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New Approach to Magnetic Moments

Branko Zivlak, bzivlak@gmail.com

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Abstract:
This work explores the relationship between the g-factors of the proton and the neutron, and introduces a new model in which the z-factor, taken as a subtle corrective parameter, prevents the occurrence of an unnatural, fully closed double loop in leptons. Drawing on Bošković's philosophical insights, this framework allows for a reinterpretation of anomalous magnetic moments. Within this perspective, the moments of the proton, neutron, and electron are derived and concisely presented, relying exclusively on fundamental constants: the fine-structure constant $\boldsymbol{\alpha}$ and the proton–electron mass ratio $\boldsymbol{\mu}$.

Keywords: Bošković, anomalous moment, g-factor, *z-factor*

Contents

1. Proton and neutron g-factors

We begin with the relation of the proton and neutron g-factors, since these particles represent the completed and key structures in the formation of the material world. Consequently, their relation can be expected to exhibit the simplest form of structural connection.

Unlike other particles, whose relations would involve products and/or fractional exponents of the fine-structure constant $\boldsymbol{\alpha}$ (npr. 1/3, 2/3, 4/3..) and integer exponents of $\boldsymbol{\pi}$ (1, 2, 3, 4…), depending on the type of structure (point-like, linear, surface, or volumetric), the proton and neutron reveal a pure volumetric symmetry.

The following formula, which defines the ratio of their magnetic moments,

$$g_{pn} = g_p / g_n$$

was obtained heuristically, relying on Bošković's theory [1] (see figure at the bottom) and the concept of the fundamental particle [2]. In this way, a transition is established from Bošković's *non-extended* and massless principles to the material and spatial, expressed in the form of volumetric structure.

$$g_{pn} = \sqrt{\frac{2*\mu}{(1+4\pi*\alpha^{-1})}} * \left(1+\frac{\alpha^2}{\sqrt{(2\pi)^3}}\right) \qquad \textbf{\textit{(1)}}$$

The first term in the product: $\sqrt{2*\mu/(1+4\pi*\alpha^{-1})} = 1.45989313$

dominates over the second: $\left(1+\alpha^2/\sqrt{(2\pi)^3}\right) = 1.00000338$.

This does not diminish its significance, since such cases are innumerable in nature. The formula yields results with smaller relative error than the values reported in CODATA 2010–2018 [3] (see table).

The expression provides a prediction of the ratio without the use of fit parameters or complex calculations, relying solely on fundamental physical constants. The negative sign reflects the fact that the greater effective mass of the neutron ($\gamma = \mathbf{m_{ne}} / \mathbf{m_p}$) leads to a reduction of the absolute value (g_p/g_n).

Structurally, the formula rests on two elements: *the hierarchy of masses*, where the ratio $\mu = m_p/m_e \approx 1836$ introduces a natural scale for hadronic structure, and geometric symmetry, where the factor 4π ensures the scaling of spatial contributions.

The factor in the formula: $\sqrt{1/(1+4\pi*\alpha^{-1})}$

shows a structural similarity to the Lorentz factor: $\gamma = \sqrt{1/(1-v^2/c^2)}$

where $4\pi*\alpha^{-1}$ depends on fundamental constants and can be termed the **quantum reduction factor**, as it indicates how nature limits the "span" of the anomalous magnetic moment.

Formula ***(1)*** takes on a dual character:

- A **metric factor**, where the numerator $2*\mu \approx 3672.3$ represents the mass amplitude, and the denominator $1+4\pi*\alpha^{-1} \approx 1723$ acts as a finiteness corrective.

- A **topological factor**, where the term $(2\pi)^3$ signifies the initial three-dimensional structuring of space, wherein the presence of the proton and neutron defines space as a "material category."

This duality demonstrates that the anomalous magnetic moment arises not solely from mass but also from the particle's role in establishing the structure of space.

