.274 \times 10^{13} \ cm = 327.4 \times 10^6 \ \ km \qquad (15)$$

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,

Gravitational frequency ω_g (14) determines gravitational radius of an elementary particle $\lambda\!\!\!^{-}_g$ (15),

which is also an **elementary radial gravitational wave**.

The **wave shell** of the **gravitational radius** 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 our Earth are **inside** a **giant gravitational wave** and, therefore, we **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 [4, 12], 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 idea about the wave nature of gravity is the discovery of the gravitational spectrum of the orbits of the planets and their satellites:

The nature

of the existing order in the arrangement of the orbits of the planets

at strictly defined **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 **relate** the **size** of the **orbits** of the planets **with** their **periods** of **revolution.** However, they **do not allow** the orbits themselves to be **calculated**. 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

$$R_i = \frac{D_i + 4}{10} \qquad (16)$$

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 (16) 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).

New theories deserve attention,
if they explain something that is inexplicable by existing theories.

The Wave Model meets this criterion!

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

Spectrum of equilibrium gravitational wave shells of particles

$$r_{\nu,q} = \lambda\!\!\!^{-}_{g} z_{\nu,q} = 327.4 \times 10^{6} \times z_{\nu,q} \quad km \qquad (17)$$

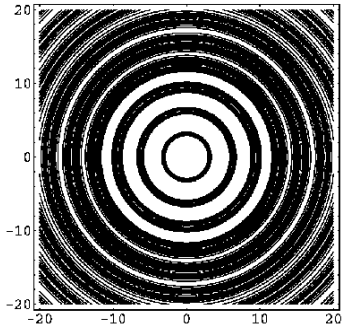
!

where $\lambda\!\!\!^{-}_{g} = c/\omega_g = 1/k_g$ is the **gravitational wave radius** of particles (15), corresponding to the **fundamental frequency** of the gravitational wave field, ω_g , determined from the **solutions** of the **equation** for the **central exchange** that we **first obtained** (см. [2, 7]):

$$\hat{F}_s = \frac{4\pi r^3 \varepsilon_0 \varepsilon_r}{1 + k^2 r^2}(1 - ikr)\hat{\upsilon} i\omega \qquad (18)$$

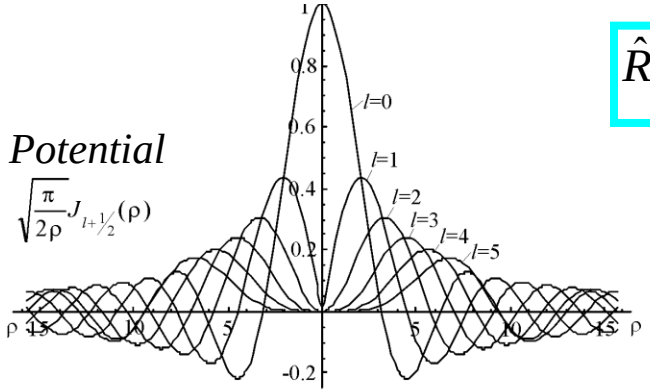
where $z_{\nu,q}$ are **roots** (zeros) of Bessel functions [15] – **solutions** of the **radial component** of the wave equation

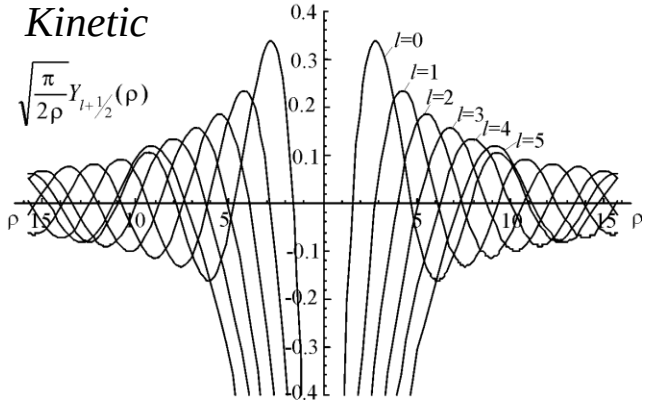
$$\Delta\hat{\Psi} - \frac{1}{c^2}\frac{\partial^2 \hat{\Psi}}{\partial t^2} = 0 \qquad (19)$$



$l = 0$

$m = 0$





General solution

of Eq. (19), $\Delta\hat{\Psi} - \frac{1}{c^2}\frac{\partial^2\hat{\Psi}}{\partial t^2} = 0$:

$$\hat{\psi} = \hat{R}_l(\rho)\Theta_{l,m}(\theta)\hat{\Phi}_m(\varphi) \qquad (20)$$

Radial solutions:

$$\hat{R}_l(\rho)/A = \sqrt{\pi/2\rho}\,(J_{l+1/2}(\rho) \pm iY_{l+1/2}(\rho)) \qquad (21)$$

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

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

$$z_{\nu,q} = \rho = kr_{\nu,q} \qquad (22)$$

$\nu = l + 1/2$ 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, $r_{\nu,q} = \lambda\!\!\!^{-}_g z_{\nu,q}$ (see. (17))

Thus, as follows from the WM,

Equilibrium orbits of planets of stellar systems and their satellites

are determined by simple, in form, equality

$$r_{\nu,q} = \lambda\!\!\!^{-}_{g} z_{\nu,q} \qquad (17)$$

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**.

