On Newton's Universal Gravitation

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Abstract. *Gravity was a constant preoccupation for Newton, stretching across his entire creation period. In the context of the cultural mutations of the 17th century, the multiple connections of this topic to metaphysics and theology show the extent to which it is complicated. Nonetheless, they also demonstrate that Newton was not a simple mathematician, but a real natural philosopher, concerned with fundamental questions of philosophy and with finding answers in accordance with the new mathematization method in natural sciences.*
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As in the case of the fundamental concepts of space, time or movement and being directly connected to them, the inevitable encounter in the 17th century between theology and modern philosophy stirred hot debates about related topics which were highly important to the new "mechanical and experimental philosophy", with gravity being one of them. The debates, sparked by Descartes, Huygens, Newton and Leibniz were continued by Kant, going all the way to Mach, Duhem, Einstein, Popper or Lakatos[2], since Newtonian gravity, a scientific and philosophical topic, proved to be very difficult to tackle formally as well as under its numerous cultural ramifications. Obviously, nowadays, gravity has become a specialized topic, pertaining to theoretical physics, completely cut-off from the initial theological and philosophical dimensions. This situation has inevitably occurred due partly to the ripening of physics and its use of a specialized

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[2] Harper, W., *Newton's argument for universal gravitation*, în Cohen, I. B., Smith, G., (ed.), *The Cambridge Companion to Newton*, Cambridge University Press, 2004, p. 174.

formal language and partly as a consequence of the continuation and deepening of trends of separation between the area of scientific knowledge and the field of religious beliefs. What is more, starting with the 18th century, certain thinkers have regarded these fields as mutually exclusive, with the disenchantment of the world and the religious symbolism crisis broadening the split. While now it is granted that the relationship between the two fields can be nuanced, from disjoint complementarity to questioning dialogue, even a superficial analysis of science history shows that, until the 17th century, complementarity was consubtsntial. Basically, some of the greatest thinkers of natural philosophy of the time were theologians, and those who were not theologians were still genuine believers (Galilei and Descartes are two well-known examples). A very interesting case is that of Isaac Newton (1642-1727). In most histories of modern philosophy we will not find Newton in the company of illustrious contemporary philosophers such as Descartes, Bacon, Locke, Leibniz, Berkeley, Hume etc., even if the field he excelled in was known in his time as natural philosophy. Considered for a long time only a champion of the experimental method applied in natural philosophy, Newton would yield a great surprise in 1936 to the researchers of his work. It was the year when Sotheby's auctioned scores of manuscripts that radically changed the perception of Newton's creation laboratory. The forgotten manuscripts had been locked in a chest for over 200 years since 1696, when they were moved from Cambridge to London. Following Newton's death, they were turned down by the libraries of the main universities in England because they contained many thoughts considered subversive from the point of view of the dogma, thus revealing a heretical Newton. John Maynard Keynes, present at the auction and being interested in Newton's alchemical studies, purchased most of the

manuscripts[3] that dealt with this delicate subject. Puzzled after studying them, he claimed that Newton was not the first modern scientist, but the last and greatest alchemist[4]. A small part of the manuscripts, the ones that dealt with theological topics, were bought by professor and rare manuscripts collector Abraham S. Yahuda[5] and after his death became property of the Library of the University in Jerusalem. A few other manuscripts became part of private collections and are very difficult to come to study today.[6] Their study reveals that Newton analyzed in depth the biblical history, like a true theologian, and had some favourite topics such as the writings of the prophets of the *Old Testament* in general, *The Book of Daniel* – in particular, as well as the last book of the *New Testament, The Apocalypse.*

Newton's "duality" can be understood in the context where there was no clear-cut distinction yet between science and faith, and the study of sacred texts and the scientific demarche specific to natural philosophy were different paths of penetrating the hidden thinking of God. Things could not

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[3] John Maynard Keynes bought most of Newton's manuscripts, donated to King's College, Cambridge, in 1946.

