

# THE "BIG G" CRISIS: The relationship between the magnitude of the discrepancy in the 'Big G' values and the critical acceleration of the MOND.

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**Abstract.** *Measurements of the gravitational constant  $G$  conducted at the world's leading laboratories contradict one another and diverge in an unexplained manner. To determine the cause of the discrepancies, we solved the inverse problem: based on the known experimental "Big  $G$ " discrepancies, we calculated the magnitude of the hidden acceleration. The hidden acceleration coincided in order of magnitude with the critical acceleration of MOND, which is driven by the gravity of the entire universe. This fact refutes the seemingly chaotic spread of  $G$  values and calls into question the very possibility of using Newton's local equation without accounting for the gravity of the entire universe. Is this an intriguing coincidence, or a direct consequence of the fact that all research groups calculated "Big  $G$ " from the local gravity equation without accounting for the acceleration caused by the gravity of the universe? Discrepancies were not caused by instrument errors, but by the omnipresent gravity of the universe, which was not accounted for in the calculations. Paradoxically, it was precisely the discrepancies that became the most valuable result of all the  $G$  measurements. In their pursuit of "Big  $G$ ," the experimenters missed a scientific discovery. A new law of nature was right within their grasp, yet they mistook it for equipment malfunction. Dear metrologists! Hidden within your vast archives lies the most monumental discovery in the field of gravity since Newton! Don't let it slip away! Remember: the number of fundamental laws of nature is limited—there aren't enough to go around!*

**Keywords:** *gravitational constant, precision metrology, Modified Newtonian Dynamics (MOND), cosmological constant, open systems, background acceleration of the Universe.*

## 1. Introduction.

Measurement results for the gravitational constant  $G$  obtained at leading laboratories contradict one another and diverge inexplicably [1–26]. Metrologists have honestly documented this chaos without attempting to force the results to conform to a single standard. Metrology is capable not only of confirming physical theories, but also of outpacing physics and refuting physical theories [1, 2]. The "Big  $G$ " crisis shows that metrology has outpaced physical theory and calls into question the completeness of the theory of gravity. "Big  $G$ " is not measured directly but is calculated from Newton's law. Newton's law is "local"—it allows us to calculate the gravitational force as if there were only two isolated bodies in the universe. Here and throughout, the discussion concerns the observable universe. In reality, the experiment takes place within the unified gravitational field of the universe. "Big  $G$ " is both a fundamental constant of the universe and a parameter of the universe. Calculating the value of "Big  $G$ " without accounting for the universe's gravity is mathematically incorrect. We must acknowledge that the influence of the universe is always present in the laboratory, and this influence must be correctly incorporated into the equation when calculating "Big  $G$ ." Newton's equation does not account for the influence of the universe. From this, we can conclude that the variation in the data is not due to measurement errors, but to a computational error. The

experiments were flawless; the error arose because physicists substituted the data into the wrong equation, assuming the universe was “empty.”

Due to the Earth’s motion and the varying geographical locations of the laboratories, the Universe factor shifts the calculation results in different ways. Taking the Universe’s gravitational background into account during the calculation stage will allow us to obtain a more accurate value for “Big G” even without conducting repeat measurements. All the necessary data is already contained both in the accumulated sets of ultra-precise measurements and in the discrepancies in “Big G” values among the world’s leading laboratories.

The paradox of the “Big G” crisis is that the spread of the data may turn out to be the most valuable result of all experiments measuring “Big G.” These “annoying” discrepancies in measurement results can give science even more than just an additional sign in the value of the constant. Hidden within these “annoying” discrepancies lie the law of gravity of the universe and the structure of the universe. Ultra-precise experiments have recorded this, and now the data sets must be analyzed to confirm that metrologists have made a discovery. The time has come to shift the focus of research from “flawed” instruments to the incompleteness of the theory of gravity and to reframe the problem of measuring “Big G” as a problem of calculating it.

## **2. The Influence of the Universe on Local Experiments. The Connection Between the Microcosm and the Megacosm.**

Discrepancies in the values of “Big G” are usually attributed to unidentified systematic errors [27]. Klein, N. proposed an alternative perspective [28–31]. He compared laboratory measurement errors of G with gravitational anomalies in galaxies within the framework of the MOND concept and found a surprising mathematical correspondence between them. According to Klein, these discrepancies may be manifestations of the same fundamental effect at low accelerations. Klein’s main conclusion: Anomalies in the rotation curves of galaxies (on a vast scale) and the chaotic Discrepancies in the values of the fundamental constant G in laboratories (on a microscopic scale) are manifestations of MOND effects beyond Newtonian dynamics. Klein’s concept is actively developed in [32]. The authors of [32] also emphasized the unified nature of the “Big G” discrepancies in laboratory experiments and gravitational anomalies in the dynamics of wide binary star systems.

The main methodological flaw in all terrestrial experiments to determine the gravitational constant lies in the assumption that the laboratory is an ideally isolated system. Newton’s classical equation:  $F = GmM/r^2$  describes the idealized interaction of two point masses in absolutely empty space. When scientists attempt to calculate the universal gravitational constant using a theoretical framework that is known to be approximate and incomplete, they naturally and inevitably obtain approximate results.

Metrologists have reached an impasse not because their instruments are imperfect, but because they are attempting to analyse a highly precise reality using an incomplete mathematical model. When measuring G, no account is taken of the background gravity generated by the total mass of the Universe. Classical calculations treat local laboratory setups as closed systems, ignoring the background gravitational influence of the entire Universe. The physical nature of this background influence from the Universe is both unique and insidious. Any measuring instrument rigidly fixed to the Earth is in a state of free fall in the direction of the Universe’s gravitational vector. A direct local

measurement of this cosmological factor on Earth is fundamentally impossible. The only option is to take it into account during the calculation stage. Failure to account for background gravity leads to a predictable systematic bias in the calculation results. It is impossible to shield oneself from gravity. Measuring ‘Big G’ in local experiments and calculating it using the local law of gravity are attempts to determine the value of the constants of the Universe whilst completely ignoring the Universe’s own gravity. In reality, the microcosm and the macrocosm are closely interconnected. This is clearly illustrated by examples of the mathematical relationship between the constants of the microcosm and the constants of the Universe. Here are some examples of cosmological equations demonstrating such a relationship:

$$\begin{aligned} \frac{G}{H_0} &= \alpha^2 \hbar r_e / m_e^2 & (1) \quad GM_U &= c^3 T_U & (2) \quad GM_U &= c^2 R_U & (3) \\ \frac{m_e c^3}{H_0 e^2} &= \frac{\alpha e^2}{G m_e^2} & (4) \quad \hbar^2 H_0 \alpha^3 &= G c m_e^3 & (5) \quad R_U G m_e &= \alpha c^2 r_e^2 & (6) \\ c^4 &= G M_U A_0 & (7) \quad G^2 M_U m_e &= \alpha c^4 r_e^2 & (8) \quad M_U r_e^2 \alpha &= R_U^2 m_e & (9) \\ M_U \Lambda \alpha r_e^2 &= m_e & (10) \quad \Lambda / G^2 &= m_e^2 / \alpha^2 c^4 r_e^4 & (11) \quad G / A_0 &= \alpha r_e^2 / m_e & (12) \end{aligned}$$

$$GM_U R_U \Lambda^2 T_U = H_0 \quad (13)$$

Where:  $M_U$  is the mass of the Universe,  $G$  is the gravitational constant,  $c$  is the speed of light,  $R_U$  is the radius of the Universe,  $m_e$  is the electron mass,  $r_e$  is the electron radius,  $\alpha$  is the fine-structure constant,  $\hbar$  is Planck's constant,  $H_0$  is the Hubble parameter,  $e$  is the electron charge,  $A_0$  is the constant of the Universe's acceleration,  $T_U$  is the time of the Universe, and  $\Lambda$  is the cosmological constant.

