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On Hooke's Rule of Nature

Abstract. *Lectures de Potentia Restitutiva or Of Spring: Explaining the Power of Springing Bodies (1678) is an important book for the history of science. This book is better known for Hooke's presentation of the law that bears his name. This law, or "Rule of Nature" as the author states, is commonly taught within the context of the analysis of elastic bodies and their deformations. However, the framework in which this law was introduced goes beyond the context in which it is currently taught. Alongside the presentation of Hooke's experiments with springs, the author established his vibratory theory of matter, in which the concepts of congruence and incongruence, initially presented in his Micrographia (1665), would be defined in greater detail. These concepts aimed to theoretically justify the movements of attraction and repulsion in nature. This paper seeks to study the Lectures de Potentia Restitutiva once again to better understand Hooke's thoughts about the rule which bears his name and his conception of gravity, which the author considered a force. Here Hooke's definitions of body and motion will be presented, as well as his actual objective when he formulated the so-called Hooke's Law. As we will see, Hooke intended to create a "philosophical scale" to measure the gravitational attraction between bodies. By considering his previous publications, such as An attempt to prove the motion of the Earth from Observations or Micrographia: or some Physiological Descriptions of Minute Bodies, or even unpublished works such as On the inflection of a direct motion into a curve by supervening Attractive principle, it becomes clear that Hooke was already opening a path toward an understanding of gravity before Newton's Principia (1687) were published. By taking into account the controversy between Isaac Newton and Robert Hooke, we also intend to strengthen the idea that Hooke was an indispensable contributor to the elaboration of a law of universal gravitation. In addition to all this, it will also be argued that the conclusions achieved by Hooke in Of Spring may have also anticipated Newton's third law of motion.*

Keywords: *theory of Universal Gravitation; Hooke's law; spring; rule of nature*

Introduction.

In 1678, Robert Hooke (1635–1703) published a pioneering scientific book: *Lectures de Potentia Restitutiva or Of Spring: Explaining the Power of Springing*

Bodies. In it, we find important observations about different branches of science, such as mechanics, geology, and meteorology. In the first part of this text, Hooke presents us with what we now call Hooke's Law, duly substantiated by his experiments in accordance with the motto of the Royal Society *Nullius in Verba* (Tinniswood, 2019). After this, Hooke also uses observations from nature, such as volcanic eruptions and records of fossilized species as evidence that the Earth has changed over time in shape and composition, and that fossils are records of species that lived in other times, concluding that "nothing in nature is exempt from change and corruption" (Hooke, 1678, p. 50). These ideas are developed in greater detail in his *Discourse of Earthquakes*, published in the *Posthumous Work* in 1705[1]. As Ellen Tan Drake has remarked (Tan Drake, 1966), in the *Discourse of Earthquakes* Hooke already presents gravity as essential to keeping the earth a globe.

The possibility of bodies moving due to forces of attraction and repulsion has been raised over time by various thinkers and has been accompanied by different theories or beliefs. In this paper, I will present the development of Hooke's ideas on this topic, especially those that are present in *Of Spring*.

Discussion.

The Law of Universal Gravitation is commonly attributed to Isaac Newton (1643–1727). Nevertheless, Robert Hooke made important contributions to the study of gravitation before Newton's publication of the *Principia*. The rivalry between Robert Hooke and Isaac Newton is well-known and has been extensively covered by several scholars (Gal, 2005).[2] These two figures lived in the same period, were part of the same circles, and, with different stances, also addressed the same problems. In 1687, Newton published his famous book *Philosophiae Naturalis Principia Mathematica*, where his Law of Universal Gravitation is propounded. Following this publication, Hooke protested that there is no acknowledgment of him in the book. Such an acknowledgment would have been fair since the two exchanged letters on gravity. Hooke had already published, in 1674, *An attempt to prove the motion of the Earth from Observations,* where he defined basilar principles towards a theory of gravitation. Newton's justification for the absence of Hooke's name in the *Principia* was that Hooke had only presented assumptions while he, Newton, presented the mathematical explanation of gravity (Westfall, 2007).

