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**Two basic criteria for the correctness of microscopic theory**

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**Abstract**

The first important criterion for the correctness of the theory, which is commonly called Gilbert's principle, is its confirmation by experimental data. To date, experimental physicists have studied the properties of a very large number of objects and phenomena of the physical world. Therefore, the lack of experimental data that are important for understanding the fundamental laws of Nature is very rare. Such a lack of measurement data caused the long-term discussion between A. Einstein and N. Bohr. Almost a hundred years ago, they and their colleagues actively discussed the role of chance in the microcosm. Since then, the opinion of the creators of quantum mechanics that radioactive decay is a purely random phenomenon had taken root. However, the majority of the physical community leaned towards this view as a result of some implicit vote without relying on measurement data. Therefore, checking the correctness of the solution to this problem required a focused experimental study. Recent results of the study of the phenomenon of beta-decay [18] have shown its forced nature, i.e., the correctness of the proponents of determinism. However, theoretical models are usually based on existing experimental data and create to explain them. Therefore, they satisfy this data, so to speak, automatically. But among the theories created in the twentieth century, there are some that are well developed mathematically, but can not explain several other properties of the objects under study [9],[14]. In this case, the application of Gilbert's principle is ambiguous. Therefore, an additional criterion is needed to determine the correctness of the microscopic theory. Since microscopic theories must rely on the equations of quantum mechanics, the coefficients of which are world constants, then the solutions of these equations must be consisting of these constants. Thus, we can formulate an additional criterion for the correctness of the microscopic theory: it should be based on relations consisting only of fundamental constants. The correctness of this criterion is seen in the work of models of superfluidity and superconductivity, models of several particles and models of the interior of stars.

Keywords: Microscopic Theory

# 1 The main postulate of natural Sciences

## 1.1 General consideration

Several theories developed by physicists in the twentieth century raise some doubts.

This is because that in the past century, theoretical physicists often considered the most exciting and important thing to build theoretical models for those phenomena and objects whose nature was not yet clearly understood and for which there was no unambiguous interpretation.

To do this, in addition to knowledge, a rich intuition and imagination was needed. Therefore, by the requirements of the main principle of natural sciences, the reliability of such models needs experimental confirmation.

Figure 1: Sir William Gilbert (1544-1603) - The British physicist proposed the first model of terrestrial magnetism, introduced the concepts of electric and magnetic fields into scientific use.

## 1.2 The Gilbert's Postulate

The main principle of the natural sciences, known as Gilbert's postulate, was formulated more than 400 years ago [3]: **all theoretical constructions that claim to be scientific must be tested and confirmed experimentally.**

Nowadays there is a solid base of experimental data for all theoretical constructions.

Only very rarely an ambiguous situation arises because there are no direct experiments that would indicate a way of its solution.

This happened at the beginning of the last century and gave rise to a long philosophical discussion by leading physicists. They debated whether the phenomena of the microcosm are probabilistic.

## 1.3 About nature of beta-decay

The question of whether radioactive decay is a purely accidental phenomenon has arisen immediately after its discovering.

The creators of quantum mechanics, led by N. Bohr, believed that this process is a manifestation of the tunnel effect and therefore it is a purely random phenomenon.

A. Einstein and other proponents of determinism in physics expressed disagreement with this explanation and considered the probabilistic interpretation of natural phenomena erroneous.

Einstein wrote quite clearly that "quantum mechanics speaks volumes, but, it doesn't bring us any closer to solving the mystery of the Creator". And "I am convinced that the Lord God does not roll the dice."

Nevertheless, the anti-determinists eventually prevailed. The physics community was convinced by the general success of the new approach and the impeccable logic of the mathematics of the quantum mechanical apparatus. It seems that all physicists today believe that radioactive decay is really a random process.

However, the solution to this problem cannot be found by methods of philosophical discussion and some kind of virtual voting.

According to Gilbert's principle, only based on data from the corresponding experiment we can find a solution to this problem.

Einstein and other determinists (for example, N. Tesla) assumed that radioactive decay occurs under some external influence, the nature of which is still unknown.

Later it became clear that the flow of cosmic neutrinos fits the description of such an external influence very well.

For this reason, various researchers have repeatedly suggested that the beta-decay of radioactive nuclei may be caused by their interaction with the neutrino flux [2]-[13].

