…*magis amica veritas*: Philosophy of Nature Beyond Relativity and Relativism.

On the Conditions of the Possibility of Truth at the Bottom of Albert Einstein's Theory of Motion as a Legacy from Galileo and Newton to Future Science.

By Ed Dellian, Berlin 26.01.05

Abstract

The title of this paper refers to Isaac Newton's device "Amicus Plato, amicus Aristoteles, magis amica veritas". The paper shows conditions of the possibility of truth characterizing the theories of motion of Galileo, Newton, Einstein and Heisenberg. A careful first philosophical, historical, and systematic investigation of hitherto ignored *geometric* properties of Galileo's and of Newton's theory of motion, based on the author's earlier work e.g. as a translator and editor of Newton's Latin *Principia* into German (1988), brings to light a most elementary law of motion, i.e. the *proportionality of "motion", as an effect, to its cause "force"*, governed by a *proportionality constant* of dimensions "space over time" [L/T]. This interaction law to read $\boldsymbol{F} = (m\boldsymbol{v}) \times C$, is confronted with the $\boldsymbol{F} = m\boldsymbol{a}$ of classical mechanics (which is not Newton's but Euler's law according to latest scientific findings), and also with the proportionality of E and p ($E/p = c = constant$) that Poynting derived from Maxwell's equations as early as 1884. The proportionality of *motion*, or *momentum*, to a different term called "impressed motive force" by Newton (i.e. Newton's true second law, not to be confounded with his concept of "centripetal force"), and a same proportionality of momentum to a different term called "energy" (not to be confounded with "kinetic energy") in some respects of modern physics, bound together by one and the same constant of proportionality C of dimensions [L/T], is shown to lie at the bottom not only of the modern theory of radiation pressure, but also of Einstein's Special Relativity (SR). The conformable philosophical implications of this foundation of Einstein's SR and of the authentic Galileian-Newtonian theory of motion are confronted with the different philosophy behind classical mechanics. By means of geometric consideration a hitherto unrecognized red thread of philosophical realism is shown to characterize the theory of motion of Galileo and Newton as well as that of Einstein's SR, and most surprisingly, to lie at the bottom of Heisenberg's indeterminacy relations as well. In rough outline a universal causal law of interaction of "cause" and "effect"

to serve as the foundation of a unified realist theory of true motion as a basis of true, i.e. *realist* science, and true, i.e. *realist* philosophy of nature comes into sight.

I Introduction: The theory of motion - a philosophical touchstone.

The theory of motion of material bodies in time and space has, and has always had, most elementary philosophical implications. Motion, the phenomenon that bodies change place relatively to one another, the falling of an apple from the tree to the ground, the rising of the sun over the hills: is matter able to move by itself? Is motion *a genuine property* of matter, as the materialists believe[1]? Or is matter essentially passive, unable to move by itself, as Newton held, according to his famous first law of motion? So that motion, according to Newton's second law, means a proportional interaction effect of some autonomous cause, or "impressed motive force", acting on a body from externally as to make it leave its proper place, and change its position relatively to the former place[2]? Motion, since this term certainly is a relational one, referring to rest: can it, as something real and true, be determined relatively to a frame of reference truly at rest? As we speak of "motion in time and space": Do "time and space" *provide* that absolute frame of reference at true rest, so that motion relatively to it can be called "absolute motion" in Newton's sense[3] ? Or is there no such thing at true rest, as Descartes, Christiaan Huygens, Leibniz, Kant, Mach and others taught against Newton[4] ? So that the motion of a body could only be determined as its changing of position *with relation to other bodies,* which "reference systems" may or may not be at rest themselves? Which means that man would never be able to really know the true state of rest or motion of *any* body, and could never decide e.g. whether it is the motion of the sun or of the earth that generates the effect of sunrise to our eyes? Aristarch of Samos, Nicolaus Copernicus, Giordano Bruno, Johannes Kepler, Galileo Galilei and Isaac Newton, who all taught the true motion of the earth: were they all wrong? Was Leibniz right, when he against Newton denied the existence of space and time "as such", and consequently fought for the principle of relativity, i.e. for the definition of motion as change of place *relatively with regard to other bodies*, thus in effect cancelling the Copernican Revolution, as Ernst Cassirer correctly emphasized[5]? Is it true what C.-F. von Weizsäcker says, that physics does not, cannot and must not distinguish between the motion of the sun relatively to the earth, and the motion of the earth relatively to the sun, both motions being quantitatively the same[6]? Or was Goethe right, when he held that man *is able* to know the truth even against evidence to the eye, saying: "*Die größten Wahrheiten widersprechen oft geradezu den Sinnen, ja fast immer. Die Bewegung der Erde um die Sonne*

- *was kann dem Augenschein nach absurder sein? Und doch ist es die größte, erhabenste, folgenreichste Entdeckung, die der Mensch je gemacht hat, in meinen Augen wichtiger als die ganze Bibel*"?[7]

It is in fact the question of man's *ability for truth* that is here at stake, "truth" to mean the real state of things and affairs, independently of any observer's subjective view. Is man bound to refer his experiences only to himself, i.e. is his view inescapably an "anthropocentric" one, or is he able to adopt a position from which he can decide about the objective reality or truth of his senses' treacherous messages - a position which I would call "cosmocentric"? It is the age-old philosophical battle between *empiricists* and *rationalists* on the one hand, from Aristotle to Immanuel Kant, who thought man's knowledge to be confined to immediate sense experience, unable to extend to a transcendent "objective reality" beyond (i.e. to Kant's *Ding an sich*, say to things like "absolute time", "absolute space", and thus to "absolute" - or *real* - motion), and *realists* on the other hand, from Plato (yes, Plato!) and the Platonist Aristarch to the new Platonists of the 16th and 17th century just mentioned above. There can be no doubt about Platonism and Realism to represent the philosophical lining of Galileo's research work for the reality and truth of the Copernican System of the World, and also of Newton's work that culminated in the publication of his "Philosophiae naturalis principia mathematica" of 1687: a book that explicitly was composed to the end to demonstrate *definitely*, i.e. *scientifically*, i.e. *mathematically*, how man *is* indeed able to know about the reality and absolute truth of real or absolute motion beyond the sense experience of relative motion only. Says Newton, in explaining the contents and the intention of his book: "*Motus autem veros ex eorum causis, effectibus, et apparentibus differentiis colligere, docebitur in sequentibus. Hunc enim in finem tractatum sequentem composui."* That is: *In what follows, an explanation will be given, of how to determine true motions from their causes, effects, and apparent differences. For this was the purpose for which I composed the following treatise* [8].

Obviously then, Newton's purpose was a genuine philosophical one. And inevitably, the purpose of everyone who, as to motion, argues for a position different from Newton's, is a philosophical one too. This is especially true, of course, in the case of Albert Einstein who was well aware of it. Now, as Einstein, in the introduction of his famous paper of 1905 "Zur Elektrodynamik bewegter Körper", seems to express clearly a *relativistic* view of motion, one could well see him standing on the shoulders of Aristotle and Descartes, of Leibniz, Kant and Mach, insofar as the definition of motion as "change of position of a body *with respect to* *other bodies*" is concerned[9]. Indeed this is the generally accepted view of Einstein's philosophical position as to the theory of motion[10]. However, to challenge this view is one purpose for which I wrote the following treatise.

II Exposition of the "Why and How" of contrasting laws of motion from Galileo to Einstein.

The *relativist* philosophical position concerning motion implies, as I have just said, an *anthropocentric* view of things. Bertolt Brecht, in his stageplay "Leben des Galilei", shows, as an example of the old and defective world-view that Galileo meant to overcome, a Vatican cardinal, proudly praising the Lord for having set him in the excellent position at the centre of everything, so that everything should refer *to him*, the man, the crown of God's creation[11].

Should we really believe that this anthropocentric aristotelic-ptolemaic scholastic view, obsolete since 1543 when Copernicus installed anew the long-forgotten Platonic *cosmocentric* (heliocentric) system of the world (as taught by Aristarch of Samos), *has been restored,* as a basis of our modern world picture, by Albert Einstein? It was the French philosopher Voltaire who once said that philosophers do not always follow their own principles. One such philosopher subtly justified himself by pointing to the fact that no guidepost does walk the way it guides. Now Einstein: Did he follow the guide of his relativist hypothesis, when he, in 1905, developed his new theory of motion? I shall show that he did not. And I shall do so by investigating the philosophical implications of the scientific theory of motion from its beginning, that is from Galileo's "Discorsi" of 1638 on, and by contrasting the most elementary law of motion of the Galileian-Newtonian geometric theory, of the Eulerian analytic-arithmetic theory, and that of Einstein's Special Relativity, with one another.

1. First: The essence of research is doubt, or, as the biochemist Albert Szent-Giörgyi once said it: "*Research is to see what everybody has seen, and to think what nobody has thought.*"[12] So I want to point to the fact that the alleged relativist Albert Einstein throughout his life insisted that his aim had been to formulate a *general* law of motion *to hold independently of the description of motion relatively to some special system of reference* (i.e. independently of the anthropocentric position of some human observer)[13]. Accordingly, for a while he even thought of calling his theory "absolute"[14]. Did he not always emphasize that his work should *not* mean a fundamental challenge or even a refutation, but *only a partial improvement* of

Newton's still unquestioned foundation of mechanics, which Einstein thought to be identical with that valid "classical mechanics" of the school that had only turned out unable to describe some very special effects of motion in his time[15]? And did he not always insist on identifying himself as a philosophical realist[16]? This may well have been the reason why Ernst Mach, who, heavily criticising Newton's "absolutes" (time, space, motion), certainly walked in the philosophical footsteps of Immanuel Kant, and who was really an anti-Newtonian, and a convinced philosophical relativist, and a dogmatic one[17], kept distant to Einstein and his work: Mach disguised the "absolute" realist implications of Einstein's theory.