(1) – это уравнение Stewart [33, 34]. (2) is Milne’s equation [35]. Erwin Schrödinger attempted to formulate Mach’s principle mathematically and, as early as 1925, proposed equation (3) [36]. A similar equation,  $M_U G = c^2 R_U$ , was derived by Bleksley [37]. (4) is Dirac’s equation [38, 39]. (5) is Weinberg’s equation [40]. (6) is the Rice equation [41]. The Tully–Fisher relation (7), well known for galaxies, also holds for the Universe. (8) – (13) are new equations derived in [42, 43]. (13) is an equation of astonishing beauty that relates all the parameters of the Universe [42].

Physics is not yet capable of unifying the microcosm and the megacosm within a single theory. From a theoretical point of view, establishing deep analytical links between fundamental physical constants and the parameters of the Universe can serve as a conceptual bridge between microscale processes and processes on a metagalactic scale. In the experimental realm, the most promising — and, to date, the only — empirical lead for detecting this connection is provided by precision measurements of the Newtonian gravitational constant  $G$ .

The crisis of reproducibility of ‘Big G’ values has traditionally been interpreted as a consequence of unaccounted-for local errors. However, the cosmological paradigm allows us to view this metrological impasse in a different light. The detected discrepancy points to the need to take into account the gravitational background of the Universe when calculating ‘Big G’ in a local experiment. Experimentally observed anomalies indicate that it is impossible to correctly calculate the

gravitational constant  $G$  within the framework of locally closed models. The Universe demonstrates a fundamental limitation on the isolation of gravitational systems: the determination of the Newtonian constant in a purely local experiment proves to be incomplete without the integration of cosmological parameters—in particular, the cosmological constant  $\Lambda$ —into the computational model. Thus, the  $G$  metrological crisis appears not as an instrumental failure, but as the first direct experimental evidence of the inseparable unity of local physics and the structure of the Universe.

The shift towards the concept of open measurement systems makes it possible to resolve a long-standing contradiction and opens up a direct method for laboratory detection of the structure of the Universe. High-precision instruments have created all the necessary conditions for this. The transition to the concept of open measurement systems radically changes the very philosophy of metrology: the instrument is no longer isolated from the surrounding world; together with the mathematical model of gravity, it becomes a sensitive element interacting with the entire structure of the Universe.

### **3. Discrepancies in the values of ‘Big $G$ ’ represent the most valuable scientific outcome of these measurements.**

We propose a radical re-examination of how these discrepancies are interpreted when determining the value of  $G$ . The phenomenon of discrepancies between the results of precision measurements carried out by independent research groups has long been regarded as a metrological impasse. We, however, maintain that this chaotic ‘range of values’ constitutes invaluable empirical data of a new order. The recorded deviations encode the large-scale structure of the Universe: the difference in numerical values between laboratories indicates the presence of a metagalactic gravitational force vector influencing the outcome of local experiments. Metrological discrepancies become a direct experimental bridge between laboratory experiments and cosmology.

The paradox of the situation lies in the fact that ‘errors’ have proved more valuable than a hypothetical perfect match. The very existence of these discrepancies paves the way for describing non-local gravity through the parameters of the Universe.

### **4. Initial data for solving the inverse problem.**

The highest value of  $G$  recorded in the history of modern measurements of the gravitational constant was  $6.7154 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$  (measured by the German PTB institute in 1995), whilst the lowest precision value was  $6.67191 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$  (obtained by the LENS collaboration at the University of Florence in 2014). The highest value among recognised high-precision tests,  $6.67586 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$ , was obtained in a BIPM experiment in 2013. The lowest value among recognised precision quantum measurement tests— $6.67191 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$ —was obtained by Italian scientists from the LENS collaboration in 2014. They used a fundamentally new method — atomic cold interferometry — and their result turned out to be at the very lower limit. The minimum value for classical torsion balances:  $6.6723 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$  was obtained by Jun Luo’s group at Huazhong University of Science and Technology in the HUST-05 experiment. Physicists from HUST are renowned for having the world’s lowest measurement error. Their results consistently ‘tend’ towards lower values.

In some historical reviews from the late 20th century, the value of  $G$  was estimated to be even lower — as low as  $6.6659 \times 10^{-11} \text{ m}^3\cdot\text{kg}^{-1}\cdot\text{s}^{-2}$ . The value of the gravitational constant  $G = 6.6659 \times 10^{-11} (\text{m}^3\cdot\text{kg}^{-1}\cdot\text{s}^{-2})$  was determined by a research team from New Zealand (MSL – Measurement Standards Laboratory of New Zealand). The official final value from the MSL, recognised by the international CODATA committee, is as follows:  $6.67387 \times 10^{-11} \text{ m}^3\cdot\text{kg}^{-1}\cdot\text{s}^{-2}$  (MSL-03).

We regard these discrepancies in the values of ‘Big  $G$ ’ as an exceptionally useful scientific result. In physics, situations where ultra-precise experiments yield different results often become the main driver of scientific breakthroughs. It is of interest to determine what unaccounted-for acceleration lies behind such a wide range of discrepancies in the values of  $G$ .

## 5. Solving the inverse problem: calculating the hidden acceleration corresponding to the discrepancy in ‘Big $G$ ’ values.