To test this hypothesis experimentally, we need to investigate the correlation between the rate of beta-decay and the intensity of time-varying neutrino flux falling on the beta-source.

The generator of this time-varying neutrino flux may be a nuclear reactor.

The pulse reactor has more advantages in setting up such an experiment, so, the IBR-2 reactor (Dubna, Russia) was used in the recent experiment [18].

This reactor produced short flashes of activity several times per second. At that, because there are short-lived beta-isotopes among the fission fragments of the reactor fuel, this reactor created a pulsed neutrino flux, which exponentially decreased after each reactor flash.

In this experiment, the decay rate was measured in an isolated beta-source $^{63}Ni$ [18]. This isotope is characterized by small energy of beta-electrons.

The measuring unit was located next to the reactor and was carefully protected from effects of reactor neutrons and gamma-quanta.

Measurements have shown that the neutrino flux of the reactor significantly increases the decay rate in the isolated source $^{63}Ni$ (Fig.2).

The same stream of reactor neutrinos affects on the beta-source $^{90}Sr/^{90}Y$ much more weakly (Fig.3) [17]. This isotope has almost a couple of orders of magnitude more beta-electron energy.

Thus, the data obtained from these measurements can be considered the experimental basis for solving the discussion of the beginning of the last century and proof of the correctness of A. Einstein's point of view that the phenomenon of beta-decay can not be random.

## 1.4 Clarifications of Gilbert's principle

### 1.4.1 Medieval supplement

Soon after Gilbert, an implicit addition to the rule for formulating of theoretical models arose among scientists. It was expressed in the general agreement that a scientific theory should not include parameters that are fundamentally impossible to measure.

This seems to have been a reaction to the religious dogma about angels, which are not detectable, but can be used to explain anything.

This is reminiscent of modern confinement, which explains the existence of unobservable quarks, having nevertheless a

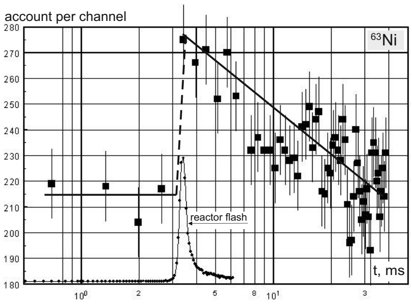


Figure 2:
The result of the accumulating registration of beta-electrons emitted by $^{63}Ni$.
Measurement time is 1 day.
The level of amplitude discrimination close to the boundary energy was chosen experimentally.
On abscissa: time in ms in the logarithmic scale [18].

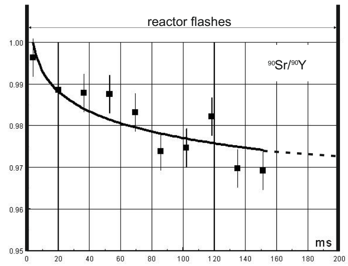


Figure 3: The result of the accumulation of registered beta-electrons emitted by the source $^{90}Sr/^{90}Y$ in the time interval between reactor flashes.
The measurement time is 3 days [17]. On the ordinate axis the account in relative units.

well-defined fractional charge and other immeasurable properties, such as color or flavor.

### 1.4.2 Modern refinement of the principle of experimental verification.

If a theory agrees with some characteristic properties of the studied objects, but cannot explain some others, then the ambiguity of Gilbert's principle in its medieval formulation becomes obvious.

There is a need to search for an additional criterion that would allow us to evaluate the correctness of the microscopic theoretical model from a fundamentally different point of view.

Since objects and phenomena of the microcosm are governed by quantum laws, they must be described by the equations of quantum mechanics and their solutions formulated in its terms. As a consequence, the basic formulas of modern microscopic theories, which are solutions of quantum equations, must be expressed by equalities consisting only of world constants.

(This, of course, does not apply to phenomenological theories that play an important role in applied physics. It is clear that this also does not apply to a large layer of theories based on the equations of electromagnetism and General relativity, since they can not be attributed to microscopic and quantum theories).

The equations of quantum physics have no other solutions.

The example of such theory is the Bohr atom model. In it, all main parameters are expressed only by ratios of world constants.

Of course, a microscopic theory does not always have to be a quantum-mechanical one. For example, the microscopic theory of Brownian motion does not obey quantum mechanics. But these two terms can be considered identical in most cases.