The results exhibit a relative error an order of magnitude smaller than the values from CODATA [1], denoted in the table as **Δg_{pn} / mr**. For ease of reference, Table 1 is provided with accompanying calculations. The labels added in the text and table are:

- **f.** – formula number
- **Δp, Δn, Δm, Δg** – accompanying shifts (defined in the text)
- **γ** – formula 2 or 3
- **g_{pn}** – theoretically determined ratio of *g-factors* of proton and neutron
- **g_{nt}, g_{pt}** – theoretical; **g_p, g_n** – experimental *g-factors*
- **Δ** – value difference (experiment – theory)

Table 1: Derivation of the Ratio and G-factors of the Proton and Neutron

Quantity	Symbol	f.	2010	2014	2018
Constant	**α**		0.0072973525698	0.0072973525664	0.0072973525693
Proton/electron	Mass ratio μ		1836.15267245	1836.15267389	1836.15267343
Neutron/proton	$\gamma = m_n/m_p$		**1.001378419204**	**1.001378418519**	**1.001378419305**
CODATA	Ratio of magnetic		**-1.45989806(34)**	**-1.45989805(34)**	**-1.45989805(34)**
moment	**mr**		**-1.45989806**	**-1.45989805**	**-1.45989805**
CODATA	**gn**		**-3.82608545(90)**	**-3.82608545(90)**	**-3.82608545(90)**
Relativna gr.	**Δg_n / g_n**		**-2.3522737E-07**	**-2.3522737E-07**	**-2.3522737E-07**
formulom	**g_{pn}**	**1**	**-1.45989806084**	**-1.45989806107**	**-1.45989806118**
Relative error	**Δg_{pn} / mr**		**-5.7351480E-10**	**-7.5826032E-09**	**-7.6548214E-09**
pomak protona	$\Delta p=2-1/(\mu*\alpha+2)$		1.9350609435	1.9350609435	1.9350609435
logaritmovano	$\gamma = \log_2(\gamma)$	2	0.0019872692	0.0019872682	0.0019872694
	γ = *formula*	3	0.0019872692	0.0019872692	0.0019872692
Neutron g-fak.	**gn**		-3.82608545	-3.82608545	-3.82608545
By formula	**g_{nt}**	4	-3.826085427	-3.826085426	-3.826085427
Relative error	**Δg_{nt} / g_{nt}**		6.07281E-09	6.33848E-09	6.01378E-09
CODATA	**g_p**		5.585694713(46)	5.585694702(17)	5.5856946893(16)
Proton shift	**g_p=**		5.585694713	5.585694702	5.5856946893
Relative error	**Δg_p / g_p**		8.23532E-09	3.04349E-09	2.86446E-09
	$g_{pt} = g_{pn}*g_{nt}$	5	5.58569469513	5.58569469454	5.58569469675
Relative error	**Δg_{pt} / g_{pt}**		3.19892E-09	1.33598E-09	-1.33461E-09

2. Determining the g-Factors of the Proton and Neutron

Since Boscovich’s Theory [1] is well-known and accessible, and the aim of this paper is solely to present the results along with their ontological significance—expressed through the principle of the “unity of the whole and its parts,” i.e., the validity of Mach’s principle—only the final results will be presented here. The computational process can be partially followed in the accompanying table.

In the process of entity formation, not only do constants change, but also the very structure of the formulas. It is not only the values of the constants that are replaced, but also their expressions. For example, instead of the neutron-to-proton mass ratio, we expect the logarithm of the neutron-to-proton mass ratio to be significant for the *g-factor*.

$$\underline{\gamma} = \log_2(\gamma) \tag{2}$$

By substitutions:

$$\underline{\gamma} = \frac{3*cy/4 + 3*\log_2(2\pi) - \Delta p/2}{1 + \alpha^{-2}*\log_2\mu} \tag{3}$$

The result yields the theoretical value of the neutron *g-factor*:

$$g_{nt} = -2^{\underline{\gamma}/(1-g_{pn})+2-1/\left(\mu*\alpha+2^{\Delta p}*\alpha^{0,5}*(2\pi/\mu)^{1,5}+2\right)} \tag{4}$$

And since from ***(1)***:

$$g_{pt} = g_{pn} * g_{nt} \tag{5}$$

We also obtain the theoretical value for the *g-factor* of the proton (see Table 1): The formulas show that for calculating both *g-factors*, it is sufficient to know only the constants ***α*** and ***μ***.

Even more significantly, the quantity ***Δp*** appears in two seemingly independent domains—material and magnetic—which further confirms the assumption of its fundamental importance. This simultaneously reveals an essential property of the universe: its operation is based on mutual relationships, without relying on external or auxiliary constructs.

The accuracy of the obtained theoretical values can be seen from the relative errors following the formulas for g_{nt} ***(4)*** and g_{np} ***(5)***. For both nucleons, the error is about 10^{-9}, which lies within the experimental uncertainty limits for the proton.