Solving the inverse problem in the context of the ‘Big  $G$ ’ crisis involves using the officially recorded experimental spread in the values of the gravitational constant ( $\Delta G$ ) to calculate the magnitude of the hidden acceleration. What was previously regarded as a dead end in metrology ( $\Delta G$ ) is, in the inverse problem, viewed as a useful signal that may indicate unaccounted-for gravity in the Universe. The calculation was performed for the pairs PTB (1995) – LENS (2014), PTB (1995) – HUST-05, and PTB (1995) – MSL-03, between which the greatest discrepancy exists. The inverse problem yielded values for the hidden acceleration. Pair: PTB (1995) – LENS (2014) –  $3.8658 \times 10^{-10} \text{ m/s}^2$ ; pair: PTB (1995) – HUST-05 –  $5.3900 \times 10^{-10} \text{ m/s}^2$ ; pair: PTB (1995) – MSL-03 –  $5.8834 \times 10^{-10} \text{ m/s}^2$ . The detected hidden acceleration is of the order of  $10^{-10} \text{ m/s}^2$ . It coincides in order of magnitude with the MOND acceleration threshold. Comparative results are given in the table in Fig. 1.

| Summary Table of Associated Hidden Accelerations |                                  |                                                   |                                                   |                                                                      |                   |                |                                                   |
|--------------------------------------------------|----------------------------------|---------------------------------------------------|---------------------------------------------------|----------------------------------------------------------------------|-------------------|----------------|---------------------------------------------------|
| No.                                              | Calculation Pair / Configuration | G max ( $\text{m}^3\text{kg}^{-1}\text{s}^{-2}$ ) | G min ( $\text{m}^3\text{kg}^{-1}\text{s}^{-2}$ ) | Delta G ( $\times 10^{-13} \text{ m}^3\text{kg}^{-1}\text{s}^{-2}$ ) | Total Mass M (kg) | Distance r (m) | Associated Hidden Acceleration ( $\text{m/s}^2$ ) |
| 1                                                | PTB (1995) – LENS (2014)         | $6.71540 \times 10^{-11}$                         | $6.67191 \times 10^{-11}$                         | 4.3490                                                               | 7.2               | 0.09           | $3.8658 \times 10^{-10}$                          |
| 2                                                | PTB (1995) – HUST-05             | $6.71540 \times 10^{-11}$                         | $6.67228 \times 10^{-11}$                         | 4.3120                                                               | 12.5              | 0.10           | $5.3900 \times 10^{-10}$                          |
| 3                                                | PTB (1995) – MSL-03              | $6.71540 \times 10^{-11}$                         | $6.67387 \times 10^{-11}$                         | 4.1530                                                               | 20.4              | 0.12           | $5.8834 \times 10^{-10}$                          |

Fig. 1. Results of solving the inverse problem: accelerations corresponding to the discrepancy have been calculated from the ‘Big  $G$ ’ discrepancies.

The result from LENS (2014) is particularly noteworthy. Here, the contribution of the universe’s gravity turned out to be the smallest. The value of ‘Big  $G$ ’ obtained by LENS (2014) tends towards the lower limit of the range.

We have presented an approximate calculation of hidden acceleration using  $\Delta G$  discrepancies. To obtain more accurate values, it is necessary to utilise raw data sets, taking into account the

geographical location of the laboratories and the time at which the experiments were conducted. A spatial-geographical analysis of 17 key historical measurements of  $G$  must be carried out to identify any correlation between the final value of  $G$  and the geographical latitude and longitude of the laboratories. In this case, solving the inverse problem will allow us to determine the angles between the cosmological vector and the working axis of the instruments. This will yield not only the exact value of the gravitational constant  $G$ , but also the magnitude of the cosmological vector and, most importantly, its direction. This is more than just an additional sign in the gravitational constant. Cosmology has long awaited this discovery. The discovery of the Great Attractor by the ‘Seven Samurai’ group was merely the first step on this path [22]. The only terrestrial experiments capable of determining the direction of the cosmological vector and its magnitude are those designed to measure the gravitational constant. Without realising it, metrologists, in their quest for the precise value of  $G$ , have created a network of spatially dispersed laboratories and accumulated vast amounts of data. This network of spatially dispersed laboratories could become a tool for studying the Universe. Future discoveries in the fields of gravity and cosmology are already contained within these data sets and in the discrepancies in the values of  $G$ . They simply need to be calculated!

## **6. The unaccounted-for latent acceleration is of the order of $10^{-10}$ m/s<sup>2</sup>.**

The values of the hidden acceleration obtained by solving the inverse problem lead us to a scale of  $10^{-10}$  m/s<sup>2</sup>. However, calculations have shown that the obtained values of the hidden acceleration exceed the critical acceleration of the MOND model. At the same time, the calculated values of acceleration are less than the theoretical maximum ( $A_0 = 10.4922... \cdot 10^{-10}$  m/s<sup>2</sup>) [44]. In the physics of open systems, this has a straightforward explanation: the formula for calculating acceleration gives the absolute maximum value of cosmic acceleration. Actual instruments in different laboratories are oriented differently relative to the cosmic acceleration vector. The force that must be taken into account when calculating  $G$  is the vector projection of the cosmological force onto the instrument’s working axis. The coefficient **Cos $\vartheta$**  must be introduced into the formula for calculating  $G$ , where  $\vartheta$  is the angle between the instrument’s working axis and the cosmological acceleration vector [44].

## **7. An additive mathematical model of gravity.**

The unaccounted-for hidden accelerations of the order of  $10^{-10}$  m/s<sup>2</sup>, shown in the table (Fig. 1), turned out to be close to the critical acceleration of MOND. The basic idea behind MOND is that Newtonian dynamics must be modified when the acceleration falls below a fixed value of  $a_0 = 1.2 \times 10^{-10}$  m/s<sup>2</sup> [45]. The threshold acceleration is incorporated into the MOND equation as a multiplier. Consequently, MOND proposes a multiplicative mathematical model of gravity. This requires the introduction of an additional interpolation function.

Based on the MOND mathematical model and the models of Milgrom’s numerous followers [46–56], we have concluded that the mathematical model of gravity should be additive, rather than multiplicative. In the new mathematical model of gravity, the additional acceleration should not be included as a multiplier; it should be included additively. Such a model does not violate the principle of superposition. Such a model does not require any modification of Newton’s formula. In such a model, the additional acceleration is not introduced manually but is calculated using the parameters

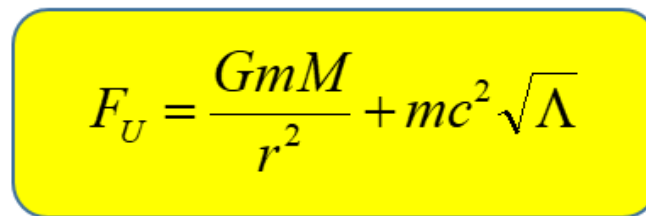
of the Universe. The value of the acceleration is obtained by solving the inverse problem for N bodies [43].

Milgrom pointed out that the critical acceleration of MOND is related to the parameters of the Universe [45]. The following proportional relationships are given in [45]:  $a_0 \sim cH_0 \sim c^2\Lambda^{1/2} \sim c^2/U$ . These are approximate proportional relationships. In the additive mathematical model of gravity, the value of the additional acceleration differs from the MOND acceleration. It has a higher value:  $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$ . Since this acceleration is, by its physical nature, related to the mass of the Universe, it is, in principle, calculable. We have derived exact equations which demonstrate the relationship between the acceleration  $10.4922... \times 10^{-10} \text{ m/s}^2$  and all the parameters of the Universe. We have obtained its value with an accuracy close to that of the gravitational constant G. The acceleration ( $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$ ) is a new parameter of the Universe [43]. It is related by exact relationships to both the constants of the microcosm and the parameters of the Universe:

$$A_0 = \frac{GM_U}{R_U^2} = \frac{R_U}{T_U^2} = c^2 \sqrt{\Lambda} = \frac{c^4}{GM_U} = GM_U \Lambda = \frac{c}{T_U} = \frac{G\hbar}{cr^3} = \dots = \frac{Gm_e}{\alpha r_e^2} = 10.4922... \cdot 10^{-10} \text{ m/s}^2 \quad (14)$$

Where: G is the gravitational constant;  $M_U$  is the mass of the Universe;  $R_U$  is the radius of the Universe;  $T_U$  is time; c is the speed of light;  $\Lambda$  is the cosmological constant;  $m_e$  is the mass of the electron;  $r_e$  is the classical radius of the electron;  $\alpha$  is the fine structure constant;  $\hbar$  is Planck's constant.

