Unknown Galileo: His Theory of Motion in Space and Time – A Discovery of Great Consequences.

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The one who wants to get to the source must swim against the stream.

Abstract.

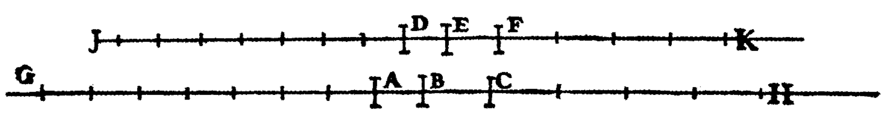
Modern natural science begins in the 17th century. It begins with Galileo's and Newton's theory of real motion of bodies relative to space and time (1638, 1687). In 1695, Gottfried Wilhelm Leibniz opposed this theory with a different one. Leibniz describes not real motion in space and time but (like Aristotle and Descartes) only changes of position of bodies relative to other bodies. This concept became part of a new mathematical analysis. It provided the foundation of the 18th century's mechanical theory, the "analytical mechanics" (Leonhard Euler, 1736/1750). This arithmetic theory succeeded in displacing Galileo's and Newton's geometric theory of motion. But one hundred years later, James Clerk Maxwell, on the basis of Michael Faraday's experimental results, developed a new mathematical theory for the motion of charged bodies in an electromagnetic field (1855/56). It implies a principle of geometric proportionality of energy and momentum (John Henry Poynting, 1884) which contradicted the well-established analytical mechanics. In order to overcome this conflict, Albert Einstein in 1905 conceived a mathematical formalism which will be called "special relativity". At the same time scientists (thanks to experimental experience) gained deeper insight into the quantized structure of reality, of space and time, matter, motion, and energy. This progress caused Max Planck in 1900, later on Werner Heisenberg (1925) and others, to develop new mathematical concepts of the theory of motion: quantum mechanics was formed. As a consequence, analytical mechanics, Einstein's theory, and quantum mechanical formalisms seem to be independently valid. But the unrealistic analytical mechanics is definitively disproved and abandoned, as a reappraisal of the long-ignored sources, Galileo's "Discorsi" (1638) and Isaac Newton's "Principia" (1687), brings to light a common foundation for the theories of Galileo and Newton, Maxwell, Einstein, and Heisenberg, which foundation is missing in analytical mechanics: It is the most basic law of nature, the law of geometric proportionality of cause and effect, of energy and momentum: $E/p = c =$ constant.

1. Galileo Galilei and Isaac Newton: The theory of local motion in space and time.

"De motu locali" reads the title of the chapter in Galileo's book of 1638 [1] which introduced the new theory of motion in Latin. "Motus localis" means "local motion", that is, the change of place of a material body from one place to another one. "Place" is a part of space. Isaac Newton defines it in the "Principia" (1687) [2]: "Place is the part of space that a body occupies". Space is built of "places", it is divided into places. Space then is a geometric entity of a discrete quantized structure, and "local motion" is the changing of the local situation of a body *measured relatively to space.* Space "in itself" (absolute space) is not a continuum without structure (against Descartes). Against Leibniz and Kant, space is also not only the order of material things "next to each other" (so that without things it was nothing). Its real structure has been demonstrated experimentally when Ole Römer in 1675 found that the light of the sun requires about 7 or 8 minutes travelling to the earth. Were space a continuum without structure, or were it "nothing", there were no distances measurable in it, that is, "insofar as there exist no parts in space no distance could ever be covered" (Newton) [3]. Therefore the light of the sun would have to appear everywhere "instantaneously" from the moment of sunrise on. This is what René Descartes indeed believed. But Galileo had already observed the propagation of light in space and time [4]. It was Ole Römer, however, who disproved the Cartesian assertion by measurement.

What is true with respect to space "in itself" (absolute space) as a real entity that has a geometrical "discrete" structure is also true with respect to time "in itself" (absolute time). "Just as the order of the parts of time is unchangeable, so, too, is the order of the parts of space. Let the parts of space move from their places, and they will move (so to speak) from themselves. For times and spaces are, as it were, the places of themselves and of all things. All things are placed in time with reference to order of succession and in space with reference to order of position. It is of the essence of spaces to be places, and for primary places to move is absurd. They are therefore absolute places, and it is only changes of position from these places that are absolute motions" (Newton) [5]. Newton explicitly rejected the relativistic alternative of Aristotle and Descartes. Nevertheless, Euler's post-Newtonian 18th century "analytical" mechanics, based on the Leibnizian "calculus" and influenced by Leibniz's relativism, considered only the changes of position of adjacent bodies [6] instead of real absolute motions (changes of place relatively to absolute space).

