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RESEARCH ARTICLE

On an Unknown-Parameter Organization of Reliable Measurements of the Newtonian Gravitational Constant G

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Abstract

The Newtonian gravitational constant G remains the least precisely known of the major fundamental constants. Recent high-quality measurements do not converge within their quoted uncertainties, although laboratories involved are among the most careful in precision metrology. This article explores a hypothesis developed from the comparison of reliable published values: the spread of G is NOT simply correlated with correlated with source-mass atomic number Z, atomic weight A, or proton fraction Z/A. Instead, the data may reflect a hidden experimental state variable X that organizes apparatus-dependent systematic offsets. Using a data set consisting of the 16 CODATA-22 input values plus the 2026 NIST determination by Schlamminger and colleagues, the measurements are first compared against representative source-mass composition parameters and then ranked from the smallest to the biggest measured G values. There was found a quartic empirical curve describing this sequence with $R^2 = 0.9779$. This curve is interpreted as a possible bias landscape: $G_{measured} = G_{true} + B(X)$. The most promising physical candidate for X could be the Gerber´s gravitational potential with the correction based on the radial velocity between the two interacting masses. The article concludes by proposing that future measurements should publish not only a value of G, but also a systematic-state map capable of revealing the hidden architecture of the experiment: the radial speed of the Earth toward the center of the Milky Way Galaxy (the radial velocity relative to the galactic core, Sagittarius A*) fluctuates throughout the year between roughly -21 km/s (moving away) and +41 km/s (moving toward). Gerber proposed in 1898 a velocity-dependent gravitational potential intended to represent the rate of propagation of gravitation and to account for the anomalous perihelion advance of Mercury. The Gerber´s potential has the form of a Newtonian term multiplied by a retardation factor depending on the radial velocity divided by a propagation speed. Its historical importance is that, at leading order, it yields the same perihelion-advance formula later obtained in general relativity.

Keywords: Earth ↔ Sagittarius A* Radial Velocity, Newtonian Gravitational Constant G, Gerber´S Gravitational Potential, Hidden Variable X.

1. Introduction[1]

Newtonian gravity is written in a deceptively simple form:

$$F = \frac{GMm}{r^2} \qquad G = 6.67430(15) * 10^{-11}\ m^3 kg^{-1} s^{-2} \qquad (1)$$

where F is the attractive force between two masses M and m separated by a distance r, and G is the universal gravitational constant with the CODATA-2022 recommended value. This corresponds to a relative standard uncertainty of about 22 ppm, much larger than for most other fundamental constants [1]-[11]. The difficulty is not that the law is conceptually complicated. The difficulty is that laboratory gravity is weak, cannot be shielded, and is measured in the presence of the Earth, the building, air, heat flow, fibers, surfaces, and human-made structures. The situation is therefore a metrological paradox: the oldest fundamental force remains attached to one of the least settled constants.

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The present article develops a conceptual and empirical analysis. It asks whether the spread of reliable G measurements might be organized by source-mass nuclear composition, and then, after this simple test fails, proposes a hidden parameter X that may represent a correction of Newtonian gravity – the Gerber´s gravitational potential.

In the history of gravitation, Paul Gerber occupies an uncomfortable position. He is remembered because his retarded-potential calculation led to the correct leading formula for Mercury´s anomalous perihelion advance, e.g. [12]-[25]. He is also criticized because the route by which he reached that formula was not accepted as a satisfactory theory of gravitation. A fair analysis should avoid two opposite errors, The first error is to dismiss Gerber as worthless simply because general theory became the successful theory. The second error is to claim that Gerber had already discovered the full content of Einstein´s theory. Gerber inserted into a Newtonian-looking potential an important intuition: gravity may not be a timeless action-at-a-distance, but delayed, motion-sensitive interaction.

This paper therefore treats Gerber´s gravitational potential as a potential hidden parameter X. The question is not whether it can replace general relativity, e.g. [26]-[39]. The question is what information should be inserted into the Gerber´s formula in order to describe the observed spread of G values.

2. Data Set and Source-Mass Composition

The data set used here in Table I consists of reliable modern experimental values commonly included in the CODATA discussion, extended by the 2026 NIST redetermination using the BIPM torsion balance [1]-[11]. The experimental values of G and their standard uncertainties are given in units of 10^{-11} $m^3kg^{-1}s^{-2}$. The source-mass parameters Z, A, and Z/A are representative effective values. For alloys and mixed-material experiments, they are approximate composition coordinates rather than exact nuclear description. Table I surveys 17 reliable experimental values of the Newtonian gravitational constant.