2. What should a general law of motion look like? What at all do we mean by the term "law of motion"? It is the legacy of Galileo and Newton to modern science that the problems of motion should be treated and understood by means not of scholastic "talkative philosophy" (Colin Maclaurin[18]), but of mathematics. In Galileo's and Newton's case, the mathematical tool for this venture was the geometry of the Ancients, i.e. *the classical theory of proportions*, as we can see it applied to the problems of motion in Galileo's "Discorsi" of 1638, and in Newton's "Principia" of 1687. Newton, in his preface of 1686, clearly expresses the reason for this choice. *Geometry,* he says, *with only few principles brought from without is able to produce many things, and it is nothing but that part of universal mechanics, which accurately proposes and demonstrates the art of measuring*[19].

Geometry the "art of measuring", and a "part of mechanics"? It was a conviction of the Platonic Renaissance at the beginning of modern times that to know something *means to measure it*. Now *true geometry* is in fact the art of measuring, while arithmetic is the art of calculating. And geometry, as we shall see, relates to philosophy. It is well known that at the entrance of Plato's academy in Athens one could read the device that nobody should enter who was not already an able geometer. Nicolaus Cusanus expressed the platonic view of geometry as the means for gaining philosophical knowledge by measurement already in 1440, in his treatise "De docta ignorantia"[20]. Galileo and Newton followed this device. Consequently, I shall also do so. That is, I shall present the Galileian-Newtonian principles of the theory of motion in the language of their geometry. It has, however, been a common usage for generations of textbook-writers to present these principles exclusively translated into the language of the arithmetic-algebraic analysis of the 18th century from the beginning. But today scholars begin to understand that this translation fails to represent the full and rich contents of the Galileian-Newtonian theory of motion[21], and thus misses especially its *philosophical* implications which to reveal is the goal of my analysis.

3. Next to this geometric presentation that may mean something new even for mathematically skilled theoretical physicists, I shall turn to the philosophy and to the laws of motion of "classical mechanics", known to nearly everybody since school-time. However, in contrasting these principles with those very different *geometric* ones of Galileo and Newton we shall see immediately what is already widely known among historians of science[22], but yet not so among other scientists[23], and not at all among philosophers[24]: The principles of the Galileian-Newtonian theory are n o t identical with those of classical mechanics, and it is misleading and really unjustified and erroneous to call classical mechanics synonymously by the name of "Newtonian mechanics". This manner is misleading and unjustified especially with respect to their v e r y different *philosophical* foundation.

In fact, classical mechanics, a *determinist* theory of motion as everybody knows, rests on philosophical principles to be judged as antipodal to the philosophy of Isaac Newton, which, as it demonstrates the unforeseen *causal generation* of motion in space and time, was correctly called the *philosophy of liberty* by Newton's amanuensis Samuel Clarke[25]. We shall see this difference clearly when we shall contrast the most elementary basis of classical mechanics, the principle "force equals mass-acceleration", with the true geometric contents of Newton's second law of motion. It reads "*Mutationem motus proportionalem esse vi motrici impressae*", to mean that every change of motion as an effect is generated by interaction with some cause called "*impressed motive force*", which effect is not equal, but *proportionate* to that *active principle* to act on bodies from externally in order to change their state of rest or of uniform straight-lined motion.

4. Finally, I shall deal with the roots of Einstein's Special Relativity that one finds in the Faraday-Maxwell theory of electromagnetism, as is generally known, and especially in the theory of radiation pressure derived from that theory.

My analysis will here again concentrate on the philosophical implications of these theories, in order to show a significant and exciting correspondence of Einstein's principles with those of the geometric Galileian-Newtonian theory of motion - a correspondence that allows for the first time to understand the read thread of *philosophical*, or *transcendent realism* that leads from the Platonic fathers of the *nuova scienca* of the 17th century to modern science. Again this read thread will not be shown by talkative persuasion, but by means of true mathematics, that is by means of classical geometry, and of the *geometric theory of proportions.*

III Realization of a Venture: The discovery of the *authentic* Galileian-Newtonian theory of motion.

1. Galileo was sentenced to revocation and livelong arrest by the Roman Church in the year 1633 for having taught (against the wording of the Bible) the motion of the earth without proof[27]. After that, how better could he defend his scientific reputation than by showing the world that he in fact h a d proven the reality of that motion? Consequently 70-years-old ill Galileo, almost blind, imprisoned in his house at Arcetri near Florence, composed a treatise "De motu locali" - that is: *on local motion* - in which he established the theory of motion thoroughly *as a realist one*, i.e. as referring motion to space and time, i.e. *to a real space-time frame of reference at true rest*[28]. Certainly everybody who has understood the conceptual relativity of the term "motion" (as referring to "rest") knows about the need of such a reference system as a basis for determining the real motion, say of the earth, or of other bodies, relatively to that system. Galileo therefore, at the very beginning of his treatise, draws two innocent straight scaled lines, infinite on principle, one to represent "time", the other to represent "space", and both of them to serve as fixed *standards,* or *scales,* for measuring the variable "times" and "spaces" covered by a body in uniform-straight-lined motion.

figure 1

I _ .__.__.__.__.__.__.__.__.D_.E__.F___.____.____.____.____.__ K time

G _.___.___.___.___.___.___.___.A__.B____.C____._____._____._____.__ H space

This figure illustrates Galileo's "Theorema I, Propositio I" to present for the first time in history the most elementary geometric law of motion; and it reads:

"*Si mobile aequabiliter latum eademque cum velocitate duo pertranseat spatia, tempora lationum erunt inter se ut spatia peracta*."

That is: *If a movable body, moving uniformly, with one and the same velocity covers two different spaces, the corresponding different times elapsed will be to each other as the covered spaces are to each other.*

According to proportion theory, this law, if we e.g. compare the relation of the spaces GA, AB to each other with that of the times ID, DE to each other, yields the following *quaternary proportion:*:

$$GA : AB = ID : DE \qquad (1)$$

Let me just concentrate on the above figure insofar as it clearly shows Galileo's *space-time frame of reference and measurement of motion.* The characteristic of this scaled frame is the fact that *corresponding segments of space and periods of time are always proportionate to each other:* Space AB is to time DE as space BC is to time EF, so that as well space GA is to time ID as space AB is to time DE, etc. etc. Galileo, as we can see here, makes use of a space-time frame of reference and measurement of motion that is characterized through some elementary constant parameter given by the quotient "segment, or element, of space, AB, over period, or element, of time, DE", and "element of space BC over element of time EF". This constant quotient evidently lying at the bottom of Galileo's theory of motion I symbolize by the letter *C* to denote *the first universal constant* of the new theory of motion. Obviously, the *dimensions* or *units* of this constant *C* read "space (AB, or BC) over time (DE, or EF)", which I shall symbolize [L/T] in the following. Physicists are used to read this symbol as the units of some "velocity" *v*. So we should note carefully that the constant *C* [L/T] as a quotient of *invariant elements* of space and time, and the symbolic representation of its dimensions [L/T] as well, means *n o t a variable velocity*, but *a universal c o n s t a n t* .

Galileo's reasoning as presented here can be found in the first chapter "De motu aequabili" (that is: *On uniform motion*) of his treatise "De motu locali" (that is: *On local motion*), which treatise is the "Giornata terza", the *third day* (i.e. the third chapter) of the discourses that he collected in his book of 1638 entitled "Discorsi e dimostrazioni matematiche intorno a due nuove scienze attinenti alla mecanica ed i movimenti locali", briefly called the "Discorsi". As it deals with *uniform* motion, Galileo measures the *velocity* of a body in motion, as a measurable physical variable, by measuring some variable *quantity of space covered* by the moving body, and some variable *quantity of time elapsed* during that very process, and by *relating both variables to one another*. Of course this relation must always remain the same so long as we deal with *uniform* motion. Now, *to measure* the quantities of variables "space" [L] and "time" [T], according to *figure 1* means *to compare* these quantities, e.g. the quantity GA of "space", and the corresponding quantity ID of "time", *with their standards*, as represented by the two straight lines of *figure 1*. Generally spoken, *to measure means to compare* (Cusanus), and a closer investigation of the process of e.g. measuring some variable "space", or "distance", shows that it consists in *relating a sought quantity to its standard*, i.e. to the *unit* of its standard. As a consequence, in our case of uniform motion *some variable quantity A of space* will be to the unit s [L] of its standard, as the corresponding *variable quantity B of time* will be to its standard's unit t [T]. The most general expression of *uniform velocity v* in the language of proportion theory then will be

$$v\,[L/T] = A\,[L] : B\,[T] = \textit{element of space } s\,[L] : \textit{element of time } t\,[T] = \textit{constant} \qquad (2)$$

or, if we replace the right side of this *equation of proportions* by the above-revealed universal constant C [L/T],

$$A : B = C\,[L/T]. \qquad (2a)$$

This formula means: In case of uniform motion, the relation of spaces traversed (A) to the corresponding times elapsed (B) *is always constant*, and this constant is given through the relation *C of the element s* [L] *of the underlying standard* of "space" *to the element t* [T] *of the underlying standard* of "time". Synonymously, as in this case all n-fold multiples of s, ns, symbolized by A, are to their element, s, as all *equally n-fold multiples* of t, nt, symbolized by B, are to their element, t, we can say (according to the definitions Euclid V 5, 6) that these quantities of space A and these quantities of time B are *proportional* to each other, and so are the *elements* of space, s, to the *elements* of time, t. The quotient C of these elements then represents the *constant of proportionality* which connects uniform velocity v with its standards, thus to form a *quaternary proportion* that does not simply *assert* this velocity v to be uniform, but *proves it.* I remember here what Plato says, in the "Timaios"-dialogue, of the power of quaternary proportions to harmoniously connect natural entities of a different kind (e.g. earth, fire, water and air) with each other.[29]

We should note that the proportionality *of the elements* of the standards of space and of time, as can be seen in *figure 1*, means *a general quality of Galileo's space-time system of* *measurement and reference.* From a philosophical point of view we may state now what follows:

1) Galileo the philosophical realist, as he refers the variable quantities of spaces and times of motion to scaled standards of space and time, with these scales *presupposes the real existence of "space" and of "time".*

2) Consequently, the said variables, as they are determined in relation to, or *relative to* the said standards, may be called "relative spaces", and "relative times", while the standards will represent what may be called "absolute space", and "absolute time" - in the same way as *every* thing that is determined in relation to a standard may be called "relative", while the standard always in a way will represent something "absolute".