Galileo represents the absolute space-time frame of reference of real (absolute) motion in the "Discorsi" as follows:



The straight lines JK (representing the discrete absolute time as a scaled standard for the measurement of finite times) and GH (representing the discrete absolute space as a scaled standard for the measurement of finite distances, or spaces), both lines coming from the infinite and vanishing also in the infinite, serve for determining by (geometric) measurement the motion of a body as change of places in space from A to B and from B to C in times DE and EF. This motion (as well as everything that is measured with reference to a standard) is measured with the help of geometric proportion theory. Galileo shows that the spaces AB and BC, which a body traverses in uniform straight-lined motion, are proportional to the corresponding times DE and EF. That is, the interrelation AB **:** BC = DE **:** EF is valid. But it is also true that the spaces s -covered (AB, BC), are as the corresponding elapsed times, t (DE, EF): AB **:** DE = BC **:** EF, or $s_1 : t_1 = s_2 : t_2$. In other words: The interrelation of spaces s traversed and corresponding times t elapsed is always the same; spaces s and times t are *proportional.* Their interrelation s/t results always in the same constant proportionality factor c having the measure (the dimension) "space over time" [S/T]. The constant c measures the interrelation of all the corresponding elements of the standards GH (space) and JK (time), that is, c represents *the constant parameter of the space-time* *frame of reference and measurement of real motion.* Consequently, c represents the very first – and to be sure the most important – “natural constant”. And, c is an indispensable part of Galileo’s new theory of motion from the very beginning [7] .

On the measure of real motion and its generating cause.

2.1. Galileo knew that the quantity of motion of a body is not given merely through its velocity v. Rather matter m must also be considered, that is, the concrete quantity that determines, for example, the weight of the body [8]. The product mv of matter m and velocity v was known to be the measure of motion in the Cartesian natural philosophy of the 17th century. In the years 1669 to 1671 the scholars John Wallis, Christopher Wren and Christiaan Huygens experimentally confirmed the measure mv to be true (corresponding to nature, that is). So Isaac Newton states that “the absolute quantity of motion is composed of the velocity and the bulk of the moving body” [9]. In the Principia he defines the quantity of motion explicitly through the product mv [10].

2.2. In Galileo’s theory *the generating cause* of uniform, straight-line motion is known. It is geometrically proportional to the quantity of motion mv. By calling this cause “energy” (symbolized by the letter E), and its effect “momentum”, the measure of which is “matter, or mass, times velocity v” (symbolized by the letter p), the geometric proportion can be expressed in Galileo’s spatio-temporal reference frame

$$E/p = c = \text{constant.} \qquad (1)$$

Isaac Newton uses the very same principle of geometric proportionality of *cause*, or *force*, E, and *effect* p (= mv) in his second law of motion. He derives this law (as well as the first one) explicitly from Galileo [11]. The factor of proportionality, c, which is the characterizing parameter of the reference frame, stands here as well for the interrelation c = S **:** T of the elements of discrete space, S, and discrete time, T. Galileo’s law as well as Newton’s has the form E/p = S/T, that is, E/p = c [12].

2.3. The Cartesians believed the measure of motion mv to be also the measure of the *cause of motion*, that is, of the motion’s “force” or “energy”. Gottfried Wilhelm Leibniz criticised this measure as being mathematically mistaken, and he developed the relativistic Aristotelian-Cartesian alternative against Newton in his “Specimen Dynamicum” (1695). Later on, in the years 1736/1750, Leonhard Euler made Leibniz’s concept of “dead force” as “accelerating force” the basic principle of the new arithmetic-analytic mechanics, which he, together with Joseph Louis Lagrange, improved in the course of the second half of the 18th century in Berlin [13]. Therefore I call it the “Berlin Mechanics” (textbooks call it “classical” or even “Newtonian” mechanics, though it has nothing to do with Newton’s geometric theory of true motion) [14].