[4] "Magic was quite forgotten. He has become the Sage and Monarch of the Age of Reason. The Sir Isaac Newton of orthodox tradition – the eighteenth-century Sir Isaac, so remote from the child magician born in the first half of the seventeenth century – was being built up. Voltaire returning from his trip to London was able to report of Sir Isaac – 'it was his peculiar felicity, not only to be born in a country of liberty, but in an Age when all scholastic impertinences were banished from the World. Reason alone was cultivated and Mankind could only be his Pupil, not his Enemy.' Newton, whose secret heresies and scholastic superstitions it had been the study of a lifetime to conceal!", http://www-history.mcs.st-and.ac.uk/Extras/Keynes Newton.html.

[5] Interesting details about professor A. S. Yahuda, one of the first Zionists born in Palestine and the Newtonian manuscripts purchased by him are to be found in Richard H. Popkin, *Plans for Publishing Newton's Religious and Alchemical Manuscripts, 1982–1998,* in James E. Force and Sarah Hutton (eds.), *Newton and Newtonianism – new studies*, Kluwer Academic Publishers, New York, Boston, Dordrecht, London, Moscow, 2004, pp. 15-22.

[6] There is, however, the possibility to read in electronic format part of the Newtonain manuscripts, due to projects started by libraries and universities, such as the University of Sussex: http://www.newtonproject.sussex.ac.uk/prism.php?id=76. Details on the projects can be found in Rob Iliffe, *Digitizing Isaac: The Newton Project and an Electronic Edition of Newton's Papers*, în James Force, Sarah Hutton (eds.), *op. cit.*, pp. 23-38.

have been otherwise, since the epistemological framework of his era, dominated by the polar mentality of late Baroque, was still heavily influenced by religion and a reference to God in such a world full of contradictions could be made as to an ultimate principle, an organizer of the world. Because of our limited nature, however, we cannot access God directly as an absolute ontological entity, but only indirectly, through the mediation of two distinct languages that echo the divine Logos and the Universe created: the sacred language revealed in biblical texts and the mathematical language of nature. Nevertheless, the end of the 17th century and the beginning of the 18th saw the end of the ideological mutation that lent science, via a subtle dialectics of opposites, many of God's attributes. This split was problematic especially in what concerns sense and showed that border crossing and the resignification of the symbolic universe of man can lead to paradox and a tension difficult to overcome. The case of Pascal is well-known especially due to the dramatic tension engendered by the collapse of the old symbolic/religious universe and the appearance of science, but for many cultivated people Newton's duality and the multiple facets of his personality and creation are surprising.

The chronology[7] of Newton's religious works sold by Sotheby's reveals the scope of his preoccupations, stretching over a period of almost 60 years.[8] The unpublished theological works, which span Newton's entire creation period, reveal the great importance he gave to this topic. If we also add the alchemical manuals, we will notice that their weight is much greater

[7] Jean-François Baillon, *Présentation,* in Isaac Newton, *Écrits sur la religion*, Gallimard, 1996, pp.12-14.

[8] The hypothesis of the extension of Newton's preoccupations for religious subjects to his entire creative period comes into conflict with an older hypothesis which states that a devastating fire in 1693 where many Newtonian manuscripts burnt to a crisp would have triggered his inclination to study more thoroughly theological topics.

than the scientific creation per se, which only includes two works published during the author's life, as well as several articles published in *Philosophical Transactions* and conferences given mainly at the *Royal Society.* In fact, Newton's scientific work cannot be understood outside the religious context. How does Newton's interest for theology and natural philosophy alike justify? The answer, depending on the context of late Baroque in England and Newton's multipolar personality, cannot elude the fact that, to him, truth and certainty can only be achieved within theology and Mathematics.[9]

> "*Perfectly suitable for the world they describe, the laws of Mathematics he discovered express what God allows to be foreseen about His presence in the world. If these laws can be seen as an expression of the divine Verb, it is because they are not intrinsic to the world, but express the way God materializes in it."*[10]

Continuing the scholastic tradition, natural philosophy is but the attempt to know God through secondary causes. However, this is a complicated endeavour, since the text of the Scripture, as well as the text of nature are enciphered and corrupt, so Newton acts like a hermeneut who has to interpret these texts in a manner closer to the rabbinic or negative hermeneutics, according to which the truth is "elsewhere", through a shift from symbol to sign.