The additive mathematical model of gravity (Fig. 2) incorporates both the local law of gravity (Newton's law) and the law of the cosmological force  $F_{Cos} = (mc^2)\sqrt{\Lambda}$  (the gravity of the Universe). The additive mathematical model of gravity  $F_U = GmM/r^2 + (mc^2)\sqrt{\Lambda}$  describes the gravitational interaction of an open system.



$$F_U = \frac{GmM}{r^2} + mc^2 \sqrt{\Lambda}$$

Fig. 2. A mathematical model of gravitational interaction in an open system. Where: m and M are the masses of the bodies, r is the distance, c is the speed of light in a vacuum, G is the gravitational constant, and  $\Lambda$  is the cosmological constant.

The additional acceleration  $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$  is incorporated into the new mathematical model of gravity as a supplementary term. In our model of an open (non-local) system, the fundamental acceleration  $c^2\sqrt{\Lambda}$  is not a threshold value. It is always present and complements the local acceleration  $GM/r^2$  for any value of the local acceleration. Newton's law is incorporated into the new mathematical model unchanged, as an integral part. Equation (Fig. 2) unites local gravity and the gravity of the Universe into a single, indivisible law, rather than treating them separately. This is a mathematical model of gravitational interaction for an open system. The equation includes the speed of light, which determines the speed at which gravity propagates. In 2017, physicists observed the

merger of two neutron stars for the first time [57]. This observation showed that gravitational waves travel exactly at the speed of light.

When calculating  $G$ , one must use the value of the projection of the cosmological force vector onto the local force vector:

$$F_U = \frac{GmM}{r^2} + mc^2 \sqrt{\Lambda} \bullet \text{Cos } \vartheta \quad (15)$$

The value of the additional acceleration, which must be taken into account when calculating the constant  $G$ , depends on the angle  $\vartheta$  between the Newtonian force vector and the cosmological force vector:

$$A_{0-\vartheta} = c^2 \sqrt{\Lambda} \bullet \text{Cos } \vartheta \quad (16).$$

### 8. The new acceleration constant $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$ .

An approximate value of the additional acceleration  $A_0$  can be obtained using the approximate value of the mass of the observable Universe ( $M_U \approx 1.45 \cdot 10^{53} \text{ kg}$ ) [58, 59] and the limiting value of the force – the Planck force ( $F_P = 1.210^{27} \times 10^{44} \text{ N}$ ). The resulting acceleration value is:  $a_{MU} \approx F_P/M_U \approx 8.347 \cdot 10^{-10} \text{ m/s}^2$ . The calculated acceleration is approximately 7 times greater than the MOND threshold.

Using the cosmological constant measured by the Planck space telescope,  $\Lambda \approx 1.1 \cdot 10^{-52} \text{ m}^{-2}$ , and calculating the acceleration using the formula  $c^2 \sqrt{\Lambda}$ , we obtain:  $a_\Lambda \approx c^2 \sqrt{\Lambda} \approx 9.426 \cdot 10^{-10} \text{ m/s}^2$ , which is approximately 8 times greater than the MOND threshold. Solving the inverse problem also yields an acceleration several times greater than the MOND threshold (Fig. 1).

As a result, we have three independent calculations that lead us to the same conclusion: for precision physics and metrology, a discrepancy of almost 6-8 times is a huge gap that cannot be called a "coincidence." The MOND acceleration is just the tip of the iceberg. For precision physics and metrology, a more accurate value of the additional acceleration  $A_0$  is needed.

To calculate a more accurate value of the acceleration  $A_0$ , we combined the disparate cosmological equations of Schrödinger, Milne, Rice, and Tully–Fisher into a single system of cosmological equations. As a result, we have obtained a system of algebraic equations (Fig. 3) which has a solution. The additional acceleration  $A_0$  is calculated from a system of cosmological equations. The system of cosmological equations includes the Milne equation ( $GM_U = c^3 T_U$ ), the Schrödinger equation ( $GM_U = c^2 R_U$ ), the Rice equation ( $R_U G m_e = \alpha c^2 r_e^2$ ) and the Tully–Fisher equation ( $c^4 = GM_U A_0$ ) (Fig. 3).

$$\begin{cases} GM_U = c^3 T_U \\ GM_U = c^2 R_U \\ R_U G m_e = \alpha c^2 r_e^2 \\ c^4 = GM_U A_0 \end{cases}$$

Fig. 3. A system of cosmological equations, used to calculate the additional acceleration  $A_0$ .

In addition to the acceleration  $A_0$ , the system of cosmological equations of the Universe allows all the parameters of the observable Universe to be determined with a high degree of accuracy. Solving the system of equations (Fig. 3) yields the following values for the parameters of the Universe (Fig. 4):

$$\begin{aligned} G &= 6.67430 \dots \bullet 10^{-11} \text{ kg}^{-1} \text{ m}^3 \text{ s}^{-2} \\ M_U &= 1.15348 \dots \bullet 10^{53} \text{ kg} \\ R_U &= 0.856594 \dots \bullet 10^{26} \text{ m} \\ T_U &= 2.85729 \dots \bullet 10^{17} \text{ s} \\ A_0 &= 10.4922 \bullet 10^{-10} \text{ m} / \text{ s}^2 \end{aligned}$$

Fig. 4. Values of the parameters of the Universe derived from the system of cosmological equations.

All the calculated values of the parameters of the Universe have a precision close to that of the gravitational constant. This represents an unprecedented level of precision for the parameters of the observable universe. Previously, the values of these parameters were known only approximately in cosmology and astrophysics. The acceleration caused by the mass of the Universe is of the same order of magnitude as the critical acceleration of the MOND model, but exceeds it in absolute value (Fig. 5).

$$A_0 = 10.4922 \dots \bullet 10^{-10} \text{ m/s}^2$$

Fig. 5. New acceleration constant.