Newton's response is still controversial: firstly, because in science the mathematical explanation needs to be supported by a theory, and secondly, because Hooke is said to have arrived at a part of the mathematical explanation, which would make Newton's claim false. Richard Westfall concludes that Newton was influenced by a letter sent to him by Hooke, in which the latter presented his idea about the possibility of a reciprocal attractive force between the Sun and the planets that would be inversely proportional to the distance between the bodies (Westfall, 2007).

[1] These ideas are pioneering in the history of geology. James Hutton (1726–1797), considered the founding father of geology, only wrote about these issues one hundred years later. Ellen Tan Drake even calls Hooke the "true founder of the science of geology".

[2] Such as, Michael Nauenberg, Mary B. Hesse, Alexandre Koyré, Ofer Gal, Richard Westfall, Allan Chapman, Michael Hunter, Simon Schaffer, John Gribbin, P.J Pugliese, among others.

Alexandre Koyré (1952) also highlighted this letter in 1952. If we look at the original correspondence, no doubt remains about this:

But my supposition is that the Attraction always is in a duplicate proportion to the Distance from the Center Reciprocall, and Consequently that the Velocity will be in a subduplicate proportion to the Attraction and Consequently as Kepler Supposes Reciprocall to the Distance. And that with Such an attraction the auges will unite in the same part of the Circle and that the neerest point of accesse to the center will be opposite to the furthest Distant. (Turnbull, 1960, p. 309)

Throughout Hooke's work, we can follow the development of his thought toward a theory of universal gravitation. In his *Micrographia*, Hooke presents for the first time the concepts of *congruence* and *incongruence*, which would be key concepts in the theoretical foundation of his theory of gravitation and which would be taken up again in *Of Spring*. Through experiments with liquids in very thin tubes, Hooke realized that there exist what we nowadays call adhesion and cohesion forces. These forces were defined by the author in terms of their affinity to the concepts of *congruence* and *incongruence*, which he defines as follows:

By Congruity, I mean a property of a fluid body, whereby any part of it is readly united with any other part, either of it self, or of any other similar, fluid, or solid body; And by Incongruity a property of a fluid, by which it is hindred from uniting with any dissimilar, fluid or solid body. (Hooke, 1664, p. 12)

The notion that there exist driving forces in nature which bring things together or move them apart takes us back to the ideas of Empedocles. In the 5th century BC, this philosopher provided us with one of the first analogies of attraction and repulsion ever recorded. The pre-Socratic philosopher presents love and hate – union and separation – as driving forces of nature: "And these things never cease their continual interchange, now through Love all coming together into one, now again each carried apart by the hatred of Strife" (Kirk, et. al. 2013, p. 287). Love and hate were for Empedocles the driving forces of the cycle of life, forces which are found in equal quantity in the cosmos. Also attributed to Empedocles is the idea that "Strife is at odds with the roots, but Love is in harmony with them". With hate things repel each other and move away, with love they attract and move closer.

From a conceptual point of view, Empedocles's theory is close to the ideas of *congruence* and *incongruence* used by Robert Hooke to talk about the phenomena of attraction and repulsion in nature. The difference and the innovation of Hooke's theory lie in the fact that Hooke based his concepts on experiences and observations of the physical world – we have moved from philosophy to science. In Hooke's analysis of this phenomena, he continues to try to establish the causes of attraction and repulsion in nature. For this purpose, he first propounds the cause of *fluidity*, which he understands, as we can see below, as a "certain pulse or shock of heat":

And that we may the better find what the cause of Congruity and Incongruity in bodies is, it will be requisite to consider, first, what is the cause of fluidness; and this I conceive, to be nothing else but a certain pulse or shake of heat. (Hooke, 1664, p. 12)

The author continues in this vein by then explaining what he understands as *heat*:

(…) for Heat being nothing else but a very *brisk* and *vehement agitation* of the parts of a body (as I have elsewhere made *probable*) the parts of a body are thereby made so *loose* from one another, that they easily *move any way*, and become *fluid*. That I may explain this a little by a gross Similitude, let us suppose a dish of sand set upon some body that is very much *agitated,* and shaken with some *quick* and *strong vibrating motion*, as on a *Milstone* turn'd round upon the under stone very violently whilst it is empty; or on a very stiff *Drum*-head, which is vehemementy or very nimbly beaten with the Drumsticks. By this means, the sand in the dish, which before lay like a *dull* and unactive body, becomes a perfect *fluid*; and ye can no sooner make a *hole* in it with your finger, but it is immediately *filled up again*, and the upper surface of it level'd. Nor can you bury a *light body*, as a piece of Cork under it, but it presently *emerges* or *swims* as 'twere on the top; nor can you lay a heavier on the top of it, as a piece of Lead, but it is immeditely *buried* in Sand, and (as 'twere) sinks to the bottom. (…) The first of these Examples manifests, how a body actually *divided* into small parts, becomes a *fluid* and the latter manifests by what means the agitation of heat so easily *loosens* and unties the parts of *solid* and *firm* bodies. Nor need we suppose heat to be anything else, besides such a motion; for supposing we could *Mechanically* produce such a one *quick* and *strong* enough, we need not spend *fuel to melt* a body. Now, that I do not speak this altogether groundless, I must refer the Reader to the Observations I have made upon the shining sparks of Steel, for there he shall find that *the same* effects are produced upon small chips or parcels of Steel by the flame, and by a *quick and violent motion*; and if the body of *steel* may thus melted (as I shew it may) I think we have little reason to doubt that almost *any other* may also. (Hooke, 1664, pp. 12–13)

When Hooke defines heat as "a very *brisk* and *vehement agitation* of the parts of a body", he is already defining heat as "movement". It is also noteworthy that Hooke attributed the driving force of particles to heat, which in his view is nothing more than "constant motion".[3] In *Micrographia* we can find a good introduction to Hooke's vibratory theory of matter, but it is in *Of Spring* that Hooke further developed his ideas on this subject. In 1678, Hooke gave us a further definition of *congruity* and *incongruity*:

By Congruity and Incongruity then I understand nothing else but an agreement or disagreement of Bodys as to their Magnitudes and motions.

Those Bodies then I suppose congruous whose particles have the same Magnitude, and the same degree of Velocity, or else an harmonical proportion of Magnitude, and harmonical degree of Velocity. And those I suppose incongruous which have neither the same Magnitude, nor the same degree of Velocity, nor an harmonical proportion of Magnitude nor of Velocity (Hooke, 1678, p. 7).

These definitions are consistent with those that Hooke presented in his *Micrographia*, but here the emphasis is given to the notions of harmony and velocity.

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[3] These conclusions are already backed by experiments, which may place Hooke as one of the predecessors of the ideas of Benjamin Thompson (1753–1814). In *An Inquiry concerning the Source of Heat which is excited by friction*, Thompson presents several experiments from which he concludes that it is possible to generate heat with friction or movement and that we can therefore infer that heat is related to motion. However, the author is not yet firm in his statement. Thompson shows in this text that he has a practical notion of how heat is produced with friction, but the theoretical formulation presented by Hooke is more refined.

In *Of Spring*, we can see that Hooke defines the congruent and incongruent behaviors of bodies according to their motion. In other words, Hooke tells us that bodies are congruent or incongruent depending on the harmony or disharmony of their behavior concerning other bodies. Hooke elaborates on these concepts in more detail in his vibratory theory of matter, in which body and motion are defined:

By Body I mean somewhat receptive and communicative of motion or progression. Nor can I have any other Idea thereof, for neither Extension nor Quantity, hardness nor softness, fluidity nor fixedness, Rarefaction nor Densation are the proprieties of Body, but Motion or somewhat moved.

By Motion I understand nothing but a power or tendency progressive of Body according to several degrees of Velocity (Hooke, 1678, p. 7).