3) Absolute space, and absolute time, representing the system of reference and measurement of motion in Galileo's context, must be understood as being at true rest themselves. Consequently, every local motion that is determined in relation to that Galileian system may be understood as "absolute motion". This is the sense of Galileo's term "motus localis"

4) Relative spaces, or variable quantities of space, and relative times, or variable quantities of time, since they are determined in relation to their absolute standards, take part in the reality of these absolutes according to the Platonic principle of "methexis" (i.e. *participation*).

5) The absolute space-time system of reference and measurement of true motion, as it is built by *proportionate scaled standards of space and time*, may be understood as some *lattice*, with the above-decoded universal constant of dimensions [L/T] to work as a *lattice constant.* This lattice is demonstrated to the eye in Galileo's "Discorsi", *figure 10*: In this figure that refers to uniformly accelerated motion, the scale ACIO represents the standard of time, while CE, EB, IH, HG, GN, NF etc. represent the units of the standard of space. The relation of AC to CE, of CI to NG, of IO to RQ etc. represents the always constant quotient of the elements of space and time that constitute the lattice APO[30].

6) Every measured quantity of relative space, or of relative time, since it is always determined in relation to its proper *scaled standard*, must represent *a discrete multiple* of this standard's unit, or element, in the sense of Euclid V 5. Consequently, such measured quantities of

relative spaces, or distances, and of relative times will always appear not as *unstructured magnitudes,* but as *quantized quantities* of space and of time. And this means that at the bottom of Galileo's geometric theory of motion we find a *quantum theory of motion.*[31]

7) Galileo's theory is basically a theory of *uniform straight-lined motion.* This kind of motion cannot take place but in idealized spaces free of any outside resistance, and consequently it is not subject to sense experience, as physicists know. The concept of uniform straight-lined motion in time and space then represents something *transcendent,* as well as (the scaled standards of) "absolute space" and "absolute time" just characterized do represent *transcendent elements of Galileo's theory.* Since Galileo was certainly convinced of the reality of "space and "time" as given with these standards, and of the reality of local motion with respect to this reference frame, we may understand his philosophy as teaching the reality of transcendent things (such as e.g. the motion of the earth) *in general*, i.e. as *transcendent realism.*

2. All that we have found so far in Galileo's theory of motion we shall find again in Newton's "Principia" of 1687. It is well known to historians of science that Newton felt himself to be the successor to Galileo who had died the same year when Newton was born[32]. In the "Principia", Newton explicitly refers to Galileo's findings, even attributing to him, as their inventor, the germ of the new theory of motion, i.e. the first two of the "axiomata sive leges motus", the *laws of motion*[33] he presents at the head of his treatise "De motu corporum liber primus", which is "book I" of the three "books" the "Principia" consists of.

Book II of the "Principia" is concerned with the motion of bodies *against outside resistances* of e.g. water or air. Book III, "De mundi systemate", explains *the system of the world* by means of the propositions of the first two books. The basic book I then, in contrast to book II, treats the transcendent motion of bodies *free of any outside resistance,* as did Galileo. Accordingly, Newton basically treats transcendent uniform straight-lined motion too. So his first law of motion states that *every body by itself continues in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by external forces impressed.* From a philosophical point of view we learn here that Newton teaches a true *causal theory of motion*, i.e. the generation of material motion by interaction with real causes, or "forces" external to the body and thus different from it, in contrast to the materialist view of motion as a genuine property of matter itself, and of "forces" as only *names* of such properties of matter[34]. In Newton's explanatory comment to this law, he argues analogously that bodies according to our sensory perception always are *changing* their state of rest or uniform motion as an effect of the actions of outside forces such as resistance of the air, or as the force of gravity. In consequence of this fact, however, we are able to know truly that a body, if *not compelled* by outside forces to change its state, will continue to stay in its state of rest or of uniform straight-lined motion ad infinitum. Obviously, by means of this *indirect demonstration,* Newton tells the reader that, and how, man is indeed able to learn the truth about such a transcendent thing like "uniform straight-lined motion" that can never be observed in nature. This is certainly a most remarkable content of Newton's first law of motion with respect to the intrinsic *transcendent realism* of Newton's theory as well as to his *method of research.* As I have already shown elsewhere[35], Newton's method so to speak is "deduction from experience". Contrary to the methodological meaning of "deduction" of classical (i.e. Aristotelian-scholastic) philosophy, which is to logically derive individual knowledge from general hypothetical principles, Newton deduces general principles, or "laws of motion", from individual phenomenal experiences[36]. Says he, in his preface of 1686: *The whole burden of philosophy seems to consist in this - from the phenomena of motions to investigate the forces of nature, and then from these forces to demonstrate the other phenomena; and to this end the general propositions in the first and second Book are directed.*

Accordingly, Newton's first and second law of motion show the *causal interaction of material bodies with "forces of nature" that generate changes of their state of rest, or uniform straight-lined motion.* And this is the contents of Newton's *second law of motion* to read: "*Mutationem motus proportionalem esse vi motrici impressae, et fieri secundum lineam rectam qua vis illa imprimitur*." That is: *The change of motion is proportional to the impressed motive force; and it is made in the direction of the right line in which that force is impressed.*

Uniform straight-lined "motion", described by Galileo mainly as "velocity" *v*, represented by quantities of space and quantities of time in relation to the units of space and time (eqs. 2, 2a), as a quantity had been investigated more profoundly after Galileo's death (1642) by John Wallis, Christopher Wren, and Christiaan Huygens, in the years 1669-1671. These men found that this "motion" of a body as a mathematically defined quantity has to be measured by the *product of the body's velocity v with the quantity of matter m the body represents:* so that e.g. quantitatively the motion of a double body, $2m$, with velocity $v/2$ is $2mv/2$, and consequently is quantitatively the same as the motion *mv* of a single body *m* with velocity *v*. Now Newton, in the second law, states the proportionality of a motion-generating impressed motive force *F* with the generated uniform-straight-lined motion *mv*, which quantity *mv* itself, respectively the variable *v* ("spaces" over "times"), is (according to eqs. (2), (2a)) as the quantity that forms the above-shown constant *C*. According to proportion theory, however, if a quantity *F* is proportional to another quantity, *mv*, which itself is as a third quantity, *C*, the proportion *F* **:** *mv* will result in the same third quantity, *C*. Newton's second law then will read *F* **:** *mv* = *C*, or

$$\boldsymbol{F} = m\boldsymbol{v} \text{ times } C \,, \qquad (3)$$

the fat ***F*** and ***v*** expressing what today is called the "vector quality" of these quantities, i.e. their quality to work *in a determined direction* in space. In a more special version, i.e. if the force ***F*** acts on a body that is already moving uniformly in an straight line, the "change in motion" produced by ***F*** will be given as the difference ? between the former and the latter state of uniform straight-lined motion, symbolized ? *m**v***, so that we obtain

$$\boldsymbol{F} = ?\ m\boldsymbol{v} \times C \,. \qquad (3a)$$

As this symbolic representation of Newton's second law may sound rather strange to those who by relying on their textbooks have learned the law to read ***F*** = *m**a*** (with ***a*** = acceleration, or the derivation of velocity with respect to time, *d**v**/dt*), I must stress the point again that historians of science know for a while about Newton's second law to be n o t identical with the algebraic formula ***F* = *ma* .** Some of them have already seen that it is not *d(m**v**)/dt* but ? *m**v*** what Newton puts in relation to "force" ***F*.** But, as they ignored Newton's specific *geometric* method, they could not understand the requirements of geometric proportion theory in this context, so that they erroneously put the active force ***F*** *not proportional, but e q u a l to its effect,* which error of course made them ignore and eliminate the *constant of proportionality C.* Some others, who at least understood Newton's law as a proportionality, but believed in ***F* = *ma***, meant mass *m* to work as constant of proportionality between ***F*** and ***a***; ignoring, however, that in Newton's law *m* is part of the entity *m**v*** which *as such* is proportional to ***F*,** so that *m* is *not available* as factor of proportionality between that entity and ***F***. Others wanted to get rid of the unwelcome constant of proportionality (which Newton's law so evidently requires) "by a good choice of units"[37], presupposing, however, that the units, or the dimensions of ***F*,** should read [mL/T^2] exactly like those of mass-acceleration *m**a***. It is clear that, starting on this assumption, they are able to obtain from the relation ***F*** *over m**a*** a *dimensionless* "proportionality constant" that, of course by another "good choice of units", could easily be put equal to " 1 ", and consequently could be *removed* from the equation. In fact this argument is invalid, since it, instead of Newton's *proportionality* of force ***F*** and its effect, presupposes at will the *equality* of both these entities. By the way, if this method to eliminate a constant of proportionality were possible and true, it should have worked long ago to clean physics of *all* universal constants (such as the gravitational constant, Planck's constant *h*, and Einstein's constant *c*, all of them representing *proportionality constants between physical quantities of different kinds*[38]).