2.4. Euler’s mechanics exhibited substantial deficiencies when at the beginning of the 19th century Sadi Carnot studied the mechanism of steam engines, from which thermodynamics emerged. In the middle of the 19th century the Leibnizian-Eulerian “Berlin Mechanics” turned definitely out to be defective: It couldn’t mathematically describe the phenomena of motion of charged bodies through an electromagnetic field, that is, in the space where the field extends. So James Clerk Maxwell, on the basis of Michael Faraday’s experimental results, conceived a new mathematical theory of motion, the “Maxwell equations” (in the years 1855/56). In 1884, John Henry Poynting derived formula (1) E/p = c from these equations. Since Maxwell’s theory, unlike the analytic Berlin Mechanics, again describes real motions relative to space (to the field extended in space), it is no wonder that the geometric proportionality of energy (cause) and momentum (effect) had its comeback as the basic principle of this theory as well as of Galileo's and Newton's. It comes to light that Galileo had been right when he understood geometry to be the language of nature so that he who ignores geometry must hopelessly wander around like in a labyrinth [15].

2.5. In the year 1900 Max Planck, forced by experimental results, presented a new concept of "energy". Planck's formula describes a proportionality of quantized radiation energy and the frequency f of the radiation: $E/f = h =$ constant. Planck's law once more includes the principle of proportionality of energy and momentum, $E/p = c$. This comes to light as soon as one learns that momentum in quantum mechanics obeys the relation $p = h/\lambda$. Put into Planck's formula, $E/f\lambda = p$ results, and, since $f\lambda = c =$ constant, once again one gets formula (1), $E/p = c$ - that is, the proportionality of energy and momentum.

2.6. In 1905, Albert Einstein conceived his "special relativity" theory. It was meant to bridge the gap between the theory of motion of analytic mechanics and Maxwell's electromagnetic theory. Actually Einstein just inserted into the Poynting formula a dimensionless numerical conversion factor. As a consequence he obtained the relation $E/mc = c$, or $E = mc^2$, for the case of light propagation (with the supposed propagation velocity $v = c$). Insofar as the product mc describes the momentum p of light ($p = mc$), in Einstein's formula the basic principle $E/p = c$ reappears yet again. Einstein himself has demonstrated the central role that the principle $E/p = c$ is playing in his theory, independently of any "relativistic" implications [16] .

2.7. In 1925 Werner Heisenberg conceived his quantum mechanical relations $\Delta E \times \Delta t \geq h$, and $\Delta p \times \Delta s \geq h$, which, when put together, recapitulate the relation $E/p = c$, as shown in footnote 12. Again this is no surprise, because Heisenberg's considerations explicitly presuppose this very relation [17].

3. The proven general validity of the relation $E/p = c =$ constant bespeaks of a consistent theory of motion extending from Galileo to Einstein's special relativity and to Heisenberg's quantum mechanics, and reveals the irreparable deficiency of the analytical "Berlin mechanics" (Euler-Lagrange). The fact that in Heisenberg's and especially in Einstein's theory single elements of the theory of motion are interpreted or reinterpreted in a new way, (think of Heisenberg's "indeterminacy"-interpretation, and of Einstein's concept of velocity-dependent mass) results from the arbitrary interpretation of the constant c only as the "vacuum velocity of light", which decision entails other reinterpretations and misinterpretations. Another aspect is the motivation of the interpreters to deny the real spacetime background of reality, based either on ignorance or on an ideological "anti-metaphysical tendency" (Ernst Mach, 1883), and to invent hypotheses which instead import the worldview of Aristotle, Descartes, Leibniz, Kant and Ernst Mach (i. e., anthropocentrism, subjectivism, materialism, relativism). The consequences of such generally sceptical interpretations, which, from a realist point of view, are mostly absurd, show that these approaches do not accord with the structure of natural reality (which is the objective measure of all things). The real spacetime foundation of all natural science, now successfully demonstrated, shows them all to be groundless. Therefore, the renovation of a theory of motion based on real spacetime entails momentous consequences for the modern world view.[18] From this fact arises massive opposition of all sceptics who, in contempt of the truth,

are not at all interested in an objective and therefore true description of reality, or who even hold that such a description and therefore truth itself would be impossible. Opposition grows the more massive, the clearer becomes the direction in which a realistic view leads. This direction, which is certainly and absolutely repulsive to the zeitgeist, is illuminated by the following words of Isaac Newton: “And if Natural Philosophy in all its parts shall at length be perfected, the bounds of Moral Philosophy will be also enlarged. For so far as we can know by Natural Philosophy what is the first cause, what power he has over us, and what benefits we receive from him, so far our duty towards him, as well as that towards one another, will appear to us by the light of Nature.” [19]

I want to thank Robert E. Ulanowicz for his lasting friendship and encouraging help.

Footnotes

1 Galileo Galilei, Discorsi, transl. and ed. Ed Dellian, Hamburg: Felix Meiner Verlag, Philosophische Bibliothek Nr. 678; 2015.