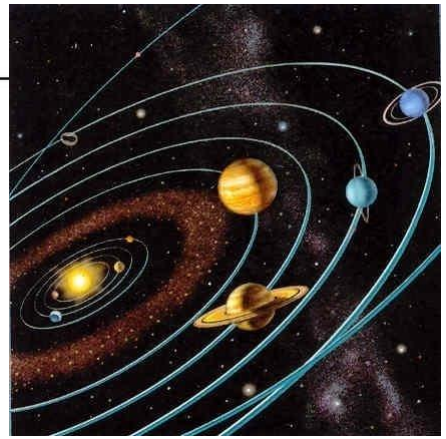
Solution (17) is **implemented** in the **first approximation** in the **spectrum** of **Kepler's shells-orbits**, if we **assume** that these **shells** are **spherical** and, therefore, **orbits** are **circular** (see Table 1).

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 (17):

$$r_s = r_1 \frac{z_{m,s}}{z_{m,1}} \quad ! \qquad (23)$$

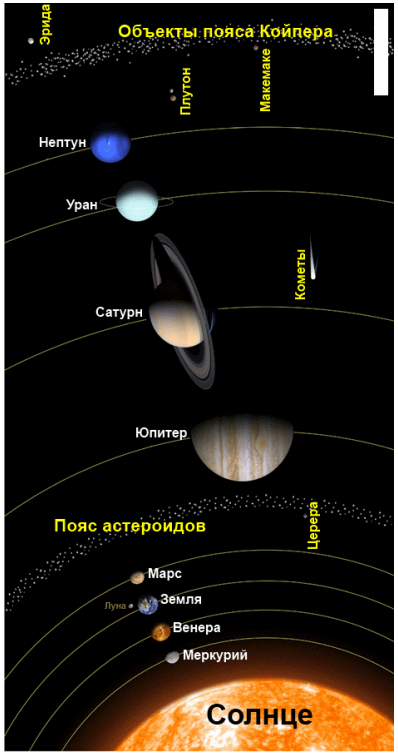
If we take as a **basis the** gravitational **wave shell** $r_1 = 57.91\,Mkm$ of the **Sun**, where the **orbit** of the **planet Mercury** is **located**, then we **arrive** at the following **gravitational spectrum** corresponding to the **solutions** of the **first-order** Bessel functions (Table 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 (23):

$$r_s(j_{1,s}) = r_1 \frac{j_{1,s}}{j_{1,1}} \quad \text{and} \quad r_s(y_{1,s}) = r_1 \frac{y_{1,s}}{j_{1,1}} \qquad (24)$$

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

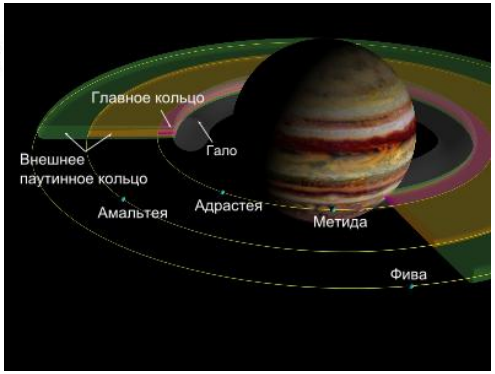
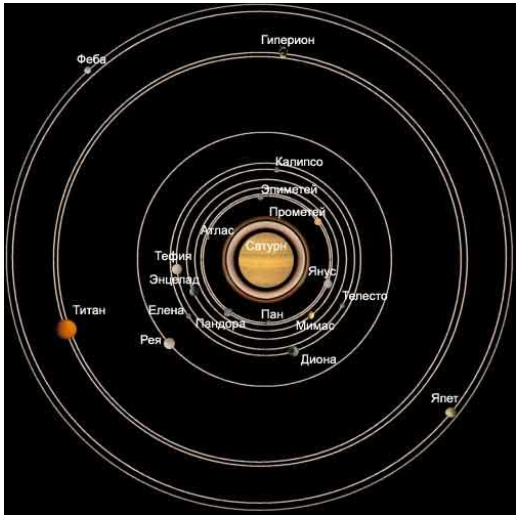


Table 4

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)