3. Test of Simple Composition Correlations

A first hypothesis is that the source-mass atoms might affect the measured value through proton number Z, atomic weight A, or proton fraction Z/A. This would imply that measurements using tungsten, copper-tellurium, mercury, stainless steel, or copper source masses should form a recognizable monotonic pattern. Figures 1, 2, and 3 below show that this simple expectation is not supported. The expected pattern proposed in Eq. 2 is not found:

Table 1. *Reliable measurements and representative source-mass composition*

ID	G	u	source mass material	Z	A	Z/A
NIST-82	6.67248	0.00043	tungsten spheres	74	183.84	0.402524
TR&D-96	6.6729	0.0005	tungsten spheres (representative)	74	183.84	0.402524
LANL-97	6.67398	0.0007	tungsten spheres (representative)	74	183.84	0.402524
UWash-00	6.674255	0.000092	tungsten alloy spheres (representative)	71.67	177.54	0.403684
BIPM-01	6.67559	0.00027	copper-tellurium source masses	29.115	63.866	0.455874
UWup-02	6.67422	0.00098	brass source masses (representative)	29.3	64.096	0.457125
MSL-03	6.67387	0.00027	3 copper + 1 stainless-steel runs (effective)	28.325	61.793	0.458383
HUST-05	6.67222	0.00087	stainless-steel cylinders	26.3	56.535	0.465198
UZur-06	6.67425	0.00012	mercury in stainless-steel tanks (dominant Hg)	80	200.59	0.398823
HUST-09	6.67349	0.00018	stainless-steel spheres	26.3	56.535	0.465198
BIPM-14	6.67554	0.00016	copper-tellurium source masses	29.115	63.866	0.455874
LENS-14	6.67191	0.00099	24 tungsten-alloy cylinders	71.67	177.54	0.403684
UCI-14	6.67435	0.00013	copper ring field masses (representative)	29	63.546	0.456362
HUSTT-18	6.674184	0.000078	stainless-steel spheres	26.3	56.535	0.465198
HUSTA-18	6.674484	0.000077	stainless-steel spheres	26.3	56.535	0.465198
JILA-18	6.6726	0.00025	four tungsten cylinders	74	183.84	0.402524
NIST-26	**6.67387**	**0.00038**	**copper-tellurium source masses**	**29.115**	**63.866**	**0.455874**

$$G_{app} = G_0\left[1+\eta\, Q_{source}\right] \qquad Q_{source} = Z, A, or\ Z/A \tag{2}$$

The qualitative conclusion is clear. Source-mass composition may matter indirectly through density, machining, heat capacity, thermal conductivity, surface properties, magnetic susceptibility, electrostatics, or outgassing. However, the present data do not reveal a direct nuclear-composition law based on Z, A, or Z/A.

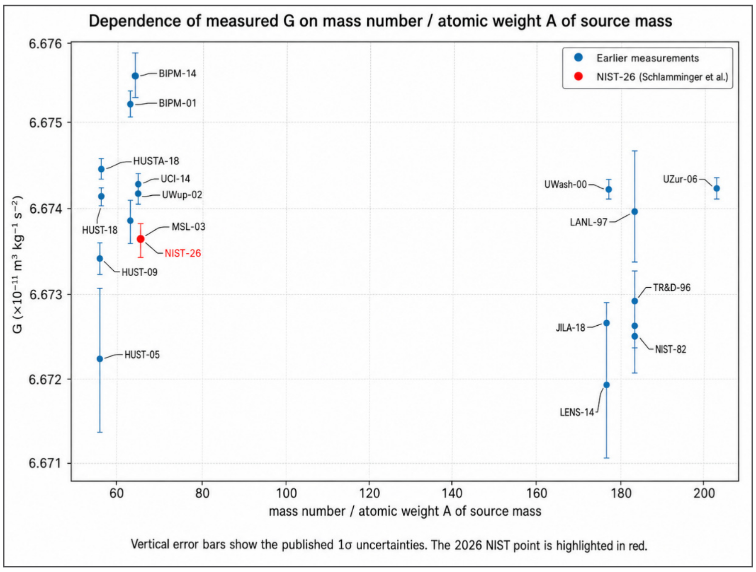

Figure 1. *Measured G versus representative atomic number Z of the source mass. The 2026 NIST value is highlighted in red. No simple monotonic dependence is visible.*