The author also propounds that the entire sensible universe consists essentially of matter and movement, these two elements being interdependent. Given the above definitions of body and motion, Hooke then proposes that vibratory movement is a fundamental component of nature:

The Particles therefore that compose all bodies I do suppose to owe the greatest part of their sensible or potential Extension to a Vibrative motion.

This Vibrative motion I do not suppose inherent or inseparable from the Particles of body, but comunicated by Impulses given from other bodies in the Universe (Hooke, 1678, p. 8).

Although the vibratory movement is not a constituent part of the body, it functions in interrelation with the matter, and matter exists in interrelation with a vibratory motion.

These definitions are the philosophical basis for Hooke's Theory of Universal Gravitation, which the author arrived at through experiments, namely his experiments with springs. By adding different weights to spring-suspended supports, Hooke measured how far the spring stretched depending on the different weights he had added:

Take then a quantity of even- drawn Wire, either Steel, Iron, or Brass, and coyl it on an even Cylinder into a Helix of what length or number of turns you please, then turn the ends of the Wire into Loops, by one of which suspended this coyl upon an nail, and by the other sustain the weight that you would have to extend it, and hanging on several Weights observe exactly to what length each of the weights do extend it beyond the length that its own weight doth stretch it to, and you shall find that if one ounce, or one pound, or one certain weight doth lengthen it one line, or one inch, or one certain length, then two ounces, two pounds, or two weights will extend it two lines, two inches, or two lengths; and three ounces, pounds, or weights, three lines, inches or lengths; and so forwards (Hooke, 1678, pp. 1–2).

In fact, by carefully observing the behavior of springs we realize that it seems impossible to completely stop their movement. A step, a breath, makes them vibrate as if this were their natural tendency. Hooke argues that motion is essential on both large and small scales, and that elasticity and vibration are connected. He also realizes that there are two fundamental types of motion: distancing and rapprochement, or attraction and repulsion. These experiments, accompanied by his vibratory theory of matter, gave rise to Hooke's Law. But what exactly is Hooke's Law?

At the beginning of *Lectures de Potentia Restitutiva*, Hooke writes: "The Power of any Spring is in the same proportion with the Tension thereof: That is, if one power stretch or bend it one space, two will bend it two, and three will bend it three, and so forward" (Hooke, 1678, p. 1). After presenting this rule, Hooke tells us that we can test it ourselves using "steel, iron or brass" (Hooke, 1678, p. 1). Additionally, the author states about this rule that "Nor is it observable in these bodys only, but in all other springy bodies whatsoever, whether Metal, Wood, Stones, baked Earths, Hair, Horns, Silk Bones, Sinews, Glass, and the like" (Hooke, 1678, p. 4), ending with "And this is the Rule or Law of Nature, upon which all manner of Restituent or Springing motion do proceed, whether it be of Rarefaction, or Extension, or Condensation and Compression" (Hooke, 1678, p. 2). Hooke tells us that we can test his rule by using different materials and applying them to bodies of different constitutions. Here we might raise the question: how does Hooke know that this rule will work for all these bodies?

According to Hooke's experiments, we should use steel, iron, or brass as materials. Nevertheless, in his conclusion Hooke writes that his rule works for several types of bodies, mentioning bodies that are not usually regarded as elastic, for example, glass. Did the author replicate the experiment with other materials despite not having described it in this text? To answer these questions, let us see what the author writes further in the text:

From this it will be easie to make a Philosophical Scale to examine the weight of any body without putting in weights, which was that which I mentioned at the end of my description of Helioscopes, the ground of which was veiled under this Anagram, c e d i i n n o o p s s s t t u u, namely, *Ut pondus sic tensio*.