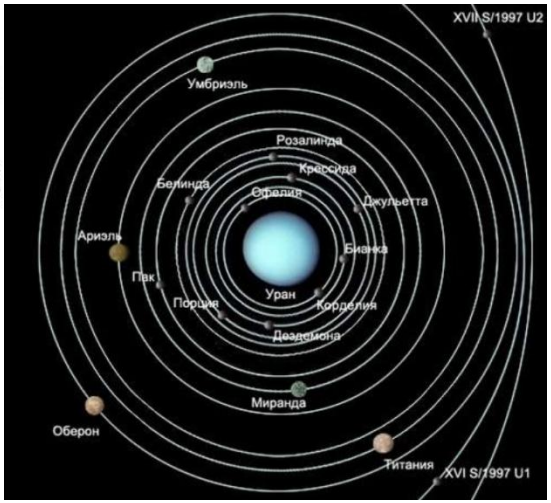


r_1=60.268 *kkm* - equatorial radius of the planet Saturn. For rings, there are indicated the distances to the center of Saturn.

Table 5

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

s	$r_s\,(j_{1,s})$	$r_s\,(y_{1,s})$	$<r_s>$ (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 (17, 23, 24) 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**.

Conclusion

Based on the Wave Model, solving the problem of gravity,

the following key discoveries were made:

1) ***The wave nature of gravitation.***
2) ***The fundamental frequency*** ω_g ***of the gravitational wave field.***
3) ***Gravitational spectrum*** $r_{v,q}$ of equilibrium wave ***spherical shells*** that determine the **radii** of the ***orbits*** of the ***planets*** of stellar systems and the ***orbits*** of their ***satellites***.

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** thanks to the **WM**.

Planets and their **satellites** move in space **along orbits** formed in **discrete regions** of the **spectrum** (17) of the **gravitational wave spherical shells** of the **particles** that make up the Sun and the planets of the Solar system.

The theoretical basis

of the discovery
of the **gravitational wave spectrum** of **particles** of matter (17)

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

were:

(*a*) **solutions** of **equation** (18) of the **Dynamic Model** of elementary particles that resulted in the discovery of the characteristic **fundamental frequency** (14)

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

of the **gravitational field** of **particles** and, corresponding to this frequency, the **fundamental gravitational wave radius** of particles (15)

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

and also

(*b*) **radial solutions** (roots of Bessel functions, $z_{\nu,q}$) of the **universal** (classical) **wave equation** (19).

It should be noted

The similarity of the spectra of wave shells of particles:

the spectrum (17)

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

of the **gravitational wave shells** of particles (and, respectively, of the **orbits** of the **planets**), due to their wave (gravitational) field of **extremely low frequency** ω_g, and

the spectrum

$$r_{\nu,q} = \lambda\!\!\!^{-}_{e} z_{\nu,q} \qquad (25)$$

of the **atomic wave shells** of particles corresponding to the **extremely high fundamental frequency** ω_e , characteristic for **atomic** and **subatomic levels**, in particular, for a hydrogen atom.

Particles, being **extremely small** and **infinitely large** at the same time, in full accordance with the DM, are described on both levels by the **same wave equation** (19),

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

Therefore, its **solutions** for both the **atomic** (25) and **gravitational** (17) levels are **similar**. The **difference** in **frequencies** and, accordingly, the **wave radii**: in (17), the wave radius is $\lambda\!\!\!^{-}_{g}$, and in (25) – $\lambda\!\!\!^{-}_{e}$.

Accordingly, there is

The similarity of the laws of interactions

The laws of exchange interaction of particles

(as well as the above spectra of their wave shells, (17) and (25))

at **both** considered **levels** of the Universe, **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):

Coulomb's

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

Newton's

$$F_{grav} = \omega_g^2 \frac{(Z_1 m_n)(Z_2 m_n)}{4\pi\varepsilon_0 r^2}$$ (11)

Both laws, **Coulomb's** (10) and **Newton's** (11), are **particular cases** of the **Universal Law** of **Exchange**,

$$F = \omega_x^2 \frac{(Z_1 m_x)(Z_2 m_x)}{4\pi\varepsilon_0 r^2}$$ (9)

Additional proof of the validity of the discovery

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

The **gravitational frequency** ω_g (14) determines the **radial time wave-period**,

$$T_g = 2\pi / \omega_g = 0.686080898 \times 10^4 \; s \qquad (26)$$

In an **orbit** with one node, only one **half-wave** of the **fundamental tone** is **placed** (see, for example, [16]). Therefore, the following

Azimuthal time wave

of the fundamental tone,

$$T_{azimuth} = 4\pi T_g = 8.621546841 \times 10^4 \; s \quad ! \qquad (27)$$

corresponds to the **radial wave period** (26). The value (27) 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 above **relationships 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.

There are confirming the words of the text of the

Emerald Tablet

found in the tomb of Hermes Trismegistus
(Tabula Smaragdina Hermetis)

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]
[Странден Д. *Герметизм*. *Его происхождение и основные учения* (*Сокровенная философия египтян*). — СПб.: Издание А. И. Воронец, 1914]

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