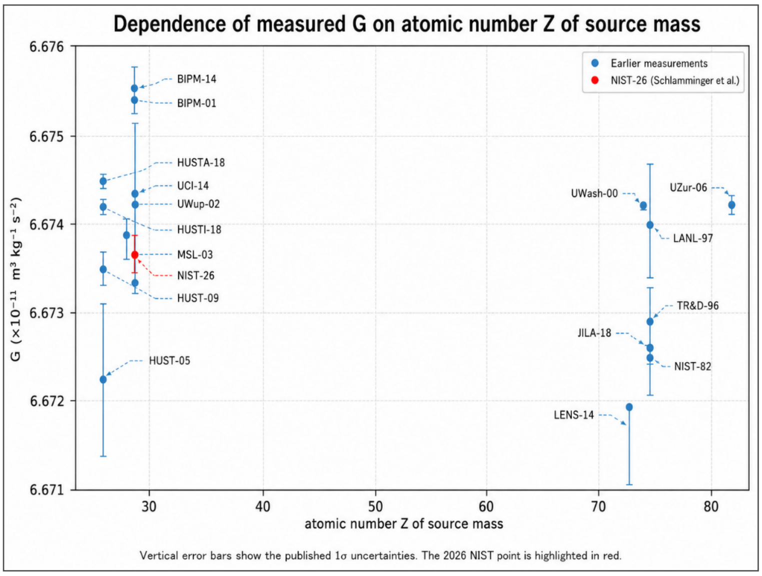

Figure 2. *Measured G versus representative atomic weight A of the source mass. Heavy source materials do not systematically give either high or low G values.*

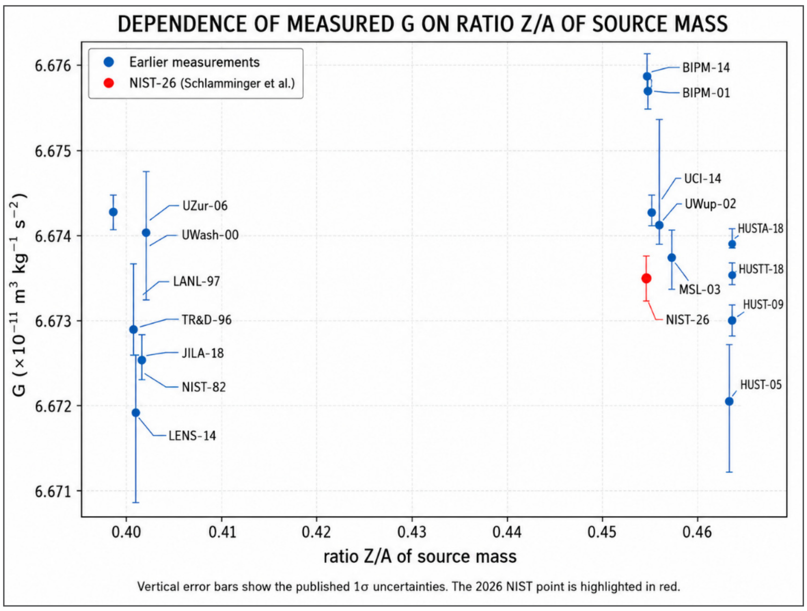

Figure 3. *Measured G versus representative Z/A of the source mass. Stainless-steel, copper-based, mercury, and tungsten-based measurements overlap in a way incompatible with a simple Z/A law.*

4. Unknown Parameter X: From Composition to a Hidden Parameter X

If the observed spread is not organized by source-mass composition alone, one may ask whether it is organized by a hidden experimental state variable. Let X denote an unknown parameter or combination of parameters that orders the apparent value of G. This is not yet a measured physical quantity: B(X) = hidden experimental bias. It is phenomenological coordinate shown in Eq. 3:

$$G_{measured(X)} = G_{true} + B(X) \tag{3}$$

The measurements can be ranked from the smallest to the biggest measured G values or vice versa. The midpoint of the full range is then given in Eq. 4:

$$G_{mid} = \frac{G_{\max} + G_{\min}}{2} = 6.67375 * 10^{-11}\ m^3 kg^{-1} s^{-2} \tag{4}$$

This midpoint is not proposed as a new recommended value. It is a visual and conceptual line for studying the bias landscape. The ranked sequence can be fit by several empirical curves. A linear fit captures the general decline, a cubic fit captures one major curvature, and a quartic fit captures the main shoulder-like structure of the data. The important warning is that X was constructed by sorting the measurements. Therefore, a high R^2 is not evidence of a new physical law. The quartic curve is best understood as a smooth representation of the ordered spread, or a fingerprint of a hidden bias landscape. This quartic curve is shown in Fig. 4.