As we can see in eqs. 3, 3a, the true dimension of Newton's ***F*** is [mL/T times L/T]. Physicists should be well aware, however, that this dimension is n o t that of (kinetic) *energy* [mL^2/T^2], because the first L/T belongs to a *variable, v,* while the second L/T belongs to a *constant, C*. Only in one very special case it is possible to form *squares* of the respective quantities of space, *s*, and of time, *t* : that is *at the very beginning of motion* ("ipso motus initio", as Newton says it, e.g. in *Lemma* X of his *method of first and last ratios of quantities,* presented in the "Principia", Book I, Section I, as that method *by the help of which we demonstrate the propositions that follow*). The reason is that at this very moment, but at this first moment of the creation of (change of) motion *only*, the said quantities of *variable* spaces and times *coincide* with the said *constant elements* of space and time[39].

Finally I want to mention the American historian of science I. Bernard Cohen who, as a Newton scholar, for a lifetime had struggled with the problem of how to correctly understand Newton's second law, especially with respect to the dimensions of the entities involved. Close to the end of his life, when he in 1999 edited a new English translation of the "Principia", containing an extensive "Guide to Newton's *Principia*" Cohen had composed, he threw in the towel - alleging helplessly, however, that Newton in the "Principia" should have "*set forth a dimensionless physics*"[40]. Cohen's problem was that he did not understand the geometric method Newton uses exclusively for the foundation of his theory of motion in Book I of the "Principia". Had he only effectively studied Newton's just mentioned *method of first and last ratios,* Cohen himself would have admitted that to impute to Newton the idea of "a dimensionless physics", say of a theory of motion without measurement, is pure nonsense.

All in all, there are no two ways about it: Newton's geometric second law as a true quaternary proportion requires four terms as an equation of proportions, two of them on each side, two of which (at the right side) to be *constants,* representing as a quotient *the constant of proportionality*. This constant, as has been derived above from Galileo's teaching, is a quotient of the elementary particles of time and space that constitute the standards of time and space relatively to which standards variable quantities of times elapsed and of spaces covered can be measured. At the same time, this set of standards provides for this theory of motion the true system of reference at absolute rest. The dimensions of this "Newtonian Constant" (as I have baptized it already in 1985 [41]) have been shown to be "space over time" [L/T], and this same result can be found in the "Principia" in various ways, as I have shown it elsewhere[42].

From a philosophical point of view we can say about this foundation of Newton's theory what follows:

1) Isaac Newton as a philosopher was a realist as well as Galileo. His theory of "absolute space" and "relative spaces", "absolute time" and "relative times", as he presents it in the "Principia", *Scholium* after definition 8, is clearly based on Galileo's method of measuring relative quantities in relation to their corresponding absolute standards. To determine quantities of velocity, as relations of spaces to times, and quantities of motion (mass times velocity) according to this method, i.e. in relation to absolute standards of space and time, then means to determine *the true, or absolute motion of material bodies in relation to a space-time system of measurement and reference, as a real, or true event in real, or true space and time* [43].

2) Absolute motion in the just explained sense, which motion of bodies to distinguish from their only relative motion with respect to one another was the end to which Newton explicitly composed Book I of the "Principia", is as *transcendent* and *unobservable* a thing as the motion of the earth, and as its standards "absolute space" and "absolute time", and it is as unobservable as uniform straight-lined motion in space void of any resistance generally is. Consequently we must see that the whole contents of the "Principia", Book I, refers to unobservable and thus transcendent things to which also that "impressed motive force" will belong which Newton, in his laws of motion, introduced into the theory of motion. We can certainly say that the whole foundation of Newton's theory of motion presented in Book I of the "Principia" reveals Newton's philosophy as *transcendent realism,* i.e. as *thoroughly Platonic*, so long as we understand that Platonism teaches the reality and truth of transcendent models,

or *absolute standards* of "ideal" absolute reality that communicate reality and truth by means of "methexis", *participation,* to their imperfect temporal images. These images mean the variable, finite, *relative* quantities of spaces and times that we empirically perceive, and that we are able to measure in relation to these standards by means of proportion theory.

3) Newton's second law of motion, as we now understand it, presents a true *causal* interaction law in the sense that it presents a *motion-generating cause,* i.e. "vis motrix impressa", and the *generated effect*, "mutatio motus", on different ontological levels, i.e. as different entities. The only means to connect these different entities as to form a meaningful interaction that can be understood and investigated scientifically, i.e. mathematically, provides *the theory of proportions* of the Ancients. The law of motion, $\boldsymbol{F} : m\boldsymbol{v} = s : t$ (eq. 2), as the law of *cause* and *effect*, now reads *philosophically,* as a *quaternary proportion* (the Greek "tetraktys"):

cause ($\boldsymbol{F}$) is to motion (m$\boldsymbol{v}$) as the element of space (s) is to the element of time (t).

This law says that motion is never generated *but in space and time*, since it implies the elements s and t. Accordingly, it provides a *realist* description of the process of generation of motion that happens in nature, in contrast e.g. to the $\boldsymbol{F} = m\boldsymbol{a}$ of school mechanics. This law of the schools, as it puts the *cause* ($\boldsymbol{F}$) and its effect ($m\boldsymbol{a}$) e q u a l , i.e. on the same ontological level, must necessarily describe the effect as emerging i n s t a n t a n e o u s l y from its cause. It is well known, however, that modern experimental physics has shown for long the shortcoming of such a concept of instantaneous force-matter-interaction. As a matter of fact, an *equation* of something ($\boldsymbol{F}$) with some other thing ($m\boldsymbol{a}$) will never express an *interaction* between these things, but only their *equality.*

4) Newton's true second law, as it is a *causal* law, is not a *deterministic* law. That is to say: it does not work as a tool that tells about the future state of things. Here we learn again that "causality" and "determinism" mean opposite, antagonistic philosophical concepts that rule each other out, as the Newtonian Samuel Clarke, and the anti-Newtonian G.W. Leibniz[44] discussed the matter.The reader of their discussion can see that it was not often-scold Newton but his philosophical antipode Leibniz who argued for the "dead" materialist-determinist "clockwork universe" allegedly created by God as a "perfect watchmaker"[45] . According to Leibniz, the quantity of motion in the whole universe should always remain invariably the same, created by God at the beginning of time. Newton, as Clarke shows, on the contrary

voted for the permanent and unforeseeable *generation of new motion*, caused by spiritual active agents, such as the "forces of nature", and the free will of living beings[46]. It is for this reason that Clarke elsewhere correctly praised Newtonianism as the true "philosophy of liberty". In fact, if it is true that living beings are free to generate e.g. the motions of their limbs *at will*, they are able to change the state of things and affairs in a way that cannot be foreseen on principle. We do not know about the "Why" and "When" of such changes to happen. We do also not know about the Why and When of other actions of the forces of nature. But we do know about the "How", i.e. about the quantitative relation between causes and effects, so that we are able to learn about the transcendent spiritual causes by investigation of their proportionate observable effects, thus to perform the scientific programme that Newton outlined in his preface of 1686 to the "Principia", when he says what I have already quoted above: *The whole burden of philosophy seems to consist in this - from the phenomena of motions to investigate the forces of nature, and then from these forces to demonstrate the other phenomena.* "To demonstrate" is not "to forecast". The idea of precalculating the future, which is the pride of science in our time, is not a part of Newton's philosophy of nature.

3. Turning now to the basic law of motion of "classical mechanics", which is represented by the just mentioned formula "force equals mass-acceleration", physicists as well as philosophers should finally accept what historians of science have found for long: This very effective formula is not Newton's, but an invention of the genius of Leonhard Euler, who developed it in his "Mechanica sive motus scientia analytice exposita" of 1736. In this work, Euler transformed the Galileian-Newtonian *geometric* foundation of the theory of motion into the *arithmetic-algebraic* language of the Leibnizian *calculus differentialis*[47]. No wonder that not only the mathematical language, but also some philosophical principles of Leibniz became adopted during that process of "positivistic interpretation", as Paolo Casini has palliatively called the conversion of the Galileian-Newtonian theory of motion into analytical mechanics to happen during the first half of the 18th century[48].

As a matter of fact, one can trace the roots of Euler's law $\boldsymbol{F} = m\boldsymbol{a}$ back to Leibniz's "Specimen dynamicum pro admirandis Naturae Legibus circa corporum vires et mutuas Actiones detegendis et ad suas causas revocandis" of 1695, which Leibniz composed as his answer to Newton's "Principia" of 1687[49]. Nevertheless, Leonhard Euler in 1750 introduced the formula to the Prussian Academy of Sciences in Berlin, where he had worked from 1741 on as a director of the mathematical class, as being exclusively his own scientific discovery, not mentioning the name of Leibniz in this context, much less that of Isaac Newton.

