Metaphysical Status of Physical Laws

Alexey Burov and Lev Burov

This article was originally published in

Plato in Late Antiquity, the Middle Ages and Modern Times:

Selected Papers from the Seventeenth Annual Conference of the International Society for Neoplatonic Studies

Edited John F. Finamore and Mark Nyvlt

ISBN 978 1 898910 909

Published in 2020 by The Prometheus Trust, Lydney, UK.

The Prometheus Trust is a registered UK charity (no. 299648)
www.prometheustrust.co.uk

Metaphysical Status of Physical Laws

Alexey Burov and Lev Burov

When Galileo professed that the book of nature is written in the language of mathematics, his claim was not at all that the natural processes are conducive to quantitative analysis, that there are relationships and correlations between measured parameters. In his time, as in ours, that would have been a banality, while the thought of Galileo was revolutionary. It was much more than counting or measuring: farmers have been counting sheep and measuring their property since prehistory. It was of an entirely different order than even the Ptolemean model, which, though a magnificent example of the ancient art of curve-fitting, had not progressed the *understanding* of nature beyond the confirmation of the fact that some regularities exist in the trajectories of the planets. In reality, Galileo was establishing a programme of searching out the postulates of nature, its mathematical principles, hidden behind complex theorems of phenomena. Galileo was much closer to the Pythagoreans with their enigmatic creed "things are numbers" than to superficial empiricist measurements a la Francis Bacon. Someone today, especially a scientist, may find it difficult to appreciate how revolutionary the idea truly was, being inundated with it from childhood. However, to a fresh set of eyes, nature does not at all bear the likeness of Euclid's construct. An adequate appraisal of Galileo's idea should place it with the borderline mad, which, according to Niels Bohr, marks any profound truth.

The idea of mathematical nature did not appear to Galileo out of a vacuum, but was a synthesis of two elements. One of them—the Pythagorean-Platonic—arose from the mathematics of antiquity, a special meditation, *theōria*, on perfect ideas. The other—the Biblical—is itself a synthesis of two principles. The first is that the material world is fundamentally good, so it deserves attention for its own sake, not only for pragmatic goals of comfort and power. The second is the idea of man as a likeness of God, which opens the possibility of comprehending the world on a big scale. The thought that the world, good in its essence, should be based on perfect forms of reason open to man's cognition, is completely natural for a Biblical

Platonist, being at the same time incomprehensible from within both the empirically-oriented common sense and those religious worldviews that do not intersect with Platonism. Galileo implicitly based his epistemic framework on the belief in a special perfection of the hidden mathematical axioms of nature, its Platonic forms or laws, which combine in themselves a sufficient simplicity to make them discoverable with a sufficient complexity to produce the richness of nature. The latter point deserves to be stressed: every little increase in complexity of laws would create a tremendous jump in difficulty of their discovery, but if they were even a little simpler, the universe would have lacked the structural variety for life, not to mention human brains. Descartes thought in a similar fashion and established the same paradigm of geometry. Thus, the Pythagorean faith of Galileo and Descartes contained this hidden opposition of complexity and simplicity. This faith is what constitutes the Platonic-Biblical foundation of physics, establishing both the general direction of cognition and its utmost value—we will even dare say, sanctity.

Although this synthesis was and still is recognized only by a handful of scientists and philosophers, its fruits did not wait long to follow: Mechanics, Electrodynamics, Special and General Relativity, Quantum Mechanics, Quantum Field Theory, electroweak unification, Chromodynamics, the Higgs field, all grouped today under the name of the Standard Model. Physics is reductionist in its very core, reducing phenomena to fundamental laws. Therefore, it not only grows in depth, pursuing new and deeper laws, but also in breadth, by applying them to more and more complex systems; its object of study is all of the material world *inasmuch as it is subject to laws*.