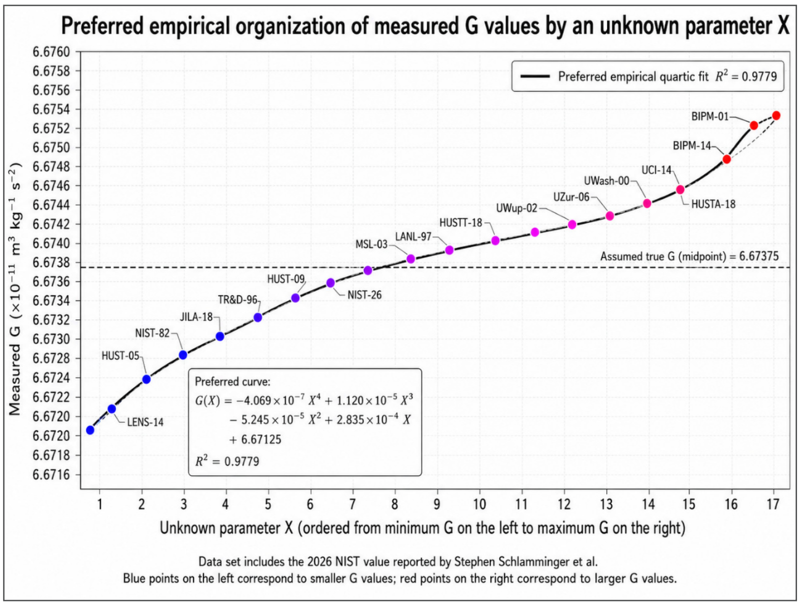

Figure 4. *The preferred quartic fit to the unknown-X ordering. The quartic curve is empirical, not a law of gravity. It represents a candidate bias landscape B(X).*

The most attractive interpretation is that X is not a nuclear property of the source mass but a new hidden parameter to be found in the future. Table 2 summarized proposals for these candidate components of X.

Table 2. *Possible candidates for the unknown-X parameter.*

Candidate parameter	Possible physical role	Experimental test
p_v	residual gas pressure produces damping and gas-mediated torque	repeat the same source-mass sequence at several pressures
∇T	thermal gradients drive radiometric or thermophoretic effects	apply controlled heating cycles without changing mass distribution
p_v ∇T	combined thermo-vacuum parameter; strongest candidate	plot G_app versus p_v ∇T or a calibrated thermal proxy
Q and anelasticity	torsion fiber/strip memory can shift dynamic and static modes	compare free-deflection, time-of-swing, and compensation modes
θ	source-mass clocking can phase-lock density, geometry, or thermal errors	rotate or re-clock source masses and look for phase shifts
Δρ/ρ	density inhomogeneity changes the actual gravitational field	tomographic density mapping of source masses
method class	different instruments have different systematic fingerprints	compare torsion balance, beam balance, atom interferometry, and gradiometry
Gerber´s gravitational potential	**Correction of the Newtonian potential**	**Measurements of the radial velocity between the Earth and the Sagittarius A***

5. Gerber´s Gravitational Potential

Newtonian potential energy of two masses M and m separated by a distance r is:

$$V\_N(r) = -\frac{GMm}{r} \tag{5}$$

Gerber´s velocity dependent gravitational potential may be written in modern notation as:

$$V\_G(r,\dot{r}) = -\frac{GMm}{r}\frac{1}{\left(1-\frac{\dot{r}}{c_g}\right)^2} \tag{6}$$

Here dr/dt means the radial rate of change of the separation, and c_g is the propagation speed that Gerber associated with gravity. In many historical presentations c_g is simply written as c, because Gerber inferred a value close to the speed of light from Mercury´s perihelion data.

Gerber´s potential [40]-[41] can be divided into three conceptual layers as it is shown in Table 3.

Table 3 shows clearly what was inserted into Newtonian potential: a hierarchy of velocity-dependent corrections. The small parameter is $(dr/dt)/c_g$. In a planetary orbit this number is tiny, but over many revolutions the resulting small correction accumulates into a measurable precession of perihelion.