This Scale I contrived in order to examine the gravitation of bodies towards the Center of the Earth, to examine whether bodies at a further distance from a Center of the Earth did not lose somewhat of their power or tendency towards it. And propounded it as one of the Experiments to be tried at the top of the Pike of *Teneriff*, and attempted the same at the top of the Tower of *St. Pauls* before the burning of it in the late great Fire; as also at the top and bottom of the Abby of *St. Peters* in *Westminster* though these being by but small distances removed from the Surface, I was not able certainly to perceive any manifest difference. I propounded the same also to be tried at the bottom and several stations deep Mines, and *Dr. Power*[4] did make some trials to that end, but his instruments not being good, nothing could be certainly concluded from them (Hooke, 1678, pp. 5–6).

We can see by reading that Hooke's aim in presenting his Rule of Nature was to construct a "philosophical scale", something whose scope was broader than just the analysis of the characteristics of bodies (strictly) considered elastic. And now we might ask: are we talking about *elastic bodies* or *bodies* in general? Are we talking about *elastic force* or just *force*? Is this rule applied to particular cases or universally? If

[4] Refers to Henry Power, author of *Experimental Philosophy* (1663)

Hooke's conclusions came from his experiments with materials like iron, steel or brass, how does he conclude that the same rule will apply to other materials, or even to the measurement of gravity as a force, as he thought it did? And what is the relation between the experiments with springs, the experiments on the top of St Peter's Abbey and a scale to measure gravitation?

If we go back and look some quotes from the text above: "From this it will be easie to make a Philosophical Scale to examine the weight of any body"; "This Scale I contrived in order to examine the gravitation of bodies towards the Center of the Earth"; "And this is the Rule or Law of Nature, upon which all manner of Restituent or Springing motion do proceed, whether it be of Rarefaction, or Extension, or Condensation and Compression", we can see that, by presenting his law, Hooke set out to find a way to measure gravity.

According to Hooke's cosmological ideas, everything is in constant motion, and body and motion are interdependent. It seems like Hooke was thinking of gravity as a giant spring and, in this way, it would be possible to use the same experiment as the one reported in *Of Spring*, but this time in high places, to measure gravity. We can thus deduce that Hooke tried to measure gravity at the top of St Peter's Abbey to compare it with the gravity at its base. Francesco Sacco tells us something pertinent about Hooke's Law in his recent book *Real Mechanical, Experimental – Robert Hooke's Natural Philosophy.* In it, Sacco argues that Hooke's Law, as it is known in classical mechanics, is not exactly what the natural philosopher was trying to formulate:

In Hooke's natural philosophy, "ut tensio sic vis" meant something different than what in classical mechanics is known as Hooke's law. The concept of elastic limit, for instance, is missing in Hooke's study of elastic bodies, and the mechanical model employed by Hooke is quantitatively incompatible with the law that still bears his name. Like Petty, Hooke thought that the law was just a form of a more general principle of matter (Sacco, 2020, p. 84).

It may seem to us that Hooke made a "leap" in his explanation because we expect to find in this text the law of elasticity as it is taught today, but Hooke's "elasticity" refers to a property of bodies that they should possess in accordance with his vibratory nature of matter. Hooke was not trying to define a *Law of Elasticity*, he was searching for a *Universal Law* applicable to all matter that could be used to create a scale for measuring all forces, and among them, the "force" of gravity. Let us go back to *Of Spring* and consult once more Hooke's definitions of body and motion:

By Body I mean somewhat receptive and communicative of motion or progression. Nor can I have any other Idea thereof, for neither Extension nor Quantity, hardness nor softness, fluidity nor fixedness, Rarefaction nor Densation are the proprieties of Body, but Motion or somewhat moved. By Motion I understand nothing but a power or tendency progressive of Body according to several degrees of Velocity (Hooke, 1678, p. 7).

For Hooke, "body is motion" and motion is a "progressive tendency of the body in different degrees of speed":

These two do always counterballance each other in all the effects, appearances, and operations of Nature, and therefore it is not impossible but that they may be one and the same; for a little body with great motion is equivalent to a great body with little motion as to all its sensible effects in Nature.

I do further suppose then that all things in the Universe that become the objects of our senses are compounded of these two (which we will for the present suppose distinct essences, though possibly they may be found hereafter to be only differing conceptions of one and the same essence) namely, Body and Motion (Hooke, 1678, p. 7).