Therefore, the requirements for microscopic physical theory must take into account this property of quantum mechanics solutions: **a microscopic theory should lead to solutions whose basic relations consist of world constants only and are, of course, confirmed by measurement data.**

This clarification of the principle of constructing a microscopic theory makes it possible to analyze the theoretical models of the twentieth century. As a result, we can determine how correct the approach of these theories to the study of the nature of the phenomena under investigation is.

# 2 Investigating the correctness of some twentieth-century physical models

## 2.1 Superfluidity and superconductivity

Microscopic theories of superfluidity and superconductivity have a well-developed mathematical apparatus. The authors of these theories were repeatedly awarded Nobel prizes. However, this does not change the essence. These theories do not satisfy Gilbert's improved principle in its modern formulation.

They do not lead to equalities made up only of world constants, and therefore, they cannot be considered as quantum theories.

### 2.1.1 Superfluidity

The foundations of the quantum mechanical model of superfluidity were formulated by F. London almost a hundred years ago [6]. He pointed out the role of the mechanism for ordering zero-point oscillations in the formation of a liquid state in the ensemble of helium atoms. According to his theory, between atoms in the ground state, there is an interaction of the type of Van-der-Waals forces, which he called as dispersion forces. F. London assumed that helium atoms in the ground state (at T=0) should make zero-point oscillation, and they can be presented as an ensemble of three-dimensional oscillating dipoles connected by electromagnetic interaction.

If to take into account that there must be different modes of zero-point oscillations and they are ordered at different temperatures [11], then we can obtain an equality for the density of superfluid helium consisting only of world constants:

$$\gamma_4 = \frac{\alpha^2}{a_B^3}\sqrt{\frac{M_\alpha^3}{2m_e}} \cong 0.1443\ g/cm^3. \tag{1}$$

Where $a_B = \frac{\hbar^2}{m_e e^2}$ is the Bohr radius,

$M_\alpha$ is the mass of the He-4 nucleus,

$m_e$ is the electron mass,

$\alpha = \frac{e^2}{\hbar c}$ is the fine structure constant.

This quantum characteristic consisting of world constants agrees well with the measured density of liquid helium equal to 0.145 $g/cm^3$ at $T \simeq T_\lambda$.

The zero-point oscillation ordering model makes it possible to calculate the temperature at which helium enters the superfluid state [11]:

$$T_\lambda = \frac{1}{3}\frac{M_\alpha c^2 \alpha^6}{k} = 2.1772K, \tag{2}$$

This value agrees very well with the measured value of the temperature of this transition $T_\lambda = 2.1768K$.

### 2.1.2 Superconductivity

In the spectrum of zero-point oscillations of the electron gas, there is a mode that creates an attraction between oscillating electrons and lowers the energy of this ensemble.

Comparing this decrease in energy at superconducting transition with the level of Fermi energy gives the ratio of these temperatures which depends only on the world constants:

$$\frac{T_c}{T_F} = \frac{9\pi}{2}\alpha^3 \simeq 5.5 \cdot 10^{-6} \tag{3}$$

The calculated values of critical temperatures $T_c$ are in good agreement with the measured values for the type I and type II superconductors (Fig.4) [11].

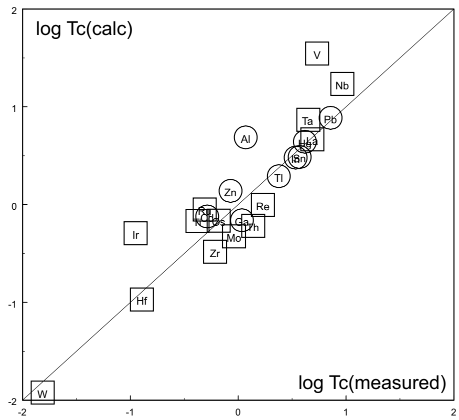


Figure 4: Comparison of calculated values of critical temperatures of superconductors with measurement data. Circles show the parameter values for type-I superconductors and squares show $T_c$ for type-II superconductors. The measured value of the critical temperature of superconductors is deposited on the abscissas axis and the calculated critical temperature is deposited on the ordinate axis [11].