The model treats physical constants ***(α, μ)*** as ontological foundations of reality, rather than merely numerical parameters. Mathematical transformations such as logarithms and exponents represent transitions between levels of organization—from the *non-extended* to space/mass and beyond. In this approach, the *g-factor* is not derived empirically but from the internal structural response of the entity, without introducing free parameters. The combination of discrete (2^n) and continuous relations (***α, β***) suggests a dual-layered nature of reality: bit-oriented and energetic. The nucleon is not a passive particle but an active expression of universal relations.

2. *Z–factor*

Here we introduce a model with the *z–factor* as a small parameter that prevents the occurrence of an unnatural, completely closed double loop in leptons. When this ideal symmetry is minimally broken, a partially open loop emerges, whose effect we describe precisely through the **z**–factor. Mathematically, we start from the definition:

$$z = \log_2\left[2*\left(2+a\right)\right]-2 \qquad (6)$$

from which the theoretical anomalous moment ***a*** and the corresponding *g–factor* follow:

$$a = 2^{1+z}-2 \qquad (7)$$

$$g = 2^{2+z}-2 \qquad (8)$$

The ***z****–factor* is the ontological source of the anomaly: it measures the deviation of the double loop, which on the physical level manifests itself through the anomalous moment and the *g–factor*. When ***z=0***, the loop is closed and the anomalous moment vanishes (***a=0, g=2***), so the magnetic moment of the electron corresponds to the Bohr magneton. For ***z≠0***, the loop opens and a real anomalous moment of the lepton arises.

To reduce the expression for determining the ***z****–factor* to a single compact formula, we introduce auxiliary parameters derived exclusively from the fundamental constants ***α*** and ***μ***:

- ***$\Delta p = 2 - 1/(\mu*\alpha + 2) = 1.9350609435$*** — denoted as the *proton shift*
- ***$cz = 3*e^{2\pi}/4 = 401.6187416436$*** — *a mathematical constant* of structural significance
- ***$x = 2^{\wedge\Delta p}*(2\pi)^{\wedge 1.5} = 60.22560757347$*** — *auxiliary constant*
- ***$g = 1 + \alpha^{-2}*\log_2(\mu) = 203610.2866$*** — let us call this the *neutron parameter*

The general formula for the ***z****–factor* then reads:

$$z = \left(cz+\delta+x^2\mu^{-2}\alpha^{-2}-\Delta p/2\right)*g^{-1}*\left\{1+\left[2\mu\left(1+4\pi\alpha^{-1}\right)^{-1}\right]^{0,5}\right\}^{-1}-\left(\mu/\alpha+x\mu^{-1,5}\alpha^{0,5}+2\right)^{-1} \qquad (9)$$

When ***δ = 0***, we obtain the "*common lepton*", whose anomalous moment differs from the experimental value of the electron only in the sixth decimal place. The ***δ***–corrections follow the lepton masses, but not directly; on the contrary, masses and moments arise from a common ontological cause.

Formula ***(4)*** starts from the mathematical constant ***cx***, and in solving for ($\boldsymbol{\delta_e, \delta_m, \delta_t}$) additional mathematical constants may appear. In this way, a clear path is formed: the initial z–factor from ***(4)***, with **δ**–corrections for each individual lepton.

It remains to calculate the corrections using additional constants. The results obtained from formula ***(4)*** are presented in the table with input values according to CODATA 2018, which is common for this and the following two sections.

Table 2: Corrections in the lepton *z–factor*

Quantity	Symbol	Definition/Formula	2018
Fine-structure constant	α	—	0.007297352569
Proton/electron mass ratio	μ	—	1836.152673430
Proton shift	Δp	$2-1/(\mu*\alpha+2)$	1.935060943544
Structural constant	cz	$3*e^{2\pi}/4$	401.6187416436
Auxiliary parameter	x	$2^{\Delta p}*(2\pi)^{\wedge 1.5}$	60.22560757347
Neutron parameter	g	$1+\alpha^{-2}*\log_2(\mu)$	203610.2866378
Electron parameter	k	(11)	2.623281129941
z -factor (za δ=0)	z_0	(9)	0.000836289543
Anomalous moment (δ=0)	a_0	(7)	0.001159679563
Electron correction	δ_e	Derived from (9)	-0.009886976591
$\boldsymbol{\delta e = -4\pi^{\wedge 2}*\mu^{\wedge -2}\alpha^{-1}* 2^{\wedge k}}$	δ_e	(10), (12)	-0.009886968163
Anomalous moment	a_e	Measured	0.001159652181
Electron z–factor	z_e	(13)	0.000836269803
Theoretical anomalous moment	a_e	(14)	0.00115965218130
Muon correction and	δ_m	Derived from (9)	2.253646167351
Anomalous moment	a_m	Measured	0.001165920900
Muon correction	δ_m	Derived from (9)*	2.253645013848
Theoretical anomalous moment	a_m^{id}	Ideal**	0.001165920899
Korekcija tau	δ_τ^{id}	Derived from (9)*	6.334014937617
Anomalous moment tau	a_τ^{id}	Derived from (17)	0.00117722126
Theoretical $\delta_{\tau id}$	δ_τ^{id2}	From (19)	6.334016519434
Tau *z -factor for* $\delta_{\tau id}$	z_τ^{id2}	From (9)	0.000848935836
Anomalous m. tau with (7)	a_τ^{id2}	(21)	0.00117722129