So far as I can see, nobody has ever rejected Euler's priority claim. How it could then happen that Euler's law in the course of time erroneously became known as a representation of Newton's second law is an open question that should be answered by further research work of historians of science. As I see things, it happened together with the general misunderstanding of Newton's "Principia" to demonstrate the law of gravitational force as its central argument, and consequently *to present "force" generally and exclusively* in the determinist shape of a differential equation. A great step in this wrong direction certainly was done when in 1788 Joseph Louis Lagrange, successor of Euler at Leibniz's Berlin Academy and its president since 1766, published, as a sort of keystone to the edifice of analytical mechanics, his "Mécanique analytique", highly praising the pretended Newtonian roots of this new science in the preface, in contrast to the book's contents. Actually Lagrange perfected the mathematical work of d'Alembert[50] and Euler in the Leibnizian spirit of the non-geometric but arithmetic-algebraic formalism of the new *calculus differentialis.*

As far as the concept of "force" is concerned, some Newton scholars, however, have already begun to understand "the primacy of impulsive forces"[51] over the concept of "centripetal force" in the "Principia". This in fact can be read in Newton's *Scholium* after *definition 8,* when he says that *the causes by which true and relative motions are distinguished, one from the other, are* the forces impressed (my emphasis) *upon bodies to generate motion. True motion is neither generated nor altered, but by some* force impressed (my emphasis) *upon the body moved*, he says there, and this corresponds with the first and the second law of motion, both of which clearly speak of only "motive forces impressed". The relation between "impressed force" and the force of gravity that Newton introduces as "centripetal force", is treated in Newton's *definition 4* to define the meaning of "impressed force". Says Newton: *Impressed forces are of different origins, as from percussion, from pressure, from centripetal force.* Centripetal force accordingly is not *to be identified* with impressed force, but is *an origin of* that force[52]. How this relation should work mechanically can be understood when Newton, in the *Scholium* after *Corollary 6* to the laws of motion, explains the mechanism of free fall: *When a body is falling, the uniform force of gravity, acting equally,* impresses (my emphasis)*, in equal intervals of time,* equal forces (my emphasis) *upon that body, and therefore generates* equal velocities (my emphasis). Newton's centripetal force, as we should be aware, then (as a *source of* force) produces *f o r c e s to generate v e l o c i t i e s* ; n o t does it produce a *continuously accelerated motion* of the falling body, as classical mechanics teaches us. In the same way, i.e. not by continuous acceleration (in the form of a continuous change of the direction of motion), but *by discrete action* to impress direction-changing force after force, and *impulse* (sic) *after impulse* on a body in uniform straight-lined tangential motion, according to Newton the centripetal force urges the body *to revolve* around the centre to which this force is directed[53]. I.B. Cohen was not able to solve the seemingly enigmatic problem of prior "impulsive" over "continuous" force, as he saw it in the "Principia"[54], only because he did not take Newton's words seriously enough, contrary to his pretended intention. He who seriously wants to respect Newton's words must clearly understand that Newton's "central argument" with respect to "force" (as cause of motion) was to show how not only uniform straight-lined motion, but *also circular motion* was generated by that *only* generative "motive force impressed" which is introduced in his first and second law of motion, and defined in his *definition 4* in the "Principia" as a most elementary and real, *active agent, and non-material principle of nature*[55].

Now, as far as the quantitative determination, i.e. the question of the space-time *dimensions* of centripetal force is concerned, it is clear from Newton's *definitions 5 - 8* as well as from his *method of first and last ratios of quantities*, especially from *Lemma X* (referring to the space-time dimensions of "force"), that *at the very beginning of the generation of motion*, i.e. "ipso motus initio", *any* finite kind of force, be that force *determined and immutable*, or be it *continually augmented or continually diminished, is directly as the spaces described in the very beginning of the motion, and inversely as the squares of the times* (*Lemma X Corol. IV*). In the *Scholium* to follow *Lemma X* Newton explains the meaning of this statement, saying:

If indeterminate quantities of different kinds are compared with one another and any one of them is said to be directly or inversely as any other, for example, if A is said to be as B directly and C inversely, the meaning is that A is increased or decreased in the same ratio as B/C, that is, that A and B/C are to each other in a given ratio.[56]

Accordingly, the "force" *F* of the said *Corol. IV* is increased or decreased in the same ratio as the quotient "spaces described to square of the times", i.e. as the quotient s/t^2 [L/T^2] to which it is in a *given*, i.e. in a *constant* ratio. Thus we obtain (vector notation omitted)

$$F/s \times t^2 = \text{constant} \tag{4}$$

or $$F = ms/t^2\,[\mathrm{mL/T^2}] \times constant \tag{4a}$$

As we above have found the dimensions of F to read [mL/T $\times$ L/T], the dimension of the constant will be that of a length s [L]. So, by path integration of the term ms/t^2 on the right side of eq. (4a), ignoring the fact that the constant s means *not a variable, but a constant,* we obtain a quantity ms^2/t^2 [mL^2/T^2] to represent what Leibniz called "vis viva", the living force, the later "kinetic energy". This procedure shows us Newton's theory closely related with (Leibnizian) analytical mechanics, but also it allows to understand the precise difference between both concepts: Newton's concept is *only* valid "ipso motus initio", that is: *at the very beginning of motion only,* as he over and over again emphasizes in this context. Since motion, to mean (according to Newton) always *uniform motion in a straight line,* is *generated* in space and time, there must exist a first and foremost state of the body that is different from its former state of rest, or of uniform motion: a first and foremost state which must be characterized by a very special relation between the entities involved, such as "time" and "space", *absolute* (i.e. as elements of the standards of measurement) and *relative* (i.e. as the first measurable quantities of the process of the body's *changing* its state). Certainly this process of *generation* of uniform straight-lined motion will be characterized by some sort of *acceleration* of the body's velocity, and this in fact comes to light through Newton's analysis of the "first and last ratios" between "space" and time", and "spaces" and "times", as he demonstrates it in Book I, Sectio I of the "Principia". However, this "acceleration", given through the term s/t^2 [L/T^2] "ipso motus initio", i.e. *at the very beginning of motion only,* will consequently not be the effect of some *continuously acting force*, but will be *restricted to the very beginning* of the new state which the body (formerly at rest, or in uniform motion) is urged to acquire. But, in the case of a nearly continual change of motion, such as in the case of *circular* motion, when a body revolving about a centre nearly continually changes its direction, so that its state "ipso motus initio" *continually* seems to take place, the "accelerating" initial "centripetal force" will in fact be given *continuously,* so long as the body revolves, by the "accelerating" term s/t^2. Newton shows exactly this in the "Principia", Book I Sectio I "De inventione virium centripetarum", Prop. I, Theor. I. Now in Leibniz's concept, on the contrary, "acceleration" is *not restricted to act at the very beginning of motion o n l y* , but is conceived as a *general, constantly acting continual force* (named "dead force" in the "Specimen dynamicum" of 1695) that produces "living force", or "kinetic energy" (to be calculated by path integration), and "motion", or "momentum" (to be calculated by time integration) in the course of time. Which method is the gist of "classical mechanics" that rests likewise on the principle of generally accelerating force, given through the term s/t^2, respectively ms/t^2 [mL/T²]. Thus we can understand that this most basic principle of classical mechanics, as it was developed by Leonhard Euler in 1736, in fact stems from Leibniz's 1695 foundation of the theory of motion, which finding shows the true origin of this principle generations of scientists erroneously had imagined to represent Newton's second law. I hitherto have found only one scholar who has correctly understood the principles of Leibniz's mechanics as a system: Ernst Cassirer; and only one scholar who has understood the true *Leibnizian spirit* of classical physics: Kurt Huber.

The true Leibnizian descent of Euler's basic law of motion of classical mechanics is corroborated as we turn to the well-known philosophical principles lying behind this law, all of them belonging to the philosophy of G. W. Leibniz:

1) The $\boldsymbol{F} = m\boldsymbol{a}$ of classical mechanics asserts an *equality* of force ***F,*** as a "cause", with its effect "continuously accelerated motion". Thus it evidently reflects Leibniz's "first principle of mechanics"[57], which he cast in the mould of a seemingly very old philosophical winged word, even though it was truly *his invention*: "Causa aequat effectum", clearly asserting "cause" and "effect" to be e q u a l (and thus undistinguishable, of course), contrary to Newton's explicit *proportionality* of cause and effect, as it is present in his second law.

2) This identification of the cause of motion with its effect reflects the *empiricist spirit* of classical mechanics. It claims to understand "causes" simply by understanding "effects", and consequently restricts science to the investigation of the empirically given motions of bodies[58]. A causal research in Newton's sense, which should mean to find the transcendent "forces of nature" that lie behind the phenomena of motion, would make no sense if the empirically given effects just *were* these forces. Obviously, then, the $\boldsymbol{F} = m\boldsymbol{a}$ of classical mechanics does not and cannot represent a *cause-effect interaction* at all.

3) It was Plato's view that there lies an "ideal" world behind the empiric one, which ideal world should be the "true reality", and the "real truth" that communicates true reality and real truth to the empiric world, and also provides the true transcendent *causes* of empirical things and events. In contrast the *identification* of cause and effect, as it *reduces* scientific research

to an investigation of empirically given effects only, breathes an anti-Platonic, say Aristotelian spirit that *denies* any such "reality behind reality". In fact one may say that it is Leibniz's well-known neo-Scholasticism that came to the fore with this empiricist foundation of mechanics on the principle "causa aequat effectum".

4) To *equate* the cause "force" with its effect "accelerated motion" means to put cause and effect on the same level with respect to space and time. This is to say that in this case the "cause" and its "effect" must occupy one and the same "place" in space and time, i.e. that they should *appear instantaneously* at the very same time at the very same place. Thus we can see the well-known principle (and problem) of *instantanity*, and of *instantaneous action at a distance,* deeply rooted in the basic law of motion of classical mechanics. It means an interesting additional aspect, by the way, to look who was the true inventor of that un-Newtonian concept of instantaneous action at a distance[59] as part of classical mechanics: In fact the philosopher Immanuel Kant, in his "Metaphysische Anfangsgründe der Naturwissenschaft" of 1786, *was the first to explicitly present this concept as part of mechanics,* as he understood it. Newton, as should be known, had strongly rejected such an interpretation of his theory of motion, in his letter to Bentley of Feb. 1692/3; and it is really not part of his teaching if one takes his principles seriously, since it contradicts and destroys the concept of interaction, and of *generation of motion in time and space.* As such an interaction concept is not part of classical mechanics, one can see here the un-Newtonian, but rather Leibnizian-Kantian spirit of this uncorrectly termed "Newtonian mechanics" once again.