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[9] Dana Jalobeanu, *Inventarea modernitãþii. Filosofie naturalã, teologie ºi ºtiinþã în secolul al XVII-lea (The Invention of Modernity. Natural Philosophy, theology and Science in the 18th century)*, Napoca Star, Cluj-Napoca, 2006, pp. 292-294.
[10] Loup Verlet, *Cufãrul lui Newton (Newton's Coffer)*, Nemira, Bucharest, 2007, p. 371.

"To give no more than one signification to a certain paragraph in the Scripture, unless, maybe as a hypothesis, where the literal meaning is meant to conceal the mythical meaning, which is nobler, like the shell covers the kernel, so that the latter cannot be tasted by the wrong person or before being granted permission by God."[11]

Gravity is a typical example of a topic circumscribed to the so-called "lay theology"[12], specific to the 17th century. The reason is that, on the one hand, gravity is not the topic of classical theological debates, as is baptism, the Holy Trinity, the afterlife or the Eucharist and, on the other hand, Galilei, Descartes, Pascal, Newton or Leibniz, some of the most important thinkers of the time, are not theologians, but lay thinkers outside the church hierarchy, some of them even being outside the academic system.

Basically, during his entire life, Newton meditated on gravity in direct connection to the properties of space and the divine attributes, approaching the topic in his well-known works *Philosophiae Naturalis Principia Mathematica* (1687) and *Opticks* (1704), as well as in *Gravitationae et Aequipondio Fluidorum* (1667?)[13], in his correspondence[14]

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[11] *Interprétation des prophéties. Fragments d'un traité sur l'Apocalypse*, in Isaac Newton, *Écrits sur la religion*, Gallimard, 1996, p. 237.

[12] Amos Funkenstein, *Teologie ºi imaginaþia ºtiinþificã din Evul Mediu pânã în secolul al XVII-lea (Theology and Scientific Imagination from the Middle Ages to the 17th century)*, Humanitas, Bucharest, 1998, p. 11.

[13] Recent studies have dated this manuscript between 1680 and 1684, that is to say in the period before writing *Principia*. See Dana Jalobeanu, *Doctrina newtonianã a spaþiului absolut ºi structura matematicã a lumii (The Newtonian Doctrine of Absolute Space and Mathematical Structure of the World)*, in Augustin Ioan (eds.), *Lost in Space*, 2003, New Europe College, p. 241.

[14] This correspondence was engendered by Bentley's necessity to clarify some subjects related to natural philosophy, found in direct connection to theology, on the occasion of his inauguration of the *Boyle Conferences*, specially created to fight atheism.

with reverend Richard Bentley between 1692 and 1693 or in *Scholia*, unpublished, also called *The Classical Scholia* (1694). Important ideas related to this topic can also be found in the famous polemic correspondence between Samuel Clarke and Leibniz (1715-1716), where Newton is known to have directly influenced Clarke's answers.

The existence of *The Classical Scholia*[15] was publicly signaled in 1832 by J. Crauford Gregory, descendant of Scottish mathematician and astronomer David Gregory (1659-1708).[16] In the archives of the latter, who was a professor at Oxford on Newton's recommendation, several of Newton's manuscripts could be found, written at the beginning of the 1690s and which were part of Newton's attempts to complete the second edition of *Principia* because, immediately after its publishing, several critics were brought regarding, among others, the meaning of the notion of gravity. The targeted additions strictly referred to sentences IV-IX in the last part of *Principia,* the Third Book or The System of the World. Unfortunately, the second edition, published in 1713 by Roger Cotes did not encompass these clarification, with the exception of *Scholium Generale,* a profound but laconic text, probably due to Newton's excessive caution in presenting his theological ideas publicly. J. McGuire[17] shows that, probably, the manuscript of the Scholia was given to David Gregory by Newton in 1694.

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[15] In the archives of the Royal Society in London there are two versions of the Classical Scholia, both coming from the Gregory Fund. Only one of the manuscripts, written in Latin (MS 247 fol. 6-14), is attributed with no doubt to Newton; this is the one used by V. Schüller for the translation into English, which we used for this study.

[16] Schüller, V., *Newton's Scholia from David Gregory's estate on propositions IV through IX Book III of his Principia*, în Lefèvre, W. (ed.), *Between Leibniz, Newton, and Kant – Philosophy and Science in the Eighteenth Century*, Kluwer Academic Publishers, Dordrecht, Boston, London, 2001, p. 213.