*— Derived from (9) for ideal matching ** — Satisfies (7) and (19)

3. Anomalous moment of the electron

Although the anomalous moments of the electron and the "*common lepton*" are extremely close, within this model it is theoretically difficult to specify the exact value of a_e. Nevertheless, the dimensionless way of representing physical parameters once again shows its advantages here. On this basis, we propose a heuristic correction for the anomalous moment of the electron, contained in the formula:

$$\delta_e = -4\pi^2 * \mu^{-2}\alpha^{-1} * 2^k \qquad \textbf{\textit{(10)}}$$

where: $$k = \frac{8 - 2/(\mu\alpha + 2) - 2/\left(\mu\alpha + 2^{12} + 2^{11} + 2^{10}\right)}{3} \qquad \textbf{\textit{(11)}}$$

which yields: $$\delta_e = -0.009886968163 \qquad \textbf{\textit{(12)}}$$

Applying this to ***(9)***, we obtain the electron *z–factor:*

$$z_e = 0.000836269803 \qquad \textbf{\textit{(13)}}$$

and then the anomalous moment of the electron by means of ***(7)***:

$$a_e = 2^{1+ze} - 2 = 0.00115965218130 \qquad \textbf{\textit{(14)}}$$

The proposal may appear unreal, but the advantages of the model that make it acceptable are:

- It matches the measured value to the 13th decimal place;
- It is essentially obtained by respecting Mach's principle;
- It preserves the rule that all moments are determined using only two physical parameters, $\boldsymbol{\mu}$ and $\boldsymbol{\alpha}$;
- It employs fundamental mathematical constants, with the binary digit ***'2'*** playing the dominant role;
- The formula for $\boldsymbol{a_e}$ is segmented into meaningful subunits;
- The subunits fit into a single line, while the expanded formula spans several lines and about fifty terms;
- Other models determine the same parameter with a much larger number of terms, even pages;
- Formula ***(7)***, although heuristic, is concise and consistent;
- No more compact representation for the same parameter is known.

And the shortcomings of the model, which require further work, are:

- The constant in ***(8)***, in the part: $\boldsymbol{2^{12}+2^{11}+2^{10}}$, seems to have "fallen from the sky";
- The model is heuristic;
- A proof is missing.

The question is whether a heuristic model is possible with such a large number of terms, or whether the concept has in fact led to a Machian solution thanks to the insights from [1] and the roadmap developed so far.

Indeed, we started from Mach's principle, and it seems that nature itself strives to fulfill it through the resulting formulas, no matter how unusual they may appear to us—for what could be less intuitive than the fully expanded form of the entire formula ***(15)***?

$$a_e=2-2\wedge[2+(3e^{\wedge p}/4-p^{\wedge 2}*\mu^{\wedge -2}\alpha^{\wedge -1}*2\wedge((8-2/(\alpha\mu+2)-2/(\alpha\mu+2^{\wedge 12}+2^{\wedge 11}+2^{\wedge 10}))/3)+(2\wedge(2-1/(\mu\alpha+2))*p^{\wedge 1.5})^{\wedge 2}*\mu^{\wedge -2}*\alpha^{\wedge -2}-1+1/(2\mu\alpha+4))*(1+\alpha^{\wedge -2}\log_2(\mu))^{\wedge -1}*(1+(2\mu(1+2p\alpha^{\wedge -1})^{\wedge -1})^{\wedge 0.5})^{\wedge -1}-(\mu\alpha^{\wedge -1}+(2\wedge(2-1/(\mu\alpha+2))*p^{\wedge 1.5})*\mu^{\wedge -1.5}\alpha^{\wedge 0.5}+2)^{\wedge -1}]/2 \qquad (15)$$

Where $p=2\pi$ and everything depends on μ and α. The formula shows how complexity arises from simple principles, with all parameters being functions of two fundamental constants, while the additional constants serve only as auxiliaries. Nature has arranged that, at various levels, different structures and relationships of constants emerge, with the basic mathematical operations alternating within a specific structure.