The process of looking for new laws continues, but it would be helpful to take stock of its main findings thus far. In an essay "Moira and Eileithyia for Genesis" we suggested a formulation of the philosophically significant qualities of the discovered laws of nature. We will permit ourselves a larger quote:

> First, the laws are endowed with a peculiar mathematical beauty, uniting in themselves formal simplicity, richness of solutions and one or another kind of symmetry, often as if suggesting itself as a hypothesis to a mind gifted with intuition. This special beauty is sometimes called elegance of the laws of nature. Thus, elegance has a decisive significance to a birth of a hypothesis, the most mysterious part of discovery. Secondly, the same elegant mathematical law captures a tremendous range of

> parameters (distances, time intervals, energies, etc.), at that with a fantastic precision, up to twelve digits. This quality of the laws can be called universality. Finally, the laws happen to be friendly to life's appearing and developing up to intellect; following the established terminology, this quality can be called anthropic.
>
> The combined presence of these three qualities allowed for their discovery by great minds, and for that reason, it seems that the most appropriate term, uniting all three, is discoverability. A universe whose laws satisfy the Discoverability Principle (DP) of being elegant, universal and anthropic we suggested to call Pythagorean.[1] It could even be that the laws of our universe constitute the simplest possible set, compatible with the DP. The only explanation of these amazing qualities of the laws is that they come from the highest mind, which created our universe capable to not only be inhabited by intelligent beings but cosmically cognized by them.[2]

The span of physical cognition, both theoretical and experimental, comprises today about 45 orders of magnitude: from the size of the universe, $\approx 10^{26}$ meters, to the scale smaller than that of the top quark and Higgs-boson, $\approx 10^{-19}$ meters. Within this cosmic span of parameters, the accuracy of some of the fundamental laws is astonishing. For instance, today, the theoretically predicted value of the electron magnetic moment agrees with its carefully measured value within the error bars of the latter, which means agreement within twelve decimal digits. A similar agreement is reached for the General Relativity. Today's humanity is discovering its—without exaggeration—cosmic scale, the scale of cosmic observers.

The divine origin of the laws was pointed out by all the founding fathers of theoretical physics, from Galileo and Newton to Einstein, Heisenberg and older Dirac; it is not a coincidence that there has not been a single skeptic among them in the antique or Humean sense of the word, or anyone characterizing themselves as atheist. Varieties of such views existed from at least the Greek classical period, including the entire lifetime of physics, as exemplified by David Hume, Ernst Mach, Richard Feynman, and a significant number of other

---

[1] Burov and Burov (2016)

[2] Burov and Burov (2017).

intellectuals. None of them, however, laid the conceptual foundations of physics, at most greatly contributing to its development upon the existing conceptual base. Here is a statement on the topic made by Einstein:

> "The interpretation of religion, as here advanced, implies a dependence of science on the religious attitude, a relation which, in our predominantly materialistic age, is only too easily overlooked. While it is true that scientific results are entirely independent from religious or moral considerations, those individuals to whom we owe the great creative achievements of science were all of them imbued with the truly religious conviction that this universe of ours is something perfect and susceptible to the rational striving for knowledge. If this conviction had not been a strongly emotional one and if those searching for knowledge had not been inspired by Spinoza's Amor Dei Intellectualis, they would hardly have been capable of that untiring devotion which alone enables man to attain his greatest achievements … This firm belief, a belief bound up with deep feeling, in a superior mind that reveals itself in the world of experience, represents my conception of God. (1948)"[3]

Atop the contemporary Mount Olympus of physics, the situation, however, is the opposite: today it is dominated by a scientistic mixture of atheism and skepticism. The question of the causes of this philosophical shift at the highest echelons of physics is important, but mostly lies outside the scope of this topic. Here we will just list some factors of different kinds that appear to be significant in this respect: the tumultuous development of physics horizontally and technically, with expertization of even the fundamental physics; seemingly irrational paradoxes of Quantum Mechanics; the historical catastrophes of the 20th century—all these factors contributed to the loss of philosophy by physicists and physics by philosophers. This unphilosophical state of physics is documented in Steven Weinberg's famously writing that "most physicists today are not sufficiently interested in religion even to qualify as practicing atheists."[4] The authors consider the renewal of this mutual understanding as one of the most important and difficult tasks before humanity.

---

[3] Einstein (1954).

[4] Weinberg (1992) loc. 3866.

On one hand, the aforementioned character of the laws confirms the Platonic theory of forms with fantastic power. On the other hand, Platonism in physics faces certain criticisms, which we will examine in what follows.