## 2.2 Neutron and its excited states

In particle physics, it is assumed that neutron consists of three fractional-charged quarks of the lower level. This provides an explanation for the reaction of converting a neutron into a proton. For that, it needs for just one of the neutron's d-quarks to somehow turn into a u-quark.

This theory does not lead to formulas consisting of world constants.

According to the electromagnetic model, a neutron is a corpuscle similar to hydrogen atom, but with a relativistic electron [10].

At that, the process of converting of a neutron into a proton does not require a complex explanation. It's just ionization of the corpuscle.

The stable state of the neutron can be found from the condition of minimum electromagnetic energy which binds electron and proton.

These calculations give estimates of the neutron mass, its magnetic moment, spin, and binding energy. These estimates agree quite satisfactorily with the measurement data [10].

Additionally, this model leads to a re-evaluation of the hyperon nature [15].

A characteristic feature of the Bohr atom is the existence of its excited states. In the ground state with minimal energy, the electron orbit of the Bohr atom contains one de Broglie wavelength. In the excited states of stacked 2, 3 or more de Broglie waves.

If we assume that such excited states can exist for neutron, we can calculate the parameters of these states, such as their magnetic moments (Table.(1)).

(According to the quark model, all heavy particles are characterized by a certain set of them, but this does not open the way for calculating the magnetic moments of particles.)

The basic equation for these calculations is equality consisting of world constants and having the length dimension.

It is well known that in quantum physics there are two values that have the dimension of length.

This is the Bohr radius

$$a_B = \frac{\hbar^2}{m_e e^2} \approx 5 \cdot 10^{-9} cm, \tag{4}$$

It characterizes non-relativistic quantum systems.

And Compton wavelength

$$\lambda_C = 2\pi\alpha a_B = 2\pi \frac{\hbar}{m_e c} \approx 2 \cdot 10^{-10} cm, \tag{5}$$

It arises in quantum theories.

A new fundamental length appears in the electromagnetic model of neutron and its excited states:

$$R_* = \frac{\hbar}{m_e c} \frac{m_e}{M_p} \left( \frac{n\sqrt{1-\vartheta^2}}{\vartheta} \right) \approx 10^{-13} cm \tag{6}$$

Where

$\vartheta$ is the solution to the equilibrium equation [15]

$$1 + \frac{1}{2n} + \left( \frac{\vartheta}{n\sqrt{1-\vartheta^2}} \cdot \frac{e^2}{\hbar c} \cdot \frac{M_p}{m_e} \right) \left[ \frac{1}{(1-\vartheta)^2} + \left( \frac{\vartheta^2}{2} - \frac{\xi_p}{2n(1+\vartheta)^3} \frac{\vartheta}{\sqrt{1-\vartheta^2}} \right) \right] = 0, \tag{7}$$

$M_p$ is proton mass,

$\xi_p = 2.79$ is the proton's anomalous magnetic moment,

$n$ is the number of de Broglie wavelengths that fit in the electron orbit.

| n | $\vartheta$ | $\mu_*$ | experimental data | Ref. |
|---|---|---|---|---|
| n=1 | 0.1991 | -1. 9367 | $\mu_{n_0} = -1.9130427 \pm 0.0000005$ | [7] |
| n=2 | 0.263 | -0.6247 | $\mu_{\Lambda^0} = -0.613 \pm 0.004$ | [7] |
| n=3 | 0.479 | 1.3779 | $\mu_{\Sigma^0_{\Sigma\Lambda}} = 1.61 \pm 0.08$ | [7] |

Table 1: Comparison of calculated values of magnetic moments with measured values. n denotes the number of de Broglie waves that fit in an electron orbit [15].

Magnetic moments of neutron and its excited states can be determined from the equation, expressed in terms of world constants:

$$\mu_* = \xi_p - \frac{(1-\vartheta^2)^{3/2}}{\vartheta} \tag{8}$$

The results of these calculations are summarized in Table.(1).

Since the calculated values are given by the electromagnetic model are in good agreement with the measured values of the hyperons magnetic moments, it can be concluded that hyperons are excited states of a neutron actually.

It is important that the nature of nuclear forces, in this case, is described by a simple and well-known quantum mechanical effect, and there is no need to introduce gluons and the strong interaction forces (at least for light nuclei), when studying it.