From the above, I draw the following conclusion:

**"The obtained value  $A_0 = 10.4922... \cdot 10^{-10} \text{ m/s}^2$  is a new acceleration constant, previously unknown in physics and cosmology. Without taking this constant into account, it is impossible to accurately measure the gravitational constant  $G$ ."**

The acceleration ( $A_0$ ) caused by the mass of the universe is an additional acceleration to the local Newtonian acceleration. When the local Newtonian acceleration is significant, the contribution of  $A_0$  to the resultant acceleration is negligible. When local accelerations are small, the contribution of  $A_0$  to the resultant acceleration is substantial. Since, in experiments to measure the gravitational constant  $G$ , the local acceleration is of the order of  $\sim 10^{-7}$ , the acceleration  $A_0$  cannot be neglected. Dependent on the angle between the vector of the Newtonian force and the vector of the cosmological constant, the contribution  $A_0$  can alter the value of  $G$  to the fourth or fifth decimal place.

## **9. The new acceleration constant $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$ complements the family of known acceleration constants.**

The constant  $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$ , which is needed to calculate the value of "Big  $G$ ," is not among the known acceleration constants in physics. This is a new constant. In physics, there are several important fixed values of acceleration that are used in science as acceleration constants:

- Planck acceleration  $a_p = 5,56073 \times 10^{51} \text{ m/s}^2$ ; Calculated from Planck units.
- classical limiting acceleration  $a_{\max} = 3,1894046 \times 10^{31} \text{ m/s}^2$ . Calculated from the formula:  $a_{\max} = c^2/r_e$ .
- critical Schwinger acceleration  $a_s = 2,3274210 \times 10^{29} \text{ m/s}^2$ . Calculated from the formula:  $a_s = m_e c^3/\hbar$ .
- gravitational acceleration created by the mass of an electron at a distance of its classical radius  $a_g = 7.65651 \times 10^{-12} \text{ m/s}^2$ , derived from Newton's law.
- MOND critical acceleration:  $a_0 \approx 1.2 \times 10^{-10} \text{ m/s}^2$ . This is an empirical constant and is not derived from the fundamental laws of physics.

All of the listed acceleration constants (except MOND critical acceleration) are related to each other through fundamental physical constants. Let's demonstrate this relationship. The ratio of the classical limiting acceleration  $3,1894046 \times 10^{31} \text{ m/s}^2$  to the gravitational acceleration of the electron  $7.65651 \times 10^{-12} \text{ m/s}^2$  yields a large number well known in physics:

$$a_{\max}/a_g = 4.1656 \cdot 10^{42} = D_0 \quad (17)$$

This is the famous large Weyl number, which was originally obtained as the ratio of the Coulomb repulsion force to the gravitational attraction force between two electrons [60].

Large Weyl numbers are frequently encountered in physics. This is the ratio of the electrostatic force of an electron ( $29,05351 \text{ N}$ ) to the force of gravitational attraction of two electrons ( $6.9746 \cdot 10^{-42} \text{ N}$ ), and the ratio of the Planck force ( $1.21027 \times 10^{44} \text{ N}$ ) to the electrostatic force ( $29.0535 \text{ N}$ ), and the ratio of the square root of the Planck force ( $\sqrt{1.21027 \times 10^{44}}$ ) to the square root of the force of gravitational attraction of two electrons ( $\sqrt{6.9746 \times 10^{-42}}$ ).

Let's look at how the other acceleration constants are related to each other in pairs. The ratio of the critical Schwinger acceleration  $2,3274210 \times 10^{29} \text{ m/s}^2$  to the gravitational acceleration of the electron  $7.65651 \times 10^{-12} \text{ m/s}^2$  yields a large number equal to the product of the Weyl number and the fine structure constant "alpha":

$$a_s/a_g = 3.03979 \times 10^{40} = \alpha \cdot D_0 \quad (18)$$

The ratio of the square of the Planck acceleration  $5,56073 \times 10^{51} \text{ m/s}^2$  to the square of the classical limiting acceleration  $3.1894046 \times 10^{31} \text{ m/s}^2$  also gives the number  $\alpha \cdot D_0$ :

$$(a_p/a_{\max})^2 = 3.03979 \times 10^{40} = \alpha \cdot D_0 \quad (19).$$

The same number  $\alpha \cdot D_0 = 3.03979 \times 10^{40}$  is also obtained from the ratio of the fundamental electric force of the electron ( $29.05351 \text{ N}$ ) to the gravitational force of interaction of the electron with the mass of the Universe ( $9.5577 \times 10^{-40} \text{ N}$ ) and the ratio of the square of the classical radius of the electron to the square of the Planck length:  $(r_e/t_p)^2 = 3.03979 \cdot 10^{40}$ ; and the ratio of the square of the characteristic time of the electron ( $t_e=r_e/c$ ) to the square of the Planck time:  $(t_e/t_p)^2 = 3.03979 \cdot 10^{40}$ .

The ratio of the critical Schwinger acceleration  $2,3274210 \times 10^{29} \text{ m/s}^2$  to the classical limiting acceleration  $3,1894046 \times 10^{31} \text{ m/s}^2$  yields the fine-structure constant  $\alpha$ :

$$a_s/a_{\max} = 7.297353 \dots \times 10^{-3} = \alpha \quad (20)$$

The ratio of the square of the Planck acceleration  $5,56073 \times 10^{51} \text{ m/s}^2$  to The square of the critical Schwinger acceleration  $2,3274210 \times 10^{29} \text{ m/s}^2$  yields the number  $D_0/\alpha$ :

$$(a_p/a_s)^2 = 5.70839 \times 10^{44} = D_0/\alpha \quad (21)$$

As we can see, the numbers  $\alpha = 7.297353 \cdot 10^{-3}$   $D_0 = 4.1656 \cdot 10^{42}$  and  $\alpha \cdot D_0 = 3.03979 \times 10^{40}$  are mathematical standards linking acceleration constants of different scales. Below it is shown how these same numbers  $\alpha = 7.297353 \cdot 10^{-3}$   $D_0 = 4.1656 \cdot 10^{42}$  and  $\alpha \cdot D_0 = 3.03979 \cdot 10^{40}$  connect the new constant  $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$  with the known acceleration constants.

## 10. The relationship of the acceleration constant $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$ with known acceleration constants.

The new constant  $A_0$  is harmoniously related to all known acceleration constants in physics. This striking relationship is mediated by the fundamental constant  $\alpha = 7.297353 \cdot 10^{-3}$  and the large Weyl number  $D_0 = 4.1656 \cdot 10^{42}$  (Fig. 6).