It makes sense to ask: how fair is it to consider physical laws as Platonic forms? One of the most common objections to the Platonist view on physics stems from the notion that physical laws are approximate. Following that, a negative conclusion is drawn about ascribing them an objective status, and instead, they are granted just an operationally-pragmatic significance. This objection, however, is based on nothing but a careless attitude to the special character of approximation in the laws. This critique of Platonism loses sight of that tremendous precision in a wide range of parameters, even in Newton's Celestial Mechanics, not to mention the precision of Quantum Electrodynamics and General Relativity described above. One part in a thousand billionth, or twelve decimal digits, and possibly more, is a bit much for an explanation of the simplicity of laws by operational pragmaticism. To explain such an extreme precision by a lucky choice of convenient formulas with very few free parameters is nothing but an absurdity; such level of agreement can only be explained by a true discovery of an objective law. But this is not yet the whole story. The character of approximation of a law of nature becomes clear with the discovery of the deeper, more general, law. The law discovered earlier still gets to keep its power not only as a convenient, simpler and often more than sufficiently precise formula but, moreover, as an exact mathematical asymptote of the law of the next level. Classical mechanics, for example, is an exact mathematical limit of the relativistic mechanics when the speed of light approaches infinity; it is also an asymptote of quantum mechanics when the Planck constant tends to zero. Thus, to base an objection to the Physical Platonism on the imprecise quality of laws—is too imprecise. The adequate characterization of laws is not approximation but asymptotic exactness. Of course, we do not know, and most likely will never know the Platonic forms of nature in their fullness. But many of their asymptotically-exact formulations on several levels are already known, and deeper asymptotes may yet be discovered.

In his famous essay "The Unreasonable Effectiveness of Mathematics," Eugene Wigner demonstrates a remarkable effectiveness of mathematics in physical discoveries. He gives the following characterization for the relation between the old, classical, and new, deeper laws:

> The present writer had occasion, some time ago, to call attention to the succession of layers of "laws of nature," each layer containing more general and more encompassing laws than the previous one and its discovery constituting a deeper penetration into the structure of the universe than the layers recognized before.[5]

The relationship between theories of different levels is not exhausted by asymptotic convergence. A kind of structural similarity between them is demonstrated by the correspondence of Hamiltonian and Lagrangian formulations of classical and quantum theories, the so called *correspondence principle*. Theistic philosopher Robin Collins characterizes these relationships between theories of different levels as “hierarchical simplicity:”

> Collins argues that General Relativity would have been almost inconceivable without the Newtonian theory of gravity already in place; even as it was, developing General Relativity took a true act of genius. Developing Newton’s law of gravity also demanded an act of genius and required not only that the laws of gravity be simple, but also that Newton’s law reduce to simple rules of planetary motion—namely, Kepler’s three laws. Even with simple laws of planetary motion, it took Kepler fifteen years of trial and error to discover them. Like an excellent tutor, the universe has not been so demanding as to ensure failure but rather has allowed us to succeed while still presenting us with worthy challenges.[6]

Due to these deep connections between the old and the new laws, physicists hardly ever make such characteristics of classical mechanics as “false” or “mistaken,” which are commonly expressed, however, by philosophers of science. We quote Wigner again to corroborate this:

> The law of gravity which Newton reluctantly established and which he could verify with an accuracy of about 4% has proved to be accurate to less than a ten thousandth of a per cent and became so closely associated with the idea of absolute accuracy

[5] Wigner (1960) 1–14.

[6] Gonzalez and Richards (2004) 215.

> that only recently did physicists become again bold enough to inquire into the limitations of its accuracy. [See, for instance, R. H. Dicke, Am. Sci., 25 (1959).] Certainly, the example of Newton's law, quoted over and over again, must be mentioned first as a monumental example of a law, formulated in terms which appear simple to the mathematician, which has proved accurate beyond all reasonable expectations.

Wigner concludes his essay with the pronouncement that the effectiveness of mathematics in physics is a "mystery which we neither understand nor deserve." Contemplating the same mystery at the end of his life, the mystery of those discoveries that he could make, Paul Dirac wrote down the following experience:

> If you are receptive and humble, mathematics will lead you by the hand. Again and again, when I have been at a loss how to proceed, I have just had to wait until this happened. It has led me along an unexpected path, a path where new vistas open up, a path leading to new territory, where one can set up a base of operations, from which one can survey the surroundings and plan future progress.[7]

Historian of science Marc Steiner shows how precisely this image reflects the experience of physical discoveries in general, concluding of the surprising openness of the universe to mathematical cognition: "the universe looks, intellectually, user-friendly."[8] Philosopher Mark Colyvan examines the question if the realist or anti-realist philosophy of mathematics can resolve the problem of Wigner's *unreasonable effectiveness* of mathematics. He formulates the problem in the following way:

> The problem is epistemic: why is mathematics, which is developed primarily with aesthetic considerations in mind, so crucial in both the discovery and the statement of our best physical theories?[9]

Later he notes that neither the mathematical realism of Quine and Putnam, nor the anti-realism of Field answer this key question. The authors agree with Colyvan that a mere assertion of objectivity of

---

[7] Farmelo (2009).