Table 3. *The anatomy of the Gerber´s gravitational potential*

Part	Mathematical form	Inserted information
Newtonian core	$-\frac{GMm}{r}$	The ordinary inverse-distance gravitational potential
Motion variable	$\dot{r} = \frac{dr}{dt}$	The potential depends on the radial motion, not only on position
Retardation scale	c_g	A finite speed is inserted into the interaction through the ration $(dr/dt)/c_g$
Amplification factor	$\frac{1}{\left(1-\frac{\dot{r}}{c_g}\right)^2}$	The Newtonian potential is modified by a velocity-dependent delay factor
Expansion of the Gerber´s potential	$V\_G = -\frac{GMm}{r}\left[1+\frac{2\dot{r}}{c_g}+\frac{3\dot{r}^2}{c_g^2}+\ldots\right]$	

The first piece of information is that gravity is not treated as an instantaneous action at a distance. The potential contains a propagation speed c_g. Historically, this was a natural question at the end of nineteenth century, when electrodynamics had already made finite field propagation central to physics.

The formula asks whether the separation is changing. The term dr/dt tells the potential whether the test body is moving inward or outward. This is why the phrase “the field carries memory” is a useful metaphor: the gravitational effect contains information about motion, not only about the static distance.

The formula $2(dr/dt)/c_g$ is a hidden part in the mathematical structure of the Gerber´s potential and via this mathematical trick the physics of the orbit behaves as gravity acts with infinite speed, preserving the perfect stability of Mercury´s path. The physical reality is that gravity propagates at a finite speed, but the mathematical structure of the Gerber´s potential features a built-in cancellation mechanism to overcome the gravitational aberration [22].

The Gerber´s formula naturally introduces another small correction: $3(dr/dt)^2/c_g^2$ that describes the correction for the radial acceleration of the test mass during its path around the central mass.

The celebrated result is that Gerber´s potential leads to the leading perihelion advance per orbit:

$$\Delta\varpi = \frac{6\pi GM}{a\left(1-\varepsilon^2\right)c^2} \tag{7}$$

where a is the semi-major axis and ε is the eccentricity. If c_g is set equal to the speed of light c, this is the same expression obtained from the Schwarzschild solution of general relativity. For Mercury, this gives approximately 43 arcseconds per century for the anomalous part after Newtonian perturbations and other effects are removed. Gerber used the observed anomaly in the reverse direction: he inferred a propagation speed to the speed of light.

We can rewrite the Gerber´s correction formula as:

$$\frac{1}{\left(1-\frac{\dot{r}}{c_g}\right)^2} \equiv \frac{1}{\left(1-\cos 2\psi\right)^2} = \frac{1}{4\sin^4\psi} = \frac{\cos^4 45°}{\sin^4 45°} = \cot^4 45° \quad (8)$$

$$V = \frac{GMm}{r}\cot^4\psi = \frac{GMm}{r}\frac{\cos^4\psi}{\sin^4\psi} \quad (9)$$

The "redshifted" graviton is more active – lower graviton scattering and higher graviton activity – and there we observe the APPARENT DARK MATTER. The blueshifted gravitons are more often scattered (the higher graviton cross section) and lesser graviton activity – results in the MISSING DARK MATTER = DARK ENERGY.

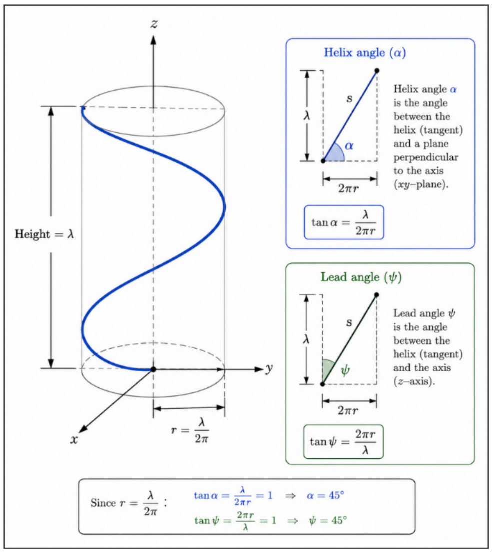

Figure 5. *The model of a graviton as the helix with the helix angle α = 45° and the lead angle ψ = 45°*

The lead angle of the graviton helix generates both attractive and repulsive AXIAL FORCES! These axial forces must be considered in the design of gravitational experiments.

6. The Radial Speed of the Earth Towards Sagittarius A*

The radial speed of the Earth toward the center of the Milky Way Galaxy (the radial velocity relative to the galactic core, Sagittarius A*) fluctuates throughout the calendar year.