### 2.3 Neutrinos and mesons

Neutrinos are born during beta-decays. They can carry away some of the released energy with the speed of light like photons too. At that neutrinos differ from photons and all other particles in that they have an exceptionally weak interaction with matter.

According to Thomson's theory, photons and gamma-quanta lose energy and are scattered into matter because their electric field accelerates electrons in substance. Only a particle that does not carry an electric field in its wave can avoid such scattering.

It can transfer all its energy due to the magnetic component of the wave, but not dissipate because there are no magnetic monopoles in nature.

But is such a magnetic wave possible?

On closer examination, it turns out that Maxwell's equations have such a solution [13].

It is not technically feasible, so it is usually ignored.

But a magnetic wave must occur when relativistic particles are born.

For a magnetic oscillation to arise in the ether, a particle with a magnetic moment must be born relativistically quickly.

The birth of a relativistic electron in beta-decay, which has a magnetic moment, according to Maxwell's equations it should be accompanied by the birth of a magnetic gamma-quantum, which takes away part of the reaction energy.

Such magnetic gamma-quanta in the twentieth century was called as neutrinos.

| meson | measured meson mass $m_{meas}$ | calculated meson mass $m_{calc}$ | $\frac{m_{calc}-m_{meas}}{m_{meas}}$ |
|---|---|---|---|
| $\pi^{\pm}$ | $273.13m_e$ | $2\frac{m_e}{\alpha} = 274.1m_e$ | $3.5 \cdot 10^{-3}$ |
| $\mu^{\pm}$ | $206.77m_e$ | $\frac{3}{2}\frac{m_e}{\alpha} = 205.6m_e$ | $-5.8 \cdot 10^{-3}$ |

Table 2: Results of calculations of the charged meson masses [16].

Since the radiation of magnetic gamma-quanta is a purely electromagnetic process, then there is no reason to assume that their description should include equalities consisting only of fundamental constants.

However, nuclear reactions involving neutrinos can be described by such equalities.

This is the chain of reactions $\pi^{\pm} \longrightarrow \mu^{\pm} \longrightarrow e^{\pm}$, in which one neutrino and two antineutrinos are born, carrying away some of the reaction energy.

Because other particles are not born in this reaction, we can estimate the masses of charged mesons. The values of these masses are determined by the fundamental constants (Table 2) [16].

# 3 Microscopic models of the star interior and measurement data

The modern astrophysics started from at the beginning of the last century. However, the astronomical data necessary to test the theoretical describing of the internal structure of stars was still missing at that time.

By the second part of the last century, the technique of astronomical measurements had grown so much that data shedding light on the interior of stars appeared.

At that time, it turned out that the theoretical ideas about the internal structure of stars do not agree very well with these data.

This can be explained, apparently, by the fact that this is the historical development of ideas about the starry interior.

The beginning of modern physics of the stellar interior can be traced from the paper of R. Emden ≪Die Gaskugeln≫, appeared in the early twentieth century. In this work, stars are considered as gas balls. The characteristics of stars are determined by equations of state of gases that forms these stars. It can be either a dwarf, a giant, a main-sequence star, and so on.

Then an important role was played by I. Langmuir's discovery of a new state of matter - plasma. It led the largest astrophysicist of this time, A. Edington, to understand that the interior of stars should consist of plasma.

He built a standard model of such a star, in which, as in a gas star, its properties were determined by the equation of state of the plasma. At the same time, the principal difference between plasma and gas has been overlooked. Plasma is an electrically polarizable medium. In it an effect of gravitationally induced electric polarization (GIEP) must be. It must absent in gas where electrons fill the atomic shells.

The properties of stars measured by astronomers - masses, radii, surface temperatures - are determined by the

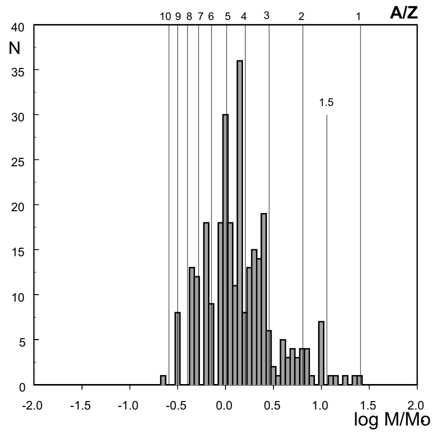


Figure 5: Mass distribution of double stars [4]. By the abscissa contains the logarithm of the mass in units of the solar mass. Lines show separate values of $A/Z$ from Eq.(9).

equilibrium state of the interstellar plasma, which depends on its electrical polarization.