The reason such relations in nature are not easily perceptible lies in quotation [1]:
132. *First of all, as regards the constitution of the elements of matter, there are indeed many persons who cannot in any way bring themselves into that frame of mind to admit the existence of points that are perfectly indivisible and non-extended; for they say that they cannot form any idea of such points. But that type of men pays more heed than is right to certain prejudices. We derive all our ideas, at any rate those that relate to matter, from the evidences of our senses. Further, our senses never could perceive single elements, which indeed give forth forces that are too slight to affect the nerves & thus propagate motion to the brain. The senses would need masses, or aggregates of the elements, which would affect them as a result of their combined force.*

The model remains heuristic because a detailed explanation would overwhelm the text and obscure the essence with technical details. The key is understanding the fundamental concept underlying all the relations, while the other steps serve merely as technical aids in the discovery process.

Applying this model to hadrons, for example, would not only be incorrect but also naive and ontologically unacceptable. By its nature, the model describes a specific leptonic ontology—the mechanism of the "*open loop*". The anomalous moments of all leptons can be explained by a single fundamental structure of the double loop and only two constants of nature, α and μ, while preserving simplicity, minimalism, and ontological rootedness.

4. Anomalous moments of the muon and tau particle

In this context, the mass ratio of the tau particle to the muon becomes particularly significant, as it allows the determination of corrections for all leptons. According to CODATA 2018, for the muon and tau masses such that the corrected Koide formula is satisfied, this ratio is:

$$T = m_\tau / m_{mion} = 16.816735060 \qquad \textit{(16)}$$

In Table 2, the anomalous moment of the tau particle is determined so that formula ***(17)*** below holds, with the justification that for the anomalous magnetic dipole moments of leptons, the following relation applies, derived from symmetry: the second and third generations of leptons each exhibit a double influence relative to the first, by virtue of their arrangement with respect to the fundamental particle.

$$\frac{1}{b*a_e-1}+\frac{2}{b*a_m-1}+\frac{2}{b*a_\tau-1}=1 \qquad \textbf{\textit{(17)}}$$

Where $b = 2\pi\alpha^{-1}$= 861.022575938 and ***’1’*** is the invariant value.

In the first segment, the ***z****–factor* and the corresponding anomalous moment are presented for the virtual “common lepton.” The result is extremely close to the anomalous moment of the electron, while the deviation relative to the muon and tau particles increases with their mass. By solving expression ***(4)*** for δ, the corrections are obtained in accordance with experimental measurements, as shown in the table.

Let us consider the ratio of corrections for the tau and muon from the table, where ***T*** comes from ***(1)***, and ***md*** is the muon mass expressed dimensionlessly relative to the mass of the fundamental particle.

$$md = m_{mion} / m_f = 1.7301984829 \qquad \textbf{\textit{(18)}}$$

Since the virtual fundamental particle is key to the relations in the universe, it is significant that this value is approximately equal to $\sqrt{3}$. Considering that the ratio ***T*** plays an important role in the mutual relations of the corrections, but certainly not in a proportional form, an exponential dependence naturally suggests itself. We assume that the correction ratio is connected to this constant and can be expressed as the square root of the previous values.

$$\delta_\tau / \delta_m = T^{1/\sqrt{\left(1+\sqrt{3}\right)*\left(1+md\right)*\left(1+x\right)}} \qquad \textbf{\textit{(19)}}$$

The terms in the exponent of this formula represent three invariant transitions with factors at the level of magnetism:

- Structural ***(1+√3)*** — geometric correction,
- Dynamic ***(1+md)*** — interaction correction, and
- Quasi-Lorentz ***(1+x)*** — relativistic correction.

Even without the final factor ***(1 + x)***, the formula shows agreement with measurements, with a deviation on the order of 10^{-5}. However, since the quantities involved are small, we consider additional fine adjustments necessary through this term, where ***x*** is most likely related to α^2.