2 Isaac Newton, Principia, Mathematische Grundlagen der Naturphilosophie, transl. and ed. Ed Dellian, Hamburg: Felix Meiner Verlag, Philosophische Bibliothek Nr. 394; 1988; 3. ed. Sankt Augustin: Academia Verlag, 2011.

3 Isaac Newton, De gravitatione et aequipondio fluidorum, German: Über die Gravitation … , Gernot Böhme ed., Frankfurt a. Main: Klostermann Verlag, 1988, p. 33.

4 Galileo Galilei, Discorsi, I 96 (First day, discussion contribution nr. 96).

5 Isaac Newton, Principia 2011, p. 89.

6 Isaac Newton, De gravitatione … p. 33.

7 Galileo Galilei, Discorsi, third day, theorem I proposition I. This constant is also an indispensable element of Newton’s theory. This I demonstrated for the first time in 1985 (cf. my essay “Die Newtonische Konstante“ in Philos. Nat.. 22 Nr. 3, 1985 p. 400).

8 Galileo Galilei, Discorsi (2015), editor’s Introduction.

9 Isaac Newton, De gravitatione …, p. 79.

10 Isaac Newton, Principia 2011, p. 83.

11 Isaac Newton, Principia 2011, p. 102 (Scholium after Corollary VI to the laws of motion). The meaning of the proportionality constant c as an element of Newton’s theory is explained in footnote 7 with another reference.

12 The rules of geometric proportion theory allow for deriving directly from the formula $E : p = S : T$ the well-known equation of products $E \times T = p \times S$, i. e. the most general combined form of the quantum mechanical relations $\Delta E \times \Delta t \geq h$; $\Delta p \times$

$\Delta s \geq h$ which Werner Heisenberg introduced to the public in 1925.

13 This concept, however, is based on a most elementary mistake, or – as Newton put it – "a wonderfully philosophical error", namely, to adopt a proportionality of accelerated motion and distance, a concept which Galileo had reduced to the absurd in the Discorsi. See Samuel Clarke, Der Briefwechsel mit G. W. Leibniz von 1715/1716, transl. and ed. Ed Dellian, Hamburg: Felix Meiner Verlag, Philosophische Bibliothek nr. 423, 1990, p. 122. (Leibniz's error, however, returns with "Hubble's law", velocity over distance = H, as a *proton pseudos* of modern Cosmology).

14 The well-known "classical" measure of "force" – force equals mass times acceleration - came into being with Leonhard Euler's analytical mechanics - the "Berlin Mechanics" as I call it. Against all textbooks it is not and it never was *Newton's* measure of force. Leonhard Euler introduced it to the public on the 3rd of September, 1750, calling it his own discovery. See L. Euler, "Découverte d'un nouveau principe de Mécanique, Mem. Acad. Roy. Sci. Berlin, vol. 6 1750 (1752) pp. 185-217. Robert E. Ulanowicz, in his book "A Third Window", 2009, p. 92, correctly criticizes its unrealistic reversibility with respect to time (also Oliver Penrose, "An Asymmetric World", Nature 2005; 438, 919).

15 Galileo Galilei, il Saggiatore (the gold balance), Rome 1723, p. 232. The same Says Newton, as follows (about 1678): "If we want to gain a true knowledge about Nature, we must, *as geometers*, do science, and as scientists we must work *geometrically,* instead of contenting ourselves with conjectures and refutations as they are propagated everywhere" (my transl. From Newton's Latin; cf. Isaac Newton, Opera quae exstant omnia, Samuel Horsley ed., London 1779-1785, vol. 3 Lectiones opticae, p. 354).

16 See Max Born, Die Relativitätstheorie Einsteins, chapter "Die Trägheit der Energie", Berlin-Heidelberg-New York-Tokyo: Springer Verlag, 1984 p. 244.

17 See Werner Heisenberg, Die physikalischen Prinzipien der Quantentheorie, Stuttgart: S. Hirzel Verlag, 1958 p. 93.

18 I have been trying to call public attention to this fact, so far in vain, cf. my essay "Newton, die Wahrheit, und die Rede von Gott", in Münchener theolog. Zeitschrift (MthZ) 51 nr. 2/2000, p. 171). To be found on my website www.neutonus-reformatus.com, nr. 16.

19 Isaac Newton, Opticks: or a Treatise of the Reflexions, Refractions, Inflexions and Colours of Light, London 1717, Query 31, at the end.