As Hooke states, "the particles composing all bodies owe the greater part of their sensible or potential extension to a vibratory movement", that is, body and motion do not exist in isolation, they are counterbalancing each other. Based on this assumption, vibratory movement is, more broadly, a characteristic of matter. Domenico Bertoloni Meli calls this worldview a "pan-elastic cosmology" (Meli, 2006, p. 245).

Now we can see clearly why Hooke refers to various materials, including materials that are not considered, in common sense, as elastic, and why the author starts from experiments with springs to measure gravity: since vibratory motion is an inherent characteristic of matter, it would be present in all bodies, from the ones we touch to the ones we observe on the sky. Thus, the method used to measure the force exerted by a weight on a spring (and vice versa) could be used to measure the "force" or "power" of gravitation. Hooke used his experiments with springs to measure *forces*. Since Hooke considered gravity as a force, he should be capable of measuring it by adapting the methods reported in *Of Spring*.[5]

Another important observation that we can make from Hooke's presentation of his Rule of Nature is that it is possible to compare it with Newton's third law of motion. Let us consider Newton's formulation of this law:

To any action there is always an opposite and equal reaction; in other words, the actions of two bodies upon each other are always equal and always opposite in direction.

Whatever presses or draws something else is pressed or drawn just as much by it. If anyone presses a stone with a finger, the finger is also pressed by the stone (Newton, 1999, p. 63).

Hooke writes something very similar in *Of Spring* when he tells us of his Rule of Nature and the experiments that demonstrate it: "The same will happen supposing the body (moved by Spring) to be proportionately heavy, and the powers of Spring the same with the former" (Hooke, 1678, p. 21). Let us now look at one of the experiments that Newton described during the discussion of his third law of motion:

I have tested this as follows with tightly wound balls of wool strongly compressed. First, releasing the pendulums and measuring their reflection, I found the quantity of their elastic force; then from this force I determined what the reflections would be in other cases of their collision, and the experiments which were made agreed with the computations. The balls always rebounded from each other with a relative velocity that was to the relative velocity of their colliding as 5 to 9, more or less. Steel balls rebounded with nearly the same velocity and cork balls with a slightly smaller velocity,

[5] Note that Hooke already considers gravity as not only a terrestrial, but also a celestial, force when he says, in his *Micrographia*, that "(…) there is in the Moon a principle of gravitation, such as in the Earth" (Hooke, 1664, p. 245).

while with glass balls the proportion was roughly 15 to 16. And in this manner, the third law of motion – insofar as it relates to impacts and reflections – is proved by this theory, which plainly agrees with experiments (Newton, 1999, p. 60).

Hooke did not use the same words as Newton, namely that forces act in opposite directions, but his experiments with springs show that this is what occurs between weight/mass and force/spring. He also described the relationship between body and motion in the following way: "These two do always counterballance each other in all the effects, appearances, and operations of Nature" (Hooke, 1678, p. 7). Concerning his Rule of Nature, Hooke assures us that "this the Rule or Law of Nature, upon which all manner of Restituent or Springing motion do proceed".

Both Hooke and Newton arrived at similar conclusions: the former used the distension of springs as a way of determining the elastic force and concluded that the force of the spring is proportional to the tension exerted; the latter, by using the separation of balls of wool as a way of determining the elastic force, concluded that the force exerted by the wool is equal and opposite to the tension exerted by the collision. While Hooke starts from a static system, Newton starts from a dynamic system, but the goal of both is to analyze and explain the force of gravitation, and both end up determining the "elastic force" in each of the cases presented. However, while Hooke claimed to have found a "Rule or Law of Nature", Newton claimed to have found a "Law of Motion". As Hooke published *Of Spring* in 1678, nine years before the publication of the *Principia*, it seems very implausible that Newton did not know of Hooke's experiments. Note that Newton mentions several names throughout the *Principia*. Nevertheless, Hooke's name is not mentioned, not even regarding the experimental determination of elastic force.