### 3.1 Masses of stars

If the GIEP effect is taken into account, masses of stars can be determined by equality [8]:

$$M_\star = \sqrt{\frac{13}{7}\frac{5^5}{\pi^3}}\frac{M_{Ch}}{(\frac{A}{Z})^2} = 13.7\frac{M_{Ch}}{(\frac{A}{Z})^2}. \tag{9}$$

The Chandrasekhar mass included in this equation consists only of fundamental constants:

$$M_{Ch} = \left(\frac{\hbar c}{G m_p^2}\right)^{3/2} m_p, \tag{10}$$

Where $A$ and $Z$ are mass and charge numbers of the nuclei that make up the plasma of the star's interior, $G$ - the gravitational constant.

This equality is consistent with distribution of stars masses measured by astronomers (Fig. 5) [4].

The network of vertical lines in this figure corresponds to different values of ratio $A/Z$ Eq.(9). As one can see, the heaviest stars are those consisting of hydrogen plasma with $A/Z = 1$ and He-3 plasma with $A/Z = 3/2$.

It turns out that many stars are made up of plasma with integer values of the ratio $A/Z = 3, 4, 5....$

### 3.2 Radii and temperatures of stars

Using the distribution of stars by mass expressed in terms of world constants (Eq.(9)), we can proceed to similar expressions for distributions of stars by radii and surface temperatures [8], which also agree well with the measurement data (Fig.(6) and (7)).

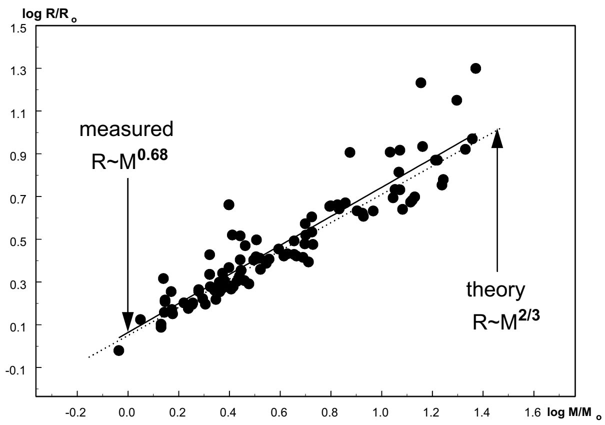


Figure 6: Dependence of the radii of close binary stars [8](in units of solar radius) from their mass (in units of the mass of the Sun), represented on the doubly logarithmic scale.

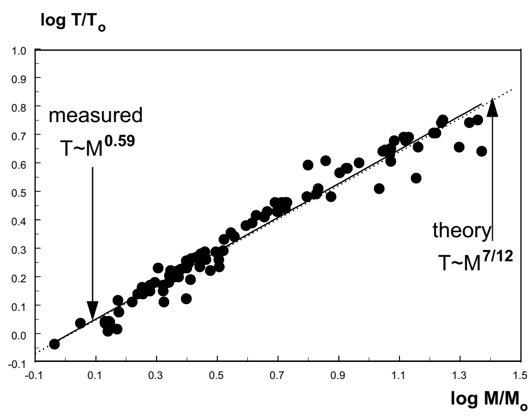


Figure 7: The dependence of surface temperature on the mass of stars, members of close pairs [8]. Temperatures are normalized to surface temperature of the Sun (5875 K), mass - per mass of the Sun. Data is presented on a double-logarithmic scale.