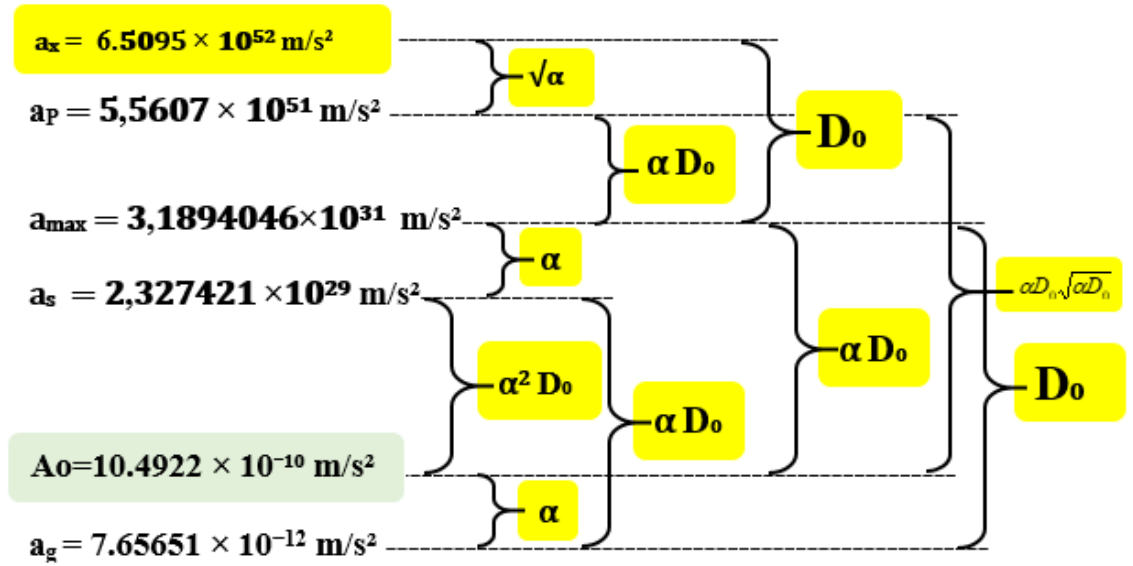


Fig. 6. Harmony of acceleration constants: the relationship of constants through the numbers “Alpha” and  $D_0 = 4.1656 \times 10^{42}$

The ratio of the classical limiting acceleration  $3,1894046 \times 10^{31} \text{ m/s}^2$  to the acceleration  $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$  gives the number  $3.03979 \times 10^{40} = \alpha D_0$ :

$$a_{\max}/A_0 = 3.03979 \times 10^{40} = \alpha D_0 \quad (22)$$

The ratio of the gravitational acceleration of the electron  $7.65651 \times 10^{-12} \text{ m/s}^2$  to the acceleration  $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$  gives the fine structure constant  $\alpha$ :

$$a_g/A_0 = 7.297353 \dots \times 10^{-3} = \alpha \quad (23)$$

The ratio of the critical Schwinger acceleration  $2,3274210 \times 10^{29} \text{ m/s}^2$  to the acceleration  $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$  yields the number  $\alpha^2 D_0$ :

$$a_s/A_0 = \alpha^2 \cdot D_0 \quad (24)$$

The ratio of the Planck acceleration  $5,56073 \times 10^{51} \text{ m/s}^2$  to the acceleration  $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$  yields the number:

$$a_p/A_0 = \alpha D_0 \sqrt{\alpha D_0} \quad (25)$$

The identified patterns in the scaling of the acceleration constants have predictive power. The patterns predict the existence of another acceleration constant ( $a_x$ ), the value of which is GREATER than the Planck acceleration (Fig. 6). The value of this constant is easily calculated using the large Weyl number  $D_0 = 4.1656 \cdot 10^{42}$  and the classical limiting acceleration  $3,1894046 \times 10^{31} \text{ m/s}^2$ :

$$a_x = \sqrt{((a_{\max})^2 \cdot D_0)} = 6.5095 \cdot 10^{52} \text{ m/s}^2 \quad (26).$$

The number  $6.5095 \cdot 10^{52} \text{ m/s}^2$  is none other than George Stoney's acceleration constant. Stoney acceleration is acceleration in the Stoney system of units. This system of natural units was proposed by the Irish physicist George Stoney in 1881, long before Max Planck proposed his famous Planck system of units [61]. In modern physics, Stoney acceleration (and the entire Stoney system of units) is extremely rare. Preference is given to Planck units. Our rediscovery of the Stoney acceleration constant  $a_x = 6.5095 \cdot 10^{52} \text{ m/s}^2$  confirms the deep connection between acceleration constants. Stoney acceleration

is also related to other acceleration constants by the scaling factors "ALPHA" and the Weyl number  $D_0 = 4.16561 \cdot 10^{42}$ .

The ratio of the square of the Stoney acceleration ( $6.5095 \cdot 10^{52} \text{ m/s}^2$ ) to the square of the number  $3.1894046 \cdot 10^{31} \text{ m/s}^2$  is equal to the large Weyl number  $D_0 = 4.16561 \cdot 10^{42}$ :

$$(a_x/a_{\max})^2 = 4.1656 \cdot 10^{42} = D_0 \quad (27)$$

The ratio of the square of the number  $6.5095 \cdot 10^{52} \text{ m/s}^2$  to the square of the Schwinger acceleration  $2.3274210 \cdot 10^{29} \text{ m/s}^2$  gives the number:  $D_0/\alpha$ .

$$(a_x/a_s)^2 = 7.8225 \cdot 10^{46} = D_0/\alpha^2 \quad (28).$$

The ratio of the Stoney acceleration of  $6.5095 \cdot 10^{52} \text{ m/s}^2$  to the acceleration  $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$  yields the number: :

$$a_x/A_0 = 6.20415 \cdot 10^{61} = \alpha D_0 \sqrt{D} \quad (29).$$

The new constant  $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$  fits perfectly into the family of acceleration constants and complements it. All known acceleration constants in physics can be easily reduced to the new constant  $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$  using the numbers "alpha" and  $D_0 = 4.1656 \cdot 10^{42}$ :

$$a_g/\alpha = 7.65651 \cdot 10^{-12} \text{ m/s}^2 / 7.297353 \cdot 10^{-3} = 10.4922 \cdot 10^{-10} \text{ m/s}^2 = A_0 \quad (30)$$

$$a_s/\alpha^2 D_0 = 2.327421 \cdot 10^{29} \text{ m/s}^2 / 2.21824 \cdot 10^{38} = 10.4922 \cdot 10^{-10} \text{ m/s}^2 = A_0 \quad (31)$$

$$a_{\max}/\alpha D_0 = 3.18940 \cdot 10^{31} \text{ m/s}^2 / 3.03979 \cdot 10^{40} = 10.4922 \cdot 10^{-10} \text{ m/s}^2 = A_0 \quad (32)$$

$$a_p/\alpha D_0 \sqrt{(\alpha D_0)} = 5.5607 \cdot 10^{51} \text{ m/s}^2 / 5.29987 \cdot 10^{60} = 10.4922 \cdot 10^{-10} \text{ m/s}^2 = A_0 \quad (33).$$

$$a_x/\alpha D_0 \sqrt{D} = 6.5095 \cdot 10^{52} \text{ m/s}^2 / 6.20415 \cdot 10^{61} = 10.4922 \cdot 10^{-10} \text{ m/s}^2 = A_0 \quad (34).$$

## 11. The absolute upper limit of the gravitational force, calculated using the constant $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$ .