Beyond this, Hooke had already taken into account the law of inertia in his text *On the inflection of a direct motion into a curve by supervening Attractive principle* (1666). The law of inertia is commonly attributed to Newton, but, Descartes and Kepler, for example, already recognized and used this law. Christiaan Huygens (1629–1695) also stated it in *De motu corporum ex percussione*: "Hypothesis I: Any body already in motion will continue to move perpetually with the same speed and in a straight line unless it is impeded" (Huygens, 1977, p. 574). Besides referring to the law of inertia, Hooke also presents us with an experiment made with a pendulum in order to demonstrate the movement of bodies through the force of gravitation. If we look at this document, we can verify that, in 1666, two years after the publication of *Micrographia,* Hooke was developing a theory of gravitation. These developments would allow him to publish his *Attempt to Prove the Motion of the Earth* in 1674, where he states for the first time, in a succinct but very efficient manner, his principal assumptions for a theory of universal gravity:

At which time also I shall explain a System of the World differing in many particulars from any yet known, answering in all things to the common Rules of Mechanical Motions: This depends upon three Suppositions. First, That all Celestial Bodies whatsoever, have an attraction or gravitating power towards their own Centers, whereby they attract not only their parts, and keep them from flying from them, as we may observe the Earth do, but that they also attract all the other Celestial Bodies that are within the sphere of their activity; and consequently that not only the Sun and Moon have an influence upon the body and motion of the Earth, and the Earth upon them, but that also (…) by their attractive powers, have a considerable influence upon every one of their motions also. The second supposition is this, That all bodies whatsoever that are put into a direct and simple motion, will so continue to move forward in a streight line, til they are by some other effectual powers deflected and bent into a Motion, describing a Circle, Ellipsis, or some other compounded Curve Line. The third supposition is, That these attractive powers are so much the more powerful in operating, by how much the nearer the body wrought up on is to their own Centers. (Hooke, 1674, pp. 27–28)

Also in his *Attempt*, Hooke describes an *experimetum crucis* to prove the Copernican hypothesis, namely by measuring the parallax of a fixed star (Hooke, 1674). When we consider the findings contained in these texts and in *Of Spring*, Hooke's contributions toward a theory of universal gravitation become undeniable.

Many scholars have wondered why Hooke was overlooked in comparison to Newton and opinions diverge. On one hand, Steven Shapin states that the main reason for the dismissal of Hooke's contributions lies in the fact that Hooke was from a lower social status, closer to the craftsman category than to the gentleman category to which, for example, Newton and Boyle belonged (Shapin, 1989). On the other hand, Ellen Tan Drake thinks that this does not explain what happened with Hooke. Tan Drake states that Hooke had, in fact, an important social status in his time and that it was the adulation of Newton that placed Hooke in his shadow, alleging that Hooke still suffers from bad press today (Tan Drake, 1966). Lisa Jardine, Hooke's biographer, also questions what happened to Hooke's reputation after his death that led him to be forgotten in a matter of few years. Jardine highlights some plausible factors: the decrease in reputation caused by his self-isolation and illness in the years before his death; the battle for his fortune after his death, which led to a dispersion of his legacy among people who did not love him, and, consequently, did not deal with his belongings properly; and the possible conspiration of Isaac Newton, who assumed the position of President of the Royal Society after his death (Jardine, 2004). It seems to us that the arguments of Ellen Tan Drake and Lisa Jardine are the most reasonable. Regardless of what led to Hooke staying in Newton's historical shadow for such a long time, it is clear today that Hooke did contribute decisively to the creation of a theory of universal gravitation and that we should, using Ricoeur's words, give him "a burial, a place in the collective memory" (Ricoeur, 2004, p. 350).

Conclusions.