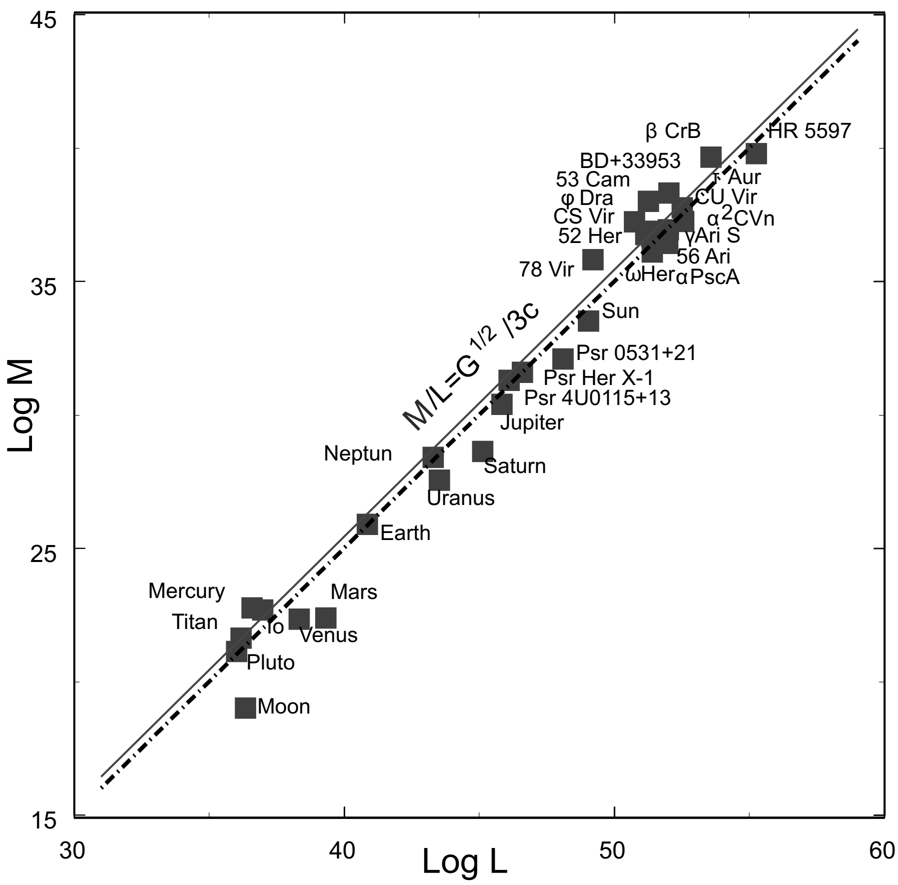


Figure 8: Measured values of magnetic moments of space bodies depending on their moments of rotation. By ordinate, the logarithm of the magnetic moment (in $Gs \cdot cm^3$) is shows, by the abscissa, the logarithm of the moment of rotation (in $erg \cdot s$) is shown. The dashed line is obtained using the least squares method. The solid line illustrates the theoretical dependence Eq.(11).

### 3.3 Magnetic moments of cosmic bodies

The rotation of cosmic bodies, inside which there is an electric polarization that occurs under the influence of their own gravity induces the appearance of magnetic moments in them. The value of the ratio of thus induced magnetic moments $\boldsymbol{\mu}$ to their moments of rotation $\boldsymbol{\mathcal{L}}$ turns out to be equal to [8]:

$$\frac{\boldsymbol{\mu}}{\boldsymbol{\mathcal{L}}} = -\frac{\sqrt{G}}{3c}. \tag{11}$$

This ratio agrees well with the measurement data (Fig.8) [8].

## 4 Conclusion

Theoretical research usually starts from some experimental data and is structured in such a way as to explain these data. However, they may not find an explanation for other experimental data related to the same research objects. There is a certain ambiguity of experimental confirmation of this theory.

Sometimes, as another strong argument in favor of such theories, the statement is made that everyone thinks so. If at that an advanced mathematical apparatus has been developed to justify such theories, then sometimes they were awarded various awards and prizes.

However, public opinion cannot replace measurement data.

Another similar argument is used when evaluating theoretical models of elementary particles.

Particles are characterized by certain properties of the real physical world: mass, spin, magnetic moment, etc.

A correct particle model should explain these properties.

In addition to these properties, it is customary to assign characteristics to particles that are necessary for their systematization into certain tables. In them, they are classified by certain parameters, for example, by the hypothetical composition of quarks from which they could be constructed.

Since this systematization is hypothetical, it cannot replace direct measurement data.

In this regard, an additional criterion for the correctness of the microscopic theory, which makes it possible to understand whether it has a scientific future or not, it seems very important.

Relying on the existence of relations of world constants in the framework of microscopic theory makes this possible.

It is important that relations of world constants are often confirmed experimentally with amazing accuracy, which strengthens the role of these theories in physics.

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