5) The relation between the force ***F*** and its material effect *m**a**,* if understood as an *equation of equals*, together with the empiricist spirit just described, gives to ***F*** the same material state as to *matter in accelerated motion, m**a**,* to result in *attributing* force (as a cause of motion) to the body *m* itself. Thus "force" becomes a *quality of matter* only, as e.g. in the case of textbook interpretations of the classical mechanic's theory of gravitation, where it is "the sun" that attracts the earth, and it is "the earth" that attracts the moon, etc. etc. Here then lies the ground for the well-known intrinsic *philosophical materialism* that characterizes classical mechanics.

6) Mathematically seen, the process of *computation* of "effects" by derivation of "forces" in applying the tools of analysis shows a not *causal-generative,* but *functional* relation between both parts of the classical law of motion. This functional relation in fact represents not a realist law of generative cause and generated effect, but a *rational* principle of reason and

consequence. We *derive* consequences (*instantaneously* on principle) by means of *logic* from their reasons, or grounds, in the same way as we (*instantaneously* on principle) derive motions from the ***F = ma*** law by mathematical logical computation. So it is the spirit of Cartesian *rationalism* that comes to the fore here [60].

7) The ***F*** = *m**a*** law of motion does not tell about an underlying spacetime system of measurement and reference, as does the Newtonian constant *C* in Newton's *authentic* second law. Consequently this "classical" law ***F = ma*** supports a *conventionalist* philosophical view as to measurement, the standards of which accordingly should always be set up - on principle *at will* - by human convention. This view implies, of course, to deny the existence of space and time "as such", and even more as *transcendent scaled standards.* Thus it mirrors again the philosophy of Leibniz who understands "space" and "time" in a materialist view, as only *relational orders of bodies* which, as they are nothing by themselves, cannot have, or represent, any metric structure, of course; and this view, mutatis mutandis, is also that of Kant with respect to absolute "space" and "time" as *transcendental* (in contrast to "transcendent") "things in themselves" about which man could not know anything. No wonder that Kant, in his just mentioned "Metaphysische Anfangsgründe der Naturwissenschaft" of 1786, displayed a mechanics that was reduced to a poor materialist science, as it presented "forces" to be nothing but *properties of matter.*

8) Space and time as absolute scaled standards being absent from the classical law of motion, this law then lacks not only such natural standards of measurement of times and spaces, but also lacks a definite *reference system* of motion. Classical mechanics wants to remove this shortcoming by introducing the concept of "inertial system" to provide the required reference system of motion. "Inertial system" means an always *material system*, say a *reference body* that is in an "inertial state" of rest or of uniform straight-lined motion. Theoretical physicists since long have proclaimed it as a dogma that any body in such a state can serve as reference system of the motion of any other body, so that of two bodies in inertial motion either can at will be used as reference system for the calculation of the other body's motion. Consequently, e.g. the motion of the earth could be calculated relatively to the sun and vice versa with the same result. From this point of view one does not (and of course cannot) decide *on principle* whether the sun or the earth *really* moves, and only adopts the Copernican system because of its mathematical simplicity, i.e. on only *pragmatic* grounds, not as "the real and true system of the world" in the sense of Copernicus and Galileo. As a result one could say that classical

mechanics in fact has adopted the well-meant advice Cardinal Roberto Bellarmin gave to Galileo in 1616, namely to teach Copernicanism as only a proper mathematical *hypothesis*, i.e. to refrain from *claiming its reality and truth.* In fact, classical mechanics, insofar as it is based on the dogma of *the equality of all inertial reference frames,* not only teaches (correctly) *the relativity of motion* with respect to a reference frame, but over and above that *also* teaches *the relativity of inertial frames*. Here this theory clearly contradicts Newton's position, but mirrors the *relativistic* (as it is) philosophical view of motion of - well - Aristotle, Descartes, Huygens, Leibniz, d'Alembert, Lagrange, Kant, Mach, and many many other fathers of this mechanics of a philosophical spirit that includes *empiricism and materialism, rationalism and scepticism*, far from referring to reality and truth, and far from rendering the true philosophy of nature of Galileo Galilei and Isaac Newton.

9) The intrinsic *determinism* of the classical law of motion, as a differential equation, ultimately, is well known. Force being conceived here as an *always steadily accelerating* agent, its effects can be precalculated, and thus can seemingly be foreseen on to the most remote future, as they seem to depend on the known initial conditions of a physical state only. Consequently, somebody who knew all the present conditions of state of the world, by applying the said differential equation would be able to precisely forecast every future state. It was Pierre-Simon de Laplace who, in 1814, conceived that superhuman intelligence (which was named the "Laplacean demon" in 1872 by the philosopher Du Bois-Reymond) in order to characterize the determinist spirit of classical mechanics, which does not allow for any unforeseeable free generation of a new state of things and affairs e.g. by something like the "free will" of living beings.

IV From Maxwell's Equations to Einstein's Special Relativity, and to Einstein's $E = mc^2$.

Now, what about Albert Einstein? I have already pointed to the fact that he, in the paper of 1905 the 100th anniversary of which we are celebrating, clearly expressed a relativistic view as to motion and its reference frame, when he initially there says that according to experience physical phenomena such as electric currencies result from the relative motion of conductor and magnet, no matter which of them "really" moves, or is moved. In the next paragraph, however, he outlines his real goal of research, claiming that - as a *consequence* of the just stated experience - *equal laws of electrodynamics and of optics should be valid in all co-*

ordinate systems (i.e. relatively to all reference frames, reference systems, or reference bodies) *that obey the equations of mechanics.* This final remark relates to the condition of uniform-straight-lined motion, or *inertial motion* to characterize all these exchangeable coordinate systems as "inertial systems". In a next step, Einstein, baptizes this condition "equal laws in all inertial systems" by the name of "Prinzip der Relativität" (*principle of relativity*), and explicitly makes it a *first essential* ("zur Voraussetzung erheben") of his ensuing considerations.

Einstein's *principle of relativity* obviously does not refer to the conceptual relativity of motion, nor does it refer to the assumed interchangeability of inertial reference frames of motion, rather it refers to the condition "equal laws in all inertial systems". Here he implicitly expresses the view that *the physical contents of natural laws* should n o t depend on the arbitrary choice of this or that reference frame, which clearly means to believe in an *absolute* contents of these laws. For instance, the falling to ground of a suitcase inside a moving train relatively to the train obeys a certain law of fall; now this very same natural law should n o t be different if the same incident were mathematically described *as seen from an observer at rest outside the train.* Clearly the falling suitcase, relatively to the position of this observer will describe not a vertical line as inside the train, but some *curved line* due to the motion of the train (i.e. of the falling suitcase's "frame of reference") relatively to this observer. This means, then, that the correct mathematical description of the suitcase's falling relatively to the outside observer will have to be the description of the said curved line, i.e. it will have to heed the motion of the train relatively to the observer. Consequently the *formal appearance* of the lawful description of the suitcase's falling to ground, seen from outside the train, *necessarily must differ* from the description of the same incident inside the train, *in order to represent equally* its *absolute* physical contents, according to Einstein's first essential "equal laws in all inertial systems". Says Einstein correctly (p. 903): "Ein starrer Körper, welcher im ruhenden Zustand ausgemessen die Gestalt einer Kugel hat, hat also im bewegten Zustande - vom ruhenden System aus betrachtet - die Gestalt eines Rotationsellipsoides...".

In Einstein's paper of 1905, a *second "absolute" essential* is stated: It is the absolute constancy of the vacuum velocity of light relatively to all inertial systems of reference. It was mainly this essential that led him to $E = mc^2$ - this formula implying a realist, or true interaction law of motion, as we shall see now.

1. Einstein, as is well known, according to the title of his paper "Zur Elektrodynamik bewegter Körper", aimed to describe (in consonance with his essentials) the motion of electrons, based on the Faraday-Maxwell theory of electrodynamics. This theory is characterized through a universal constant of dimensions "space over time" [L/T] which at first was meant to refer to the structure of "ether" as the supposed dielectric medium of electromagnetic phenomena, or of the electromagnetic "field". The law of motion of an electric-charge carrier in this field relatively to it, accordingly should have to contain the information, which the said constant gives of the space-time structure of the field, i.e. of the *frame of reference* of the electric-charge carrier's motion. Actually, John Henry Poynting, already in 1884, developed that law of motion, which - represented in modern symbols - reads

$$E = p \times c \quad [61] \qquad (5)$$

(E = energy, p = momentum, i.e. the scalar equivalent of quantity of motion $m\mathbf{v}$; c = universal constant of dimensions "space over time" [L/T]). This formula became the basis of the theory of *light pressure*, or *radiation pressure,* when the phenomenon of light to interact with matter by exerting pressure on material bodies, and in effect to produce a quantity of momentum p , i.e. material motion ($\boldsymbol{p} = m\mathbf{v}$) in this interaction, was verified experimentally by Lebedew (1890), Nichols and Hull (1901). In this still valid theory it has been undoubted up to this day that the term pc on the right side of eq. (5) of course represents an *equivalent* of the left-side entity symbolized by the letter E. The mathematical meaning of eq. (5) then is to show a proportionality of this entity E with its effect p, connected through the constant of proportionality c. Accordingly, eq. (5) clearly harmonizes with Newton's above-developed second law of motion as represented in eq. (3). Now it is certainly true what e.g. Max Jammer says, in his book on "The Philosophy of Quantum Mechanics" (p.54):

"*The view that a formal identity between mathematical relations betrays the identity of the physical entities involved - a kind of assumption often used in the present-day theory of elementary particles - harmonizes with the spirit of modern physics according to which a physical entity does not do what it does because it is what it is, but is what it is because it does what it does. Since what it 'does' is expressed by the mathematical equations it satisfies, physical entities which satisfy identical formalisms have to be regarded as identical themselves, a result in which the mathematization of physics, started by the Greek (Plato), has reached its logical conclusion*."