Taking all of this into account, we can establish the following conclusions: Hooke's Law, as we understand it today, is not exactly what Hooke was trying to formulate. Hooke intended to find a scale to measure forces, or what the author calls a "philosophical scale", whose purpose would be to measure gravity. Through his experiments with springs, Hooke came to understand the relationship between force (deformation). We can also infer that, in his experiments with springs, Hooke was already close to determining a gravitational constant. His attempts to measure the force of gravitation were not successful, as the author tells us "(…) because these places were at small distances from the surface, I was unable to observe any clear difference. I proposed that the same should be done at the bottom of some mining stations, and Dr. Power even made some experiments in this direction, however, as the instruments he possessed were not of good quality, nothing could be concluded from his data." We can thus conclude that, in *Of Spring*, Hooke was searching for an experimental, mathematical, and philosophical understanding of gravity. We can also observe that, as Centore also notes (Centore, 1970), for Hooke gravity was a mechanical (not animistic) force. Despite that, we can also find in Of Spring an anticipation of Newton's third law of motion.

This paper presents the possible contribution of an author, namely Robert Hooke, to the creation of a Law of Universal Gravitation, specifically at the time when he presented his Rule of Nature (Hooke's Law), which was created to analyze gravity. From a historical perspective, we can observe that the Law of Universal Gravitation created during the 17th century was the product of a period in science to which several authors contributed (Hecht, 2021).[6] We cannot attribute the Law of Gravitation merely to Newton and, in association with his name, give it the title of "discovery". This law was a product of philosophical and scientific discussions that began with names like Descartes, Huygens, Borelli, Kepler, Gilbert, Boulliau, Galileo, Roberval, Horrocks, and Hooke, among others, and continues until today. By focusing on Robert Hooke's contributions to the evolution of this law, we can show that science is made of layers and that Newton's mistake was that he wanted to keep the *apple of Discord* for himself. Newton was not standing on the shoulders of giants, but on the shoulders of all those who contributed to science, regardless of their size or social status.

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[6] Hecht (2021) has an enriching article on this topic.

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Про природу Закону Гука

Анотація. *"Пояснення Сили Пружних Тіл" (1678) – важлива книга для історії науки. Ця книга більш відома завдяки презентації Гуком закону, який носить його ім'я. Цей закон, або "Правило природи", як стверджує автор, зазвичай викладають у контексті аналізу пружних тіл та їх деформацій. Однак рамки, в яких було введено цей закон, виходять за межі контексту, у якому його зараз викладають. Поряд з представленням експериментів Гука з пружинами, автор створив свою вібраційну теорію матерії, в якій поняття конгруентності та неконгруентності, спочатку представлені в його "Мікрографії" (1665), будуть визначені більш детально. Ці концепції мали на меті теоретично обґрунтувати рухи тяжіння і відштовхування в природі. Ця стаття має на меті ще раз вивчити "Пояснення Сили Пружних Тіл", щоб краще зрозуміти думки Гука про правило, яке носить його ім'я, і його концепцію гравітації, яку автор вважав силою. Тут будуть представлені визначення тіла та руху Гука, а також його фактична мета, коли він сформулював так званий закон Гука. Як ми побачимо, Гук мав намір створити "філософську шкалу" для вимірювання гравітаційного тяжіння між тілами. Беручи до уваги його попередні публікації, такі як "Спроба довести рух Землі за допомогою спостережень" або "Мікрографія: деякі фізіологічні описи дрібних тіл", або навіть неопубліковані роботи, такі як "Про перегин прямого руху в криву за допомогою принципу притягання", стає зрозуміло, що Гук відкривав шлях до розуміння гравітації ще до того, як було опубліковано "Начала" Ньютона (1687). Беручи до уваги суперечку між Ісааком Ньютоном і Робертом Гуком, ми також маємо намір зміцнити ідею про те, що Гук зробив незамінний внесок у розробку закону всесвітнього тяжіння. На додаток до всього цього, також буде стверджуватися, що висновки, зроблені Гуком у "Пояснення Сили Пружних Тіл", можливо, також передбачали третій закон руху Ньютона.*

Ключові слова: *теорія всесвітнього тяжіння; закон Гука; пружина; правило природи*

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