The constant  $A_0$  allows us to calculate the absolute upper theoretical limit of the gravitational force that is, in principle, possible between two objects:

$$F_{\max} = M_U A_0 = \frac{GM_U^2}{R_U^2} = \frac{M_U R_U}{T_U^2} = M_U c^2 \sqrt{\Lambda} = \frac{c^4}{G} = GM_U^2 \Lambda = \frac{M_U c}{T_U} = \frac{M_U G \hbar}{c r^3} = \dots = \frac{M_U G m_e}{\alpha r_e^2} = 1.21027 \cdot 10^{44} \text{ N} \quad (35)$$

All the equivalent formulae (14) yield the value:  $1.21027 \times 10^{44} \text{ N}$ . This is none other than the Planck force, well known in general relativity and quantum gravity. It is noteworthy that the Planck force formulae include Planck's constant  $h$ , the speed of light and the parameters of the Universe, but do not include Planck units. These are new formulae for calculating the Planck force, derived from the acceleration  $A_0 = 10.4922 \dots \times 10^{-10} \text{ m/s}^2$ . The speed of light, which features in both the force formulas and the formula for acceleration  $A_0$ , is the speed at which gravity propagates.

An important conclusion follows from formula (35):

**"Of all the acceleration constants known in physics, only one constant  $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$  directly connects the mass of the Universe  $M_U$  with the Planck force ( $1.21027 \times 10^{44} \text{ N}$ )."**

If we consider a hypothetical gravitational attraction between an electron and the Universe, the equivalent equations (14) allow us to determine the value of the force.

$$F_{e-U} = m_e A_0 = \frac{m_e G M_U}{R_U^2} = \frac{m_e R_U}{T_U^2} = m_e c^2 \sqrt{\Lambda} = \frac{m_e c^4}{G M_U} = m_e G M_U \Lambda = \frac{m_e c}{T_U} = \frac{m_e G \hbar}{c r^3} = \dots = \frac{G m_e^2}{\alpha r_e^2} = 9.5577 \cdot 10^{-40} \text{ N} \quad (36)$$

This is a new constant. It represents the gravitational interaction between a single electron and the entire Universe. The physical significance of this constant is that it shows the total gravitational influence of the Universe on a single electron is comparable to the quantum forces of the microcosm. For example, the gravitational force constant between two electrons at a distance equal to the classical electron radius is:  $6.9746 \times 10^{-42}$  Newtons. This is 137 (!) times smaller than the new force constant.

The constant of the gravitational force between an electron and the entire mass of the Universe is  $9.5577 \times 10^{-40}$  N. The formulas for the gravitational constant between an electron and the Universe includes Planck's constant  $h$ , the speed of light and the parameters of the Universe.

The ratio of the Planck force to the gravitational force of attraction of an electron to the Universe demonstrates a surprising mathematical coincidence. This ratio yields, with high precision, a number represented by a combination of the fine-structure constant  $\alpha$  and the Weyl number  $D_0 = 4.1656 \cdot 10^{42}$ .

$$\frac{F_{MAX}}{F_{e-U}} = \frac{F_P}{F_{e-U}} = 1.26626 \cdot 10^{83} = \alpha D_0^2 \quad (37)$$

Where:  $\alpha$  is the fine-structure constant;  $D_0$  is the large Weyl number ( $D_0 = 4.1656 \cdot 10^{42}$ ).

## 12. The Tully–Fisher relation in the cosmological limit.

The ratio of the Planck force  $F_P$  to the mass of the Universe  $M_U$  yields the constant  $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$ :

$$F_P/M_U = 1.21027 \times 10^{44} \text{ N} / 1/15348 \cdot 10^{53} \text{ kg} = 10.4922 \cdot 10^{-10} \text{ m/s}^2 = A_0 \quad (38).$$

Formula (38) directly implies the Tully–Fisher relation for the Universe. In this extreme theoretical limit, relation (38) takes the following form:

$$F_P/M_U = c^4/GM_U = A_0 \quad (39).$$

From this it follows:

$$c^4 = GM_U A_0 \quad (40).$$

This is the result of the limiting transition of the local Tully–Fisher relation to the cosmological scale, when the velocity tends to the maximum possible physical limit—the speed of light ( $v_{\max} \rightarrow c$ ). In this case, the local equation for an individual object inevitably develops into an equation for the entire Universe, linking its total mass  $M_U$  to fundamental constants. We regard formula (40) as the "Tully–Fisher limit for the Universe." At the level of the Universe, the local variable ( $v_{\max}$ ) reaches its absolute limit ( $c$ ), the local mass tends to the limiting mass—the mass of the Universe  $M_U$ —and the Tully–Fisher relation turns into an exact equation that includes the parameters of the Universe:  $G$ ,  $c$ ,  $M_U$ ,  $A_0$ .

## 13. A scientific breakthrough that went unnoticed.

Having obtained contradictory data and identified 'inconsistencies', the metrology community made scientific breakthroughs in the fields of gravity and cosmology, but simply failed to notice them,

dismissing their results as flaws or errors. The true scale of the discovery made by metrologists is far more profound. Paradoxically, these discoveries were masked within the numerical chaos of the gravitational constant  $G$ . Their essence is as follows:

a) *An external gravitational factor has been experimentally detected*: for the first time in the history of science, under strictly controlled laboratory conditions, a large-scale gravitational factor of the Universe—not predicted by Newtonian classical mechanics—has been experimentally recorded.

b) *Detection of the Universe's gravitational vector*: The precise parameters, magnitude and spatial direction of the Universe's gravitational vector are encoded in the  $\Delta G$  discrepancies between laboratories. By analysing the discrepancies in the values of  $G$  between laboratories, it is possible to calculate the parameters and direction of the Universe's gravitational vector. The discovery of the Great Attractor was merely the first step on this path [22].

The paradox of the situation is that this very data scatter is the true scientific discovery that metrologists are already holding in their hands, but they refuse to acknowledge it, treating it as their own engineering failure. Laboratories have become cosmological sensors: the world's largest metrology centers—BIPM (France), HUST (China), NIST (USA), and PTB (Germany)—have unknowingly built ultra-sensitive detectors of the anisotropy of the Universe...

## 14. Conclusion.

This paper proposes a new interpretation of the long-standing metrological crisis surrounding precision measurements of the Newtonian gravitational constant  $G$ . We provide a cosmological explanation for the observed discrepancies in the values of 'Big  $G$ ' and propose a way to resolve the crisis. The historically observed chaotic scatter in experimental data obtained by the world's leading laboratories has traditionally been attributed to unaccounted-for systematic errors in local set-ups. We show that this anomaly has a profound fundamental nature and is caused by a conceptual shortcoming in the classical two-body law of gravitation,  $\mathbf{F} = \mathbf{GmM}/r^2$ . The traditional approach to measuring  $G$  is based on the erroneous assumption that the laboratory system is isolated. The gravitational field of the Metagalaxy's masses generates an irremovable gravitational background (additional acceleration  $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$ ), which superimposes on the local interaction of test bodies but is not detected by instruments. Numerous attempts to obtain a more precise value for the gravitational constant without taking into account the acceleration  $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$  have led to the 'Big  $G$ ' crisis.