[17] J. E. McGuire, P. M. Rattansi, *Newton and the 'Pipes of Pan'*, Notes and Records of the Royal Society of London, Vol. 21, No. 2 (Dec., 1966), 108-143

The Classical Scholia is important because, being focused on gravity, tries to bring argument in favour of four main principles:[18]

1. *Matter has discrete structure, made up of atoms*
2. *The gravitational pull occurs at atomic level as well as in the vacuum between the solar system bodies, in the entire Universe, respectively.*
3. *Universal attraction was an intuition of important thinkers in Antiquity, such as* Thales, Pythagoras, Leucippus, Democritus, Lucretius etc., thus, on the one hand, outlining the scope of Newton's philosophical knowledge and showing, on the other hand, that the method used by Newton in his theological studies, namely the use of and reference to primary sources, was used as such in the scientific research as well;
4. *The Ancients even guessed the existence of the law of universal* attraction, with Pythagoras and Plato (especially in *Timaeus*) bringing arguments to support this statement.

The six sentences[19] in the Third Book analyzed by Newton in *The Classical Scholia* lead to the following fundamental ideas: gravity is a real, attraction force, which occurs between all the bodies in the solar system and is directly proportional to their masses and inversely proportional to the square of the distance which separates them. Unlike the ordinary mechanical causality[20],

[18] Idem, p. 112.
[19] Newton, Is. *Principiile matematice ale filosofiei natural (The Mathematical Principles of Natural Philosophy)*, translation and notes by V. Marian, Editura Academiei Republicii Populare Române, 1956, pp. 321-328.
[20] This was one of the main criticisms from the perspective of Leibniz's physics regarding universal gravitation, considered to be occult because it did not imply the direct interaction

which implies direct contact between the bodies, the distance action of gravity occurs in vacuum, which does not resist the rotation movement of the planets, and the real cause of gravitation can only be the direct action of God. If the absolute time and space are prerequisites for the existence of objects of the physical world, having other ontological characteristics in relation to them (under the direct influence of Neoplatonism, space is *sensorium Dei*), gravity is condition of action, being the mediator through which God influences the objects of the physical world, thus determining the architecture of the world's system.

The development of the four above-mentioned hypotheses, carried out by J.E McGuire and P.M. Rattansi[21] seems to demonstrate that Newton's *The Classical Scholia* rather aligns to the Renaissance epistemological diachronism, where knowledge is a rediscovery of the Ancient, than to the transitory conscience of the Baroque:

> *"What Des-Cartes did was a good step. You have added much several ways, & especially in taking ye colours of thin plates into philosophical consideration. If I have seen further it is by standing on ye shoulders of Giants."*[22]

The Classical Scholia thus becomes a sort of Newton's creation laboratory, where many of his "unorthodox" ideas appeared and were

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between bodies but which was, however, in perfect accord with *lex tertia* or the principle of action ad reaction expressed by Newton.Even now it is difficult to understand that if we apply *lex tertia*, the pair of our weight is not the normal reaction of the support surface, but the force with which we act upon Earth and which has the of application in its centre.

[21] J. E. McGuire, P. M. Rattansi, *op. cit.* p. 112.

[22] Fragment from a letter of February 5, 1676, sent by Isaac Newton to Robert Hooke, in H.W. Turnbull, J.F. Scott, A.R. Hall. (eds.), *The Correspondence of Isaac Newton*, vol. II (1676-1687), Cambridge University Press, Cambridge, 1960, taken from http://www.isaacnewton.org.uk

developed, helping us understand the metaphysical background of his main scientific works.

In his correspondence with Richard Bentley[23], Newton tries to correlate the properties of gravity (universal attraction) with some characteristics of space and with the divine attributes. For Newton, natural philosophy is nothing but the attempt to know God via secondary causes:

> "*WHEN I wrote my treatise about our system, I had an eye upon such principles as might work with considering men, for the belief of a deity, and nothing can rejoice me more than to find it useful for that purpose.*
> *But if I have done the public any service this way, it is due to nothing but industry and patient thought.*"[24]