The same view could have been expressed much shorter by quoting from Euclid's "Elements" the first Axiom, Book 1: *Whatever is equal to something, is also equal to each other.* If A = B and C = B, then also A = C. If "force" equals the product *pc*, and "energy" equals the product *pc,* then "force" = "energy".

Consequently one should admit that the *E* of eq. (5), since it is proportional to momentum *p in the same sense as* the entity that in eq. (3) is called "vis motrix impressa" is proportional to momentum *p*, *must be identical with that entity,* the motion-generating force. Accordingly this *E* obviously cannot mean the same thing as "kinetic energy" in classical physics, which is proportional not to *p*, but *to the square* of *p*[62].

2. Already in 1864, James Clerk Maxwell had expressed the view that the constant *c* bearing the dimensions of a velocity [L/T] should represent the *velocity of propagation of light itself*. Accordingly, if one would think of propagation of light as of a motion of bodies *m,* the *momentum p* of such a body *m* should be given by the product *mc*. If we now put this momentum *p* in eq. (5), we obtain the well-known valid formula

$$E = mc^2 \tag{6}$$

that refers to the "energy *E"* of light just identified as the "vis impressa" of Newton's equivalent second law. From the just outlined history of this eq. (6) we learn that the *c squared* carries two different meanings of *c: One c* relates to the vacuum velocity of propagation of light, the other one relates to the spacetime structure of the electromagnetic field, i.e. of the *reference frame* relatively to which the momentum *mc* is determined.

3. Einstein's paper "Zur Elektrodynamik bewegter Körper" of 1905 explicitly refers to the theory of radiation pressure in § 8, where the author investigates the problem how to measure the energy of light in reference systems moving relatively to each other. Of course the result correctly shows the energy terms to formally depend on the relative velocity of the systems, as it must be according to Einstein's above-explained principle "equal laws in all co-ordinate systems" - which he misleadingly called the "principle of relativity". In order to determine what he calls "the kinetic energy of an electron", Einstein obtains a formula equivalent to

$$E = mc^2 \times a \tag{6a}$$

with a representing a dimensionless transformation rule that is simply a number at the scale from zero to infinite, depending on the magnitude of the only variable "velocity v of the electron". In case of $v = 0$ this number a becomes also 0, a result which correctly shows that the "kinetic energy" of an electron at rest (relatively to its frame of reference, say in an electromagnetic field) is zero, since the "kinesis" - the *motion* of the electron - is zero[63]. Now it is true that the full-developed theory of Special Relativity ascribes to a body *at rest* some "rest energy" $E_o = m_o c^2$; but this result cannot be found in the said 1905 paper, nor can it consistently be derived from it. In fact Einstein developed it in a second paper of 1905[64]. Here, by *presupposing at will* that a body at rest in a reference frame could nevertheless "have energy E_o " [65] , he determined the measure of this energy by measuring it as H_o relatively to another reference frame moving relatively to the first frame with velocity v, and, by applying his "principle of relativity", i.e. the condition of "equal laws in all co-ordinate systems", he inferred that this measure of H_o should also in a way represent the quantity of E_o.

Now, since this consideration is evidently begging the question with respect to the possibility of "rest energy", it proves an invalid deviation not only from the indissoluble physical linkage of "energy" with "motion", but also from Einstein's preceding paper. Consequently, this deviation (even though it had an enormous impact on the later formulation and understanding of Special Relativity) does not interest here, as the following consideration will show:

Albert Einstein, as is well-known, believed that his famous $E = mc^2$ (which should - according to his principles - represent a *most general* physical law of motion) could be derived without making any reference to the mathematical formalism of Special Relativity, by means of "classical" considerations only. Again in this proof Einstein refers to the theory of radiation pressure that clearly underlies his own theory. Einstein's way of a "classical" derivation of $E = mc^2$ is present e.g. in Max Born's famous book "Die Relativitätstheorie Einsteins", published in three editions 1920, 1921, 1924 (English), and again, in a fourth and fifth German edition, 1964 and 1969. The proof, in short, results (as it must) in the formula

$$Mv = E/c \tag{7}$$

which can be turned to $E = Mvc$, evidently equivalent to our eqs. (3) - Newton - , and (5) - Poynting - , and also evidently showing the indissoluble dependency of E from the variable v to result in $E_{(v=o)} = 0$. The reader of Max Born's book will also see that in the end there, in order to obtain exactly $E = mc^2$ as a seemingly general law of material motion, eq. (7) is *generalized* on *general considerations* that at closer investigation do not affect the true result: which is that the formula, if related to light, reads $E = mc^2$, but if it is related to matter in motion, must read according to eqs. (3), (5), and (7). In fact, these equations represent the most general interaction law of motion, while $E = mc^2$ represents just a special case of it, i.e. the case of propagation of light based on the assumption that in this case the momentum should be given by the term *mc*. Due to the above-indicated far-reaching developments of Einstein's theory since 1905, it is no wonder, however, that the editors of a new, sixth edition of Born's book (2001), in a footnote to Einstein's said derivation as presented by Born, simply, and authoritatively, reject it, without further analysis, as *useless* and *wrong*[66].

Additional remark: It is true that Special Relativity presents the full law in the form $E = m\alpha c^2$ wherein α is the already mentioned dimensionless transformation rule (the *Lorentz-factor*) that governs transformations of the law from one inertial system to another one. Accordingly, our generalized result should then read $E = (mv)\alpha\, c$. It is also true, however, that the law must adopt its most simple form if the observer of this motion *mv,* respectively *mc* in the case of light, is at rest in the frame of reference relatively to which the body *m* (say an electron) moves. And this is guaranteed also with respect to the transformation term α , insofar as the term becomes just " 1 " in this case[67]. Accordingly, the "simplest form" of Einstein's equation, with respect to "light", must of course harmonize fully with Newton's law of true, or "absolute" motion relatively to a reference system at true rest, given through the proportionality of "cause" (*force, energy*) and "effect" (*momentum* $p = mc$) .

V. Some Concluding Remarks on the Philosophy of Einstein's Equation, and on the Philosophy of Contemporary Physics in General .

The scientist philosopher Max Jammer, in his book "Concepts of Mass in Contemporary Physics and Philosophy" of 2000, recently has outlined the still existing "philosophical problem concerning the mass-energy-relation, i.e. "*the question of what, precisely, is the* *conceptual meaning of the equation* $E = mc^2$".[68] We have found that this formula represents a special case of the most basic relation

$$E : p = c = constant \qquad (8)$$

which proportionality of *E* (in Newton's formalism: *F*) and *p* (Newton's term *mv*) reveals a most basic interaction law of nature concerning the relation between some "cause" (*E, F*) and its "effect" as to material motion (*p, mv*). The relation shows a *classical quaternate proportion* if we only remember that the proportionality constant *c* means a quotient of the element of space Δs over the element of time Δt. We obtain

$$E : p = \Delta s : \Delta t \qquad (8a)$$

which result, surprisingly or not, is closely familiar to Werner Heisenberg's *uncertainty principles*, if we only write down the *equation of products* that corresponds to eq. (8a):

$$E \times \Delta t = p \times \Delta s \geq h . \qquad (8b)$$

The philosophy behind must be the same as Newton's philosophy behind his theory of motion, which we have understood as Platonic, and as a *transcendent realism* - transcendent insofar as it teaches the reality of entities such as "force", or "energy", and "uniform straight-lined motion", or "momentum" *mv*, entities that are not subject to our immediate sense experience.

Let me just emphasize the term "realism" in order to characterize the philosophical spirit that, as a red thread, leads from the correctly-understood Galileian-Newtonian theory of motion to modern physics, to Special Relativity, and to Heisenberg's foundation of Quantum Mechanics. This realism implies, contrary to classical Leibnizian-Eulerian mechanics, *local action in space and time* (in contrast to classical un-Newtonian "instantaneous action at a distance"), and *indeterminism.* The *determinism* of classical mechanics is due to the formulation of the law of motion as a differential equation that seems to allow for predicting the future based on present observations[69]. In Newton's true theory as well in Einstein's, according to the basic formula *F,* or *E,* over *mv,* or *p,* = *c* = *constant*, there works no differential equation, but a classical proportion, which allows not for predicting the future, but for the liberty of action, for true *causal generation* of motion in time and space out of *"nothing" material*, according e.g. to the cause "free will of living beings" (Newton)[70].

Modern analytic philosophers have come to identify philosophy itself with its formal medium *language*. Clearly then this philosophy as a reasonable venture must mirror the *rules of logic* of language, and will be *restricted* to these rules. "Reality" in this context does not and cannot mean anything that "really is", *independently* of human reason and understanding according to language, since already the expression that something "is" itself represents but a restricted subjective judgement according to the restricted possibilities of language and reason. As this has always been true, philosophers already knew it long ago. In order to nevertheless maintain the goal of philosophy (which is research for reality and truth), *already Plato laid upon geometry* and its mathematical rules to serve as the proper language of philosophy. Nobody was allowed to enter Plato's academy at Athens who was not already a trained geometer. In modern time, Renaissance philosophers picked up this trail again, against the traditional rationalist-empiricist Aristotelian-Scholastic spirit of the philosophy of the schools, which *nominalist* philosophy was as well an analytic a philosophy of language, as analytical philosophy is today. Galileo, in his book "Il Saggiatore" of 1623, expressed Plato's view of geometry, by saying

"La filosofia è scritto in questo grandissimo libro che continuamente ci sta aperto innanzi a gli occhi (io dico l'universo), ma non si può intendere se prima non s'impara a intender la lingua, e conoscer i caratteri, ne' quali è scritto. Egli è scritto in lingua matematica, e i caratteri son triangoli, cerchi, ed altre figure geometriche, senza i quali mezi è impossibile a intendere umanamente parola; senza questi è un aggirarsi vanamente per un oscuro laberinto." That is:

Philosophy is written in that outstanding book that is always open to our eyes (I mean the universe), but one cannot understand it unless one first has learned to understand its language, and to identify the letters in which it is written. And it is written in mathematical language, and its letters are triangles, circles, and other geometric figures, without which it is impossible to understand one single word, and without which one only errs through an obscure labyrinth.