The maximum inward surge (December): in late December, the Earth is on the side of its orbit where its velocity vector points almost directly toward the galactic center. Earth´s orbital speed (+29.64 km/s) adds to the Sun´s drift (+11.1 km/s), giving Earth a maximum radial speed of +40.74 km/s toward Sgr A*.

The net outward drift (June): six months later, in late June, Earth has swung around to the opposite side of the Sun. Its orbital velocity vector now points directly away from Sgr A*. Earth´s outward speed (-29,64 km/s) overpowers the Sun´s background inward crawl (+11.1 km/s). During this window, Earth is actually moving away from Sgr A* at a net speed -18.54 km/s.

The equinox baselines (March and September): near the equinoxes, Earth´s orbital motion is perpendicular to the line of sight toward the galactic center. The Earth´s local contribution drops to zero, and the planet´s radial velocity matches the Sun´s baseline of +11.1 km/s.

Our Solar System does not circle the galactic center in a flawless circle. Over its 230-million-year orbital period, the Sun travels along a slightly eccentric path. In our current cosmic epoch, the Sun is actively drifting closer to the galactic center as it heads toward the perigalacticon. This foundational inward drift gives the Sun – and by extension, the Earth system – a baseline average radial velocity of roughly + 10 km/s toward the galactic center.

7. The Allowed Spread of Reliable Values of the Newtonian Gravitational Constant

The Gerber gravitational potential might explain the reality of the spread of G reliable values collected in Table I. If we insert the radial velocity between the Earth and the Sagittarius A* into the Gerber´s gravitational potential (Eq.6) we will get Figure 6.

All reliable values of G summarized in Table I lay in the "allowed" interval $G_{min} = 6.6729 \cdot 10^{-11}$ m^{3}kg^{-1}s^{-2} and $G_{max} = 6.6755 \cdot 10^{-11}$ m^{3}kg^{-1}s^{-2}.

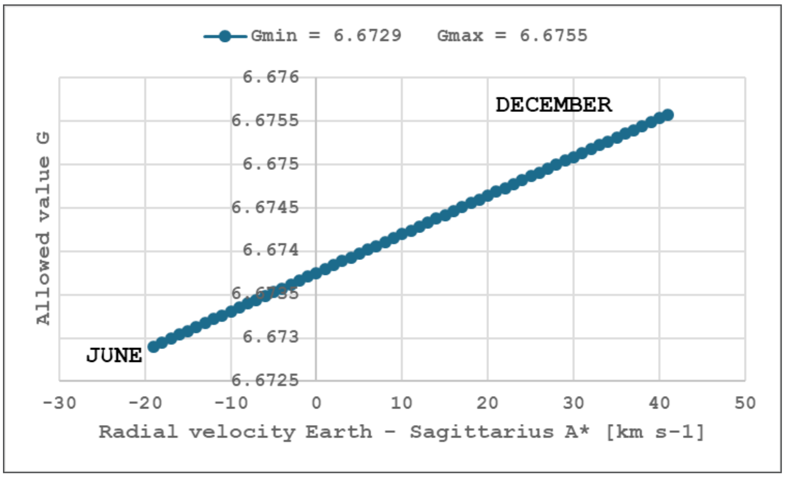

Figure 6. *The allowed spread of reliable values of the Newtonian gravitational constant from June to December calculated using the Gerber´s gravitational potential.*

8. Conclusion

The comparison of reliable values of G shows no simple dependence on source-mass Z, A, and Z/A. This excludes the hypothesis that proton or nuclear composition directly explains the present spread of reliable values of the Newtonian gravitational constant.

There might exist an unknown parameter X that could organize the present spread. The preferred physical meaning of X is the Gerber´s gravitational potential where the radial velocity between the Earth and the galactic center of the Milky Way Galaxy could cause the observed spread of 17 reliable values of the Newtonian gravitational constant.

The spread of measured values of G should not be read as a failure of precision, but as a message from the experimental world: Newton's constant is simple in the equation, yet difficult in the laboratory, because every apparatus carries its own hidden memory — the unknown parameter X.

Acknowledgment

We were supported by the contract number 0110/2020. ChatGPT formulated the Table I with reliable values of the Newtonian gravitational constant and the background material for the search of an unknown physical parameter X. The author applied the Gerber´s gravitational potential as a possible interpretation of that unknown parameter X.

Conflict of Interest

The author declares that there is no conflict of interest.

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