An important stake, nevertheless, is theological, namely the possible connection between distance action and the Eucharist, a connection that Newton tried to avoid. The Eucharist or Communion is a sacrament which, starting with the scene of the Last Supper described in the Synoptic Gospels, is based on the transubstantiation doctrine, that is to say the real transformation, through the Holy Ghost, of the bread and wine into the body and blood of Jesus Christ. The Anglican Church's position concerning the Eucharist was similar to that of the Catholic Church, supporting transubstantiation, namely the physical transformation of wafer and wine into the body and blood of Jesus Christ. Lutheranism, Leibniz's religion,

[23] Idem, p. 94. in Sir Isaac Newton, *Elemente de cosmologie (Elements of Cosmology)*, Dacia, Cluj-Napoca, 2001 (chronological table, translation and notes by Cosmin Cãluºer), p. 19.
[24] Idem, p. 94

also accepted transubstantiation. To some Protestants, however, this was not a real transformation, but a symbolic representation, namely a spiritual presence. Is gravity an essential property of matter or, in other words, an innate quality, or is it a mere appearance of the preset harmony of this world, an "occult" quality, as Leibniz saw it? If it were an "occult" quality, then gravity, just like ether[25], later, would be inconceivable and, integrating contradictory characteristics, could not have the attribute of existence. In a letter[26],[27] from May 10, 1715, sent to princess Wilhelmina Charlotte Caroline, Leibniz accuses Newton of opposition to Lutheranism by denying the real presence at the same time and in several places of the body and blood of Christ in the Eucharist. Transubstantiation and ubiquity are not the only things to make the Eucharist absurd from Newton's perspective, but other phenomena as well, which Leibniz probably only guessed, but which are explicitly stated by Newton in one of his manuscripts (Yahuda Ms., 14, 20)[28]. D. Bertoloni Meli considers that the *Theodicy Essays* could offer a key to make out the connection between gravity and the Eucharist.[29] Indeed, after observing that the Eucharist even divides Protestants through how they relate to the text of the Scripture, Leibniz asserts that we can understand transubstantiation if we accept the analogy *real action-*

[25] Towards the end of the 19th century there were three theories concerning the physical properties of ether, each one being upheld experimentally: 1) ether is completely undragged (the stelar aberation discovered by Bradley in the 18th century already); 2) ether is partially dragged (Fizeau's experiments); 3) ether is completely dragged (experiments Michelson-Morley). These contradictory properties of ether determined Einstein in 1905 to give up the theory of its existence and state the theory of restrained relativity.
[26] D. Bertoloni Meli, *Caroline, Leibniz, and Clarke*, Journal of the History of Ideas, Vol. 60, No. 3 (Jul., 1999), p. 474.
[27] Loup Verlet, *op. cit.,* pp. 366-367.
[28] Idem, p. 182.
[29] D. Bertoloni Meli, *op. cit.,* p. 475.

presence.[30] The *real action* is directly connected to mechanical causality, implying the direct interaction between bodies, in the sense of the contact forces found in the collision theory or Cartesian mechanics. The *presence* implies a simultaneous distance action on several bodies. Even though this action at a distance seems to pertain to a miracle[31] rather than to the laws of nature, it does not surpass the powers of the Creator. From this perspective, Newtonian gravity is a permanent miracle, as it cannot be explained through the nature of objects. In the circular motion, the momentary speed being tangent to the trajectory, the bodies should move on the tangent and therefore, move away from the centre. As a metaphysician rather concerned with the theological explanation of the architecture of the Universe than with the secondary physical causes the mathematical form of which was, however, represented by Newton's universal attraction law, Leibniz uses the properties of monads as substantial entities capable of action in order to explain this architecture. Obviously, physical bodies are not monads, but aggregates that relate to monads as to superior realities. The system of monads, orderly and hierarchical, the preset harmony of which is in a subtle accord with the best of the possible worlds, reflects precisely the architecture of divine creation. *Natura non facit saltus,* there is only continuity and hierarchy in the order of existence as well as in the order of action. The inter-monad accord subordinated to preset harmony and the intrinsic activity, respectively the gradual perception of the monads, explains their Baroque dynamism in accordance with the law of

[30] G. W. Leibniz, *Eseuri de teodicee (Theodicy: Essays on the Goodness of God, the Freedom of Man and the Origin of Evil),* Polirom, Iaºi, 1997, pp. 55-57.
[31] G. W. Leibniz, *Opere filozofice (Philosophical Writings)*, vol. I, Editura ªtiinþificã, Bucharest, 1972, p. 559.

conservation of energy,[32] without any further need for gravity or any other type of action at a distance.