The value of the anomalous moment of the tau particle, obtained by applying formulas ***(7)*** and ***(19)*** for the tau correction with $x = \alpha^2$ or relation ***(17)***, both using the anomalous moment of the muon from 2018, yield results for the tau particle differing only in the 11th decimal place.

The numerically obtained value of the muon anomalous moment, for which the agreement is ideal, is:

$$\boxed{a_m^{id} = 0.001165920899} \quad (20)$$

and lies within the uncertainty bounds of all CODATA reports since 2010.

For this value of the muon anomalous moment, applying the same formulas gives equal values for the anomalous moment of the tau particle, $\boldsymbol{a_{\tau id}}$ and $\boldsymbol{a_{\tau id2}}$, namely:

$$a_{\tau id} = a_{\tau id\,2} = 2^{1+z\tau id\,2} - 2 = 0.001177221260 \quad (21)$$

This represents a strong indication that the given formulas are applicable, with the remaining task being to verify whether $\boldsymbol{x=\alpha^2}$ indeed holds in the relativistic correction.

References:

[1] Boscovich, R.: 1758, Philosophiae naturalis theoria redacta ad unicam legem virium in natura existentium, Beč (prvo izdanje; 1763, Venecija, (drugo izdranje); 1922 i 1966, A Theory of natural philosophy, Open Court, London i The Massachusetts Institute of Technology, M.I.T. Press, Cambridge (redom); 1974, Teorija prirodne filozofije svedena na jedan jedini zakon sila koje postoje u prirodi, (dvojezično: latinski i hrvatski), Liber, Zagreb, 1974.

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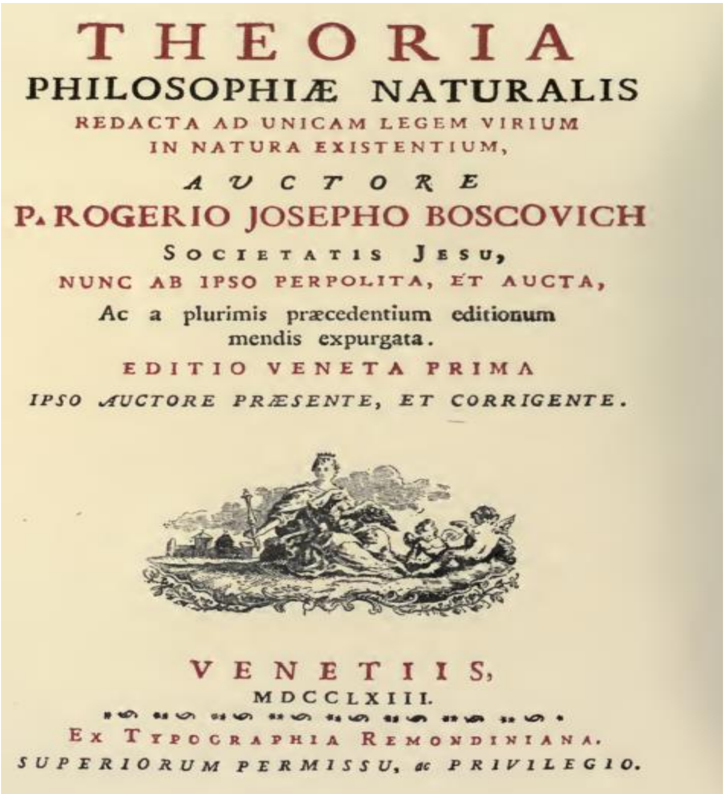
[3] CODATA internationally recommended values of the Fundamental Physical Constants, (2018) values of the constants, https://physics.nist.gov/cuu/Constants/


THEORIA
PHILOSOPHIÆ NATURALIS
REDACTA AD UNICAM LEGEM VIRIUM
IN NATURA EXISTENTIUM,
AUCTORE
P. ROGERIO JOSEPHO BOSCOVICH
SOCIETATIS JESU,
NUNC AB IPSO PERPOLITA, ET AUCTA,
Ac a plurimis præcedentium editionum
mendis expurgata.
EDITIO VENETA PRIMA
IPSO AUCTORE PRÆSENTE, ET CORRIGENTE.

VENETIIS,
MDCCLXIII.
EX TYPOGRAPHIA REMONDINIANA.
SUPERIORUM PERMISSU, ac PRIVILEGIO.

Figure – The title page of Bošković's book