The most valuable scientific result of the 'Big  $G$ ' measurements is the discrepancies in its values. These discrepancies are directly linked to the fact that the mathematical model of gravity does not take into account the gravity of the Universe's immense mass. This completely refutes the chaotic nature of the discrepancies, transforming the 'crisis' into a fundamental discovery. The spread of  $G$  values is not random garbage, but a value strictly limited by cosmological constants. The most unexpected aspect is that an ordinary torsion balance or atomic interferometer in an underground laboratory, designed to measure the interaction between two spheres, suddenly becomes a cosmological instrument.

Analytical resolution of the crisis: The extended equation of gravitational interaction for open systems,  $\mathbf{F}_U = \mathbf{GmM}/r^2 + m\mathbf{c}^2\sqrt{\Lambda} \cdot \mathbf{Cos}\vartheta$ , allows for the contribution of the cosmological factor. The additional term  $m\mathbf{c}^2\sqrt{\Lambda} \cdot \mathbf{Cos}\vartheta$  mathematically describes a hidden force of cosmic origin to which

terrestrial instruments are blind. However, the instruments' inability to detect this force does not negate the ubiquity of the cosmic force. The discrepancy in the values of  $G$  between laboratories is explained by the fact that the calculations did not take into account the vector of the Universe's background force, which is projected onto the instruments' measuring axes at different angles depending on their spatiotemporal orientation.

Without conducting further experiments, it is possible to utilise existing data archives and, by applying the open-system formula ( $\mathbf{F}_U = \mathbf{GmM}/r^2 + \mathbf{mc}^2\sqrt{\Lambda} \cdot \mathbf{Cos}\vartheta$ ), not only obtain the exact value of  $G$ , but also achieve a scientific breakthrough in gravity and cosmology.

## 15. Final Remarks.

1. For most 19th-century scientists, Newton's law was the holy grail. If an experiment yielded results that did not fit with Newton's law, the blame was placed on the 'imperfection of the instruments' rather than on the formula itself. With the advent of Einstein's general theory of relativity and quantum mechanics, physicists finally realised that Newton's law is merely a local approximation, rather than a model of the universe's gravity. Metrologists have reached a point of precision where it is simply impossible to ignore the influence of the rest of the universe on a laboratory instrument. To calculate "Big  $G$ ", metrologists need a formula that takes into account the gravity of the universe.

2. Solving the inverse problem shows that the divergence in the values of  $G$  is caused by an additional acceleration not taken into account in its calculations, which, in order of magnitude ( $10^{-10}$ ), coincides with the critical MOND acceleration but exceeds it in absolute value. From the cosmological equations, an exact value for the new acceleration constant has been obtained:  $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$ .

3. The new mathematical model of gravity, derived on the basis of the acceleration constant  $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$ , takes the form:  $\mathbf{F}_U = \mathbf{F}_{\{\text{Newton}\}} + \mathbf{F}_{\{\text{Universe}\}} \cdot \mathbf{Cos}\vartheta$ . It supplements Newtonian gravity ( $\mathbf{F}_{\{\text{Newton}\}}$ ) with the gravity of the Universe ( $\mathbf{F}_{\{\text{Universe}\}}$ ) and incorporates the angle  $\vartheta$  between the force vectors. The constant  $G$  must be calculated not from the local law of gravity, but using the formula for an open system.

4. Terrestrial measurements of  $G$  completely ignore the background gravity exerted by the total mass of the Universe, introducing a systematic shift. Because Earth-bound instruments are in perpetual free fall toward the Universe's global background gravity vector, direct local measurement of this factor is impossible.

5. This is not a "FIFTH FORCE"; it is the same gravitational force, caused by the enormous mass of the Universe. The magnitude of  $G$  was measured in the presence of this force, but it was not included in the calculations. This gravity of the Universe is not recorded by earthly instruments however, it exists and must be taken into account in calculations, since  $G$  is a parameter of the Universe. The contribution of this gravitational force is insignificant, but sufficient to change the value of  $G$ .

6. The Limit of Newton's Equation: This cosmological background is absent from Newton's equation. When we attempt to calculate a universal constant using an approximate framework, we inherently obtain approximate values. The missing step is not improving the instrument's protection from external forces, but integrating this cosmic acceleration vector into the data post-processing process.

7. The Triumph of Metrology: All the groups achieved such a high level of measurement accuracy that they were able to eliminate local systematic errors. Ironically, it was precisely this level of precision that enabled them to identify an unknown external factor of a gravitational nature, yet to interpret it as an unexplained discrepancy in the results. The triumph of metrology lies not only in achieving ultra-high precision, but also in the fact that it was metrology, rather than theoretical physics, that detected the deviations indicating the presence of an unknown external factor of a gravitational nature, not accounted for by Newton's law.

8. Metrology has, in effect, overtaken and surpassed local physical theories of gravity by experimentally identifying an external background factor which will now enable us to transform a dead end in the field of measurement into a breakthrough in the fields of cosmology and gravity.

9. The Limits of the Newtonian Framework: While experimentalists have meticulously accounted for every conceivable local systematic factor, the completeness of the underlying law has never been assessed in itself in this context. No group measuring  $G$  did so. As  $G$  is a universal constant, Einstein's General Relativity links it to the background curvature of spacetime. Newton's law ignores this background gravity entirely. Because we are calculating  $G$  using an incomplete/approximate formula, we inherently obtain divergent, approximate values.

10. The opportunity to discover the true, unified value of  $G$  has not been missed, and no group needs to perform new measurements. Leading global laboratories have already accumulated a colossal array of ultra-precise empirical data. The key is to shift the calculations from the formula of an isolated system to the formula of an open system. We propose a retrospective analysis of these existing datasets to recalculate the raw values by factoring in the actual acceleration caused by the gravitational influence of the Universe's total mass.

11. Scientific Breakthrough: Recalculating using the new formula will add the required signs to  $G$ . What is more, by obtaining conflicting data, all the laboratories thereby made discoveries in the fields of gravity and cosmology, but they put it down to an instrument error. These discoveries, paradoxically, are hidden in the discovered discrepancies in  $G$  values. This is even more than the additional signs added to  $G$ .

The essence of these discoveries is as follows:

a) An additional external gravitational factor, absent from Newton's law, has been experimentally detected.

b) The global gravity vector of the Universe has been experimentally detected. Its value and direction are hidden in the discrepancies (and the Great Attractor is only the first step in this cosmic puzzle).

12. It's time for metrologists to shed their false sense of guilt over the "Big  $G$ " accuracy problem. It's time to discrepancy see that this isn't a "historical failure," but a discovery in gravity and cosmology, made through metrologists' experiments. There is no "Big  $G$ " crisis—there is a crisis in gravity theory. The so-called "G-crisis" is an artifact of calculations, not a consequence of measurement instrument errors. The chaotic scatter of results when measuring the gravitational constant  $G$  is not an error in the instruments, but a missed discovery. These discrepancies point to a discovery in cosmology, and to a new law of gravity that is superior to Newton's law.

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