Supposing, therefore, that gravity is an innate quality of matter, then, being exclusively attractive, it must be analyzed in connection to the finite or infinite character of space.

1. **Space is finite**. The gravitational pull exerted between all bodies in the Universe causes, in time, their evolution to lead, in accordance with the law of universal attraction, to their concentration into an enormous, spherical central body that will comprise all the mass of the Universe. Or, since astronomical observations do not confirm this hypothesis of the tendency to coalesce towards a central body, space cannot be infinite.
2. **Space is infinite**. The gravitational pull, even if exerted between any two given bodies in the Universe, can only be significant for the bodies found at an adequate relative distance, so that small "isles" form here and there in the infinite Universe, such as our solar system. For Newton, however, the qualitative differentiation of matter within the solar system cannot be done on the basis of the natural causes that derive from the existence of innate gravity, but on the basis of a divine supraordinate factor.

[32] The physics of the 20th century will prove that there is a deep connection between symmetry, which can be viewed as an extent of the harmony of nature and the conservation law (Nöether's theorem). Thus, the homogeneity and isotropy of space are governed by the laws of the conservation of impulse, of the angular momentum respectively, and the law of energy conservation corresponds to the uniformity of time.

Universal gravity is the ultimate expression of the unity of the sky and earth, started by Galilei, which allows to explain the cosmic movements of planets and their satellites, of comets and also the free fall of bodies, the movement of projectiles or tides. Admitting the point of view of the era regarding the fact that matter is influenced by mechanical causality, with bodies not being able to exert their influence on others at a distance, Newton cannot give a mechanical explanation to the nature of gravity and acknowledges that:

> *"It is inconceivable that inanimate brute matter should, without the mediation of something else, which is not material, operate upon and affect other matter without mutual contact, as it must be, if gravitation in the sense of Epicurus, be essential and inherent in it. And this is one reason why I desired you would not ascribe innate gravity to me. That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a vacuum without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it. Gravity must be caused by an agent acing constantly according to certain laws; but whether this agent be material or immaterial, I have left to the consideration of my readers."*[33]

[33] Isaac Newton, *Philosophical Writings,* edited by Andrew Janiak, Cambridge University Press, 2004, pp. 102-103.

The interaction at a distance implied by innate gravity seems, indeed, to be an "occult" quality that leads to an unacceptable universal animism. If for Leibniz, God himself is contained by the principle of sufficient reason, so that he cannot violate the laws of logic, for Newton the cause of gravity may be an *Agent*[34] that acts in accordance with the laws of Mathematics, namely the law of universal attraction. The laws of Mathematics are the expression of that encoded language used by God to speak about his presence in the world. Responsible for the architecture of the Universe and allowing us to explain the rotation motion of planets around the Sun on elliptical orbits, universal gravity seems, however, to be in accord with the Eucharist, which was so despised by Newton.[35] This is why Leibniz could not but notice that Newton did not accept the mysterious way in which God is present in the world through the Eucharist, while accepting the "mundane" miracle of gravity, thus trying to ridicule his opponent.[36] Even though he repeatedly asserts that gravity is not essential to matter because, otherwise, God Pantocrator could be eliminated from the world as it is for atheists, or secluded in transcendence as it is for Leibniz, as in the case of the child apprentice, the law of universal attraction shows the opposite. This is the direction in which physics was going to evolve, because there will be a considerable difference between Newtonian physics, where God is the supreme architect, and post-Newtonian physics at the end of the 18th century, entirely secularized and mathematicized, where the

[34] The agent or the active principle is universal, as revealed by Newton's alchemical studies. Thus, it governs, in accordance with the divine project, the entire world, from the movement of planets to fermenting and putrefaction. See Betty Teeter Jo Dobbs, *The Janus faces of genius. The role of alchemy in Newton's thought*, Cambridge University Press, 1991, pp. 4-5.
[35] Loup Verlet, *Op. cit.*, p. 367.
[36] Ibidem.

name of God can no longer be pronounced, as it cannot be captured in an equation.

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