[8] Steiner (1998).

[9] Colyvan (2001).

mathematics is not enough to respond to Wigner's problem, but it does not mean, as we are trying to show, that it is possible to avoid this assertion.

The incompatibility of scientism with the discoverability of the fundamental laws of the cosmos is today becoming obvious to those scientists who cannot be suspected of any sympathy to religious worldviews. Theoretical physicist Sabine Hossenfelder discusses in her recent book "Lost in Math" the strange role of mathematical beauty in physical discoveries: "Why should the laws of nature care what I find beautiful?" she asks, noting that "Such a connection between me and the universe seems very mystical, very romantic, very not me." One can only welcome such sharpness as hers in the problem statement of the compatibility of naturalism and faith in the discoverability of the laws:

> I doubt my sense of beauty is a reliable guide to uncovering fundamental laws of nature, laws that dictate the behavior of entities that I have no direct sensory awareness of, never had, and never will have. For it to be hardwired in my brain, it ought to have been beneficial during natural selection. But what evolutionary advantage has there ever been to understanding quantum gravity?[10]

Graham Farmelo, the author of Paul Dirac's biography "The Strangest Man," also considers the reverse relation of physics and mathematics in his latest book "The Universe Speaks in Numbers:"[11]

> In Dirac's 1939 lecture 'On the Relation Between Mathematics and Physics', he wrote that 'as time goes on, it became increasingly clear that the rules that the mathematician finds interesting are the same as those that Nature has chosen.' In recent decades, these words have begun to look remarkably far-sighted. Not only is mathematics 'unreasonably effective' in physics, as Eugene Wigner famously observed, the opposite is also true: physics is unreasonably effective in mathematics. Could this two-sided unreasonableness be leading us to a unified understanding of physics and mathematics, as Dirac proposed?

[10] Hossenfelder (2018) 4.

[11] Farmelo (2019).

One of the first critics of the Platonic theory of forms was Aristotle. While he admitted the objectivity of forms in general and mathematical forms in particular, he leaned towards denying their independent existence, concluding his “Metaphysics” by stating that it seems to him that objects of mathematics are not separable from sensible things, as “some say.” Mathematics, however, emerged entirely out of viewing its forms purely in terms of their interrelation, carefully and systematically separating them from the physical world, exactly as those “some” say, which is particularly evident in the number theory. For example, the ancient Pythagoras theorem, of the impossibility of representing the square root of two by a ratio of integer numbers, was proven without any reference to the physical world. Moreover, this theorem contains an implicit distancing from the physical world, where one can always find a practically acceptable approximation. Even geometry, which bears an obvious resemblance to physical objects, was constructed by the laws of its internal deductive logic, free from any connection to the physical entities. If the antique thinkers accepted Aristotle’s conclusion in regards to the non-existence of mathematical forms by themselves, independently from the sensible things, the construction of the Pythagorean-Platonic mathematics would not have occurred, and mathematics would have remained that which it was before Pythagoras: a collection of instructions for surveyors and architects. The conclusion of “Metaphysics,” even softened by the “seems,” is, per se, lethal for mathematics. It is no wonder that among the great mathematicians from antiquity to our time there has not been a single adherent of the Aristotelian view on mathematics, and it was not by chance that Peripatetics were the main opponents of the father of mathematical physics, Galileo.

Another objection to Platonism emerges from equating it with an extreme reductionist take on the theory of forms that extends to the mind of man himself, as a wholly natural entity. The objection points out the metaphysical and ethical contradictions of such a far reaching reduction. The most powerful argument against this level of reductionism can be found in rational thought itself, which in no way fits on the Procrustean bed of laws and chance. This objection to total reductionism appears to be valid, but it refutes not Plato's theory of forms but the extension of this theory to the thinking subject. The subject is only partially determined by forms, even in their combination with the quantum randomness, but also partially free, being one of the particular termini of being. Schrödinger wrote that he could see himself accepting the emergence of life purely by laws and chance but that in respect to thought the idea is absurd. Any trust to reason is precluded by this unacceptable-to-Schrödinger claim, which can lead to nothing but absolute skepticism, in the spirit of Descartes' demon, in turn a position incompatible with the faith in the power and value of scientific cognition. By precluding reason's trustworthiness, a total reductionism annihilates also its own foundation, the faith in the power of fundamental laws, leading, therefore, to the paradox of the Cretan Epimenides, "all Cretans are liars." In order to avoid this, it is necessary to accept mutual irreducibility of the triad of forms, chance and minds. We are forced to exclude thought or the mind from the physical world, which is subject to laws and chance, but at the same time leave to the mind the ability to perceive the material objects and act upon them. In other words, the subjection of nature to laws becomes limited not only by chance but also by the actions of thinking beings. And while randomness is partially lawless only in a single event, yet obeys laws statistically, creative actions cannot be captured by any statistic in principle; in them law comes up against the absolute limit of its power, since each creative act is necessarily unique. Therefore, on a deep enough level, natural objects must reveal a Platonic-mental-random trialism: being to a certain degree determined by law and chance, while letting the mind perceive and act upon them. The chance works here as a placeholder when there is no mind. The first thinker who noticed the necessity for such a trialism in the atomic motion seems to have been Epicurus, who, starting from considerations such as these, introduced *clinamens*, small acausal changes in the trajectories of atoms as placeholders for the free will. Particle-wave duality of quantum mechanics represents these clinamens, the triadic Platonic-mental-random nature of the quantum objects.

The human mind interacts with the material world through the media of the brain, body and life. Life, viewed in this way, is an interface between mind and physical matter; that can be used as a general definition of life. Taking up this intermediary place in being, the living nature is determined by laws to a lesser degree than the physical, yet it is not as free as the mind. Another significant difference between the living and the physical is tied to evolution. Composite physical objects are subjected to degradation and decay by the action of the Second Law of Thermodynamics. Life is also not free from it, being subject to disease and death. At the same time, however, life, after its mysterious appearance on our planet, did not remain in its original, simplest form, but systematically and no less mysteriously developed with evolution. In that last respect, life is more similar to a growing mind, than to degrading matter.

Physics, being a science of the subjection of nature to mathematical laws, is, therefore, limited by two mysteries: the mystery of the origin of its own laws and the mystery of subjectivity, the interaction of mind and matter, which includes the mystery of life. On the other hand, the question of the possibility and reason for the intersection between the blossoming complexity of the world and the Platonic elegance of its discoverable laws leads to the creative foundations of being, to the theoria of Demiurge and the Good.

Bibliography

Burov, A. and Burov, L. 2016. *Genesis of a Pythagorean Universe*. In *Trick or Truth? The Mysterious Connection Between Physics and Mathematics*, ed. A. Aguirre, B. Foster and Z. Merali, The Frontiers Collection, FQXi, Springer International Publishing, pp 157-170.

Burov, A. and Burov, L. 2017. *Moira and Eileithyia for Genesis*. FQXi contest *Wandering Towards a Goal*.

Colyvan, M. 2001. *The Miracle of Applied Mathematics*. Synthese 127: 265–277.

Einstein, A. 1954. *Ideas and Opinions*. Crown Publishers. Kindle Edition, p. 52.

Farmelo, G. 2009. *The Strangest Man: The Hidden Life of Paul Dirac, Quantum Genius*. Faber & Faber. Kindle Edition, loc. 8537

Farmelo, G. 2019. *The Universe Speaks in Numbers*. Faber & Faber;

Gonzalez, G. and Richards, J. W. 2004. *The Privileged Planet: How Our Place in the Cosmos Is Designed for Discovery*, Regnery Gateway.

Hossenfelder, S. 2018. *Lost in Math*. Basic Books. Kindle Edition.

Steiner, M. 1998. *The Applicability of Mathematics as a Philosophical Problem*. Harvard University Press, p. xvii.

Weinberg, S. 1992. *Dreams of a Final Theory.* Vintage Books, Kindle Edition.

Wigner, E. 1960. *The Unreasonable Effectiveness of Mathematics.* Communications on Pure and Applied Mathematics, 13: 1–14.