It is certainly true that "*he that would understand a book written in a strange language must first learn the language"* (Isaac Newton[70a]). Galileo, far beyond only assigning geometry to the "book of nature" as its proper language, here presents it *as the language of philosophy,* the language of *philosophy of nature* as that part of philosophy in general, with which it began in olden times and still begins today, every day when somebody starts thinking. This my essay is to show that Galileo was true, and that natural science, if it follows not the rationalism of talkative philosophy, but Galileo's recommendation *concerning geometry,* might legitimately continue to aim at a really true, i.e. a *philosophic* representation of the true objective reality, and of the real truth, notwithstanding the most sophisticated and most reasonable analytic and semantic objections of the uninitiated. Let me conclude here with Galileo's words, to be found in his "Dialogo" of 1632, and let me render the quote in German by saying (positively even to those philosophers who have criticized Einstein by calling his philosophical views trivial if not erroneous[71]):

Im Streit um Rechtsfragen oder um andere menschliche Dinge, in denen es weder Wahres noch Unwahres gibt, mag einer wohl auf seinen Scharfsinn, seine Schlagfertigkeit und seine größere Belesenheit vertrauen und hoffen, dass der in diesen Dingen Überlegene auch als der Klügere erscheinen und beurteilt werden wird; aber in den Naturwissenschaften, deren Schlüsse wahr und notwendig sind, und wo menschliche Willkür nichts vermag, muss man sich hüten das Falsche zu verteidigen, weil tausend Männer wie Demosthenes und tausend wie Aristoteles nichts ausrichten gegen irgendeinen mittelmäßigen Kopf, der das Glück gehabt hat die Wahrheit zu erkennen.

In my English: *When struggling for questions of law, or other human affairs beyond truth or untruth, one may well trust in one's intelligence, ready wit and wider reading, hoping superiority in these respects might also pass for superior wisdom; but in natural philosophy, the conclusions of which are true and necessary, and where human arbitrariness has no power, one must beware of defending the wrong, because thousand men like Demosthenes, and thousand like Aristotle, can get nowhere against some mediocre head who with good luck has found the truth.*

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Footnotes and references

1) I quote from Hans Steußloff et al.(eds.), "Dialektischer und historischer Materialismus", 16 th ed. Berlin 1989, a standard textbook of the study of Marxism-Leninism, p. 42 f.: "Materie in allen ihren Erscheinungsformen ist sich bewegende Materie. Die Idee der Einheit von Materie und Bewegung hat sich in der Entwicklung der materialistischen Philosophie ..gefestigt.. Engels bezeichnete die Bewegung als *inhärentes Attribut der Materie. Die Bewegung ist die Daseinsweise der Materie."* The book also explicitly argues for the "Selbstbewegung der Materie", i.e. *the principle of self-organisation of matter*. The view of motion as a *property of matter* shares e.g. Immanuel Kant. See "Kritik der reinen Vernunft", 1787, Elementarlehre, II. Teil, I. Abt. II. Buch II. Hauptstück III. Abschnitt , 3. Analogien der Erfahrung, A (Erste Analogie) - Bewegung als "Akzidenz der Materie"; see also Kant's little known "Metaphysische Anfangsgründe der Naturwissenschaft" of 1786, Phoronomie, Erstes Hauptstück, Erklärung 1 und Anmerkung 1 (Materie als "Subjekt" der Bewegung, i.e. matter as *cause* of motion).

2) Isaac Newton, "Philosophiae naturalis principia mathematica", London 1687, the "Principia". In the following I shall generally refer to my German selected edition of 1988 (Isaac Newton, "Mathematische Grundlagen der Naturphilosophie", Felix Meiner Verlag Hamburg) as "Principia 1988". Newton's first and second law of motion reflect the author's view that matter in itself is essentially passive, and is *not* the *subject, or cause* of (generation of) motion (as Kant held), but the *object of forces to act on a body "from outside"* - which means that these forces are *not properties of matter*, but rather *matter-independent non-material natural entities in their own existence.*

3) Newton, in the "Principia", *Scholium* after *Definition 8*, expands his view of *space* (absolute and relative), *time* (absolute and relative), and *motion* (absolute and relative) so that "absolute motion" clearly is understood as *motion relatively to a spacetime frame of reference at true rest* (cf. "Principia" pp. 43-52).

4) Newton, in the "Principia", *Scholium* after *Definition 8* , says that we do not know a body at true rest, so that we cannot determine true rest (and true motion) by observing the relative positions of bodies (p. 47), i.e. by using material bodies as *reference systems.* Consequently, as he aims at the true determination of true motion, he develops *an*

immaterial spacetime frame of reference at true rest, based on the *true reality* of "space" and "time". This very reality, however, was, and has always been denied by philosophers of the Aristotelian-scholastic school of thought, by Descartes, and by Newton's contemporaries Ch. Huygens and G.W. Leibniz as well. After Newton, in particular the philosopher Immanuel Kant spread the view of "space" and "time" as being nothing in themselves. And this is the view of philosophers up to this day, since philosophy never has accepted Newton's realist philosophy of nature. In fact, philosophers know nearly nothing about Newton's *relational* theory of relative and absolute space, and relative and absolute time, and relative and absolute motion. Rather they accuse Newton of having held "space" and "time" to be just *absolutes* - contrary to experience showing them as measurable *variables*. In fact philosophers do not even accept Newton as a philosopher, rather they call him only a *mathematician, and a physicist* who's philosophical views, or "theological pronouncements" (R. Torretti p. 57) as expressed in the said *Scholium*, and especially in the *Scholium generale* (added to the "Principia" in the second edition, 1713), cannot and must not be understood by a modern theoretical physicist. Physicists then, who often (and often with good reasons) shy away from contemporary philosophy, readily accept this judgement of the experts in philosophy, so that in the end *nobody* cares about the true philosophical Newtonian theory of space and time.

5) G.W. Leibniz and all those philosophers who deny the independent reality of time and space must consequently abandon the plan to determine the "true motion" of anything. To believe that one could never definitely decide if a body "really" moves, finally means that Copernicus, Galileo and Newton, when they wanted to discover the true motion of the earth, aimed at something that could never be achieved. Consequently Ernst Cassirer characterized Galileo who wanted to show the real system of the world as sort of a Don Quixote, fighting against windmills. At the same time, Cassirer praises Leibniz for having shown against Newton *the general and indissoluble relativity of motion as the last word of any logical and epistemological analysis.* See G.W. Leibniz, Hauptschriften zur Grundlegung der Philosophie, E. Cassirer ed., Leipzig 1904, part C (introduction to the Leibniz-Clarke-Correspondence of 1715/1716). It may well be, however, that reality and truth is not a matter of logic and epistemology, say of rationalism, but rather one of onto-logic or *realism*, based on the transcendent reality of space and time as principles of mathematics (geometry).

6) C.-F. von Weizsäcker, in his book "Aufbau der Physik" (München 1985), p. 257, asserts: "Man kann dieselben Bewegungen nach Belieben geozentrisch oder heliozentrisch beschrei-
ben". One should see, however, that this is evidently physically wrong, since the "helio-centric" motion $m_E v$ of the earth with mass m_E of course is *not* "the same" as the "geocent-ric" motion $m_S v$ of the sun with mass m_S, even if it may be true that the quantity *v of velocity* is the same in both cases. This my view shares correctly Robert Disalle, "Newton's philosophical analysis of space and time", in: The Cambridge Companion to Newton, I. Bernard Cohen and George E. Smith eds., Cambridge 2002, p. 51.

7) This quote of Goethe (1831, the year before he died)) I took from Erwin Chargaff, "Warnungstafeln", Stuttgart 1982, p. 166. In English it reads: *The greatest truths often if not always contradict our sense experience. The motion of the earth around the sun - what could be more absurd according to all appearances? Nevertheless it is the greatest, most sublime, most momentous discovery man has ever made, in my view much more impor tant than the whole Bible.*

8) The complete quote, from "Principia 1988" p. 52, reads: "Wie man aber die wahren Bewegungen aus ihren Ursachen, ihren Wirkungen und ihren scheinbaren Unterschieden, und umgekehrt, wie man aus den wahren oder scheinbaren Bewegungen deren Ursachen und Wirkungen ermitteln kann, wird im Folgenden ausführlicher gezeigt werden. Denn zu diesem Zweck habe ich die folgende Abhandlung verfasst."

9) Einstein begins his essay stating that in the "Anwendung der Elektrodynamik Maxwells auf bewegte Körper" (i.e. *when applying Maxwell's electrodynamics to the motion of bodies)* the observable phenomena only depend "von der Relativbewegung von Leiter und Magnet" (i.e. *on the relative motion of the conductor and the magnet).* Thus Einstein here considers "motion" only as *change of position of bodies relatively to each other.* This view exactly corresponds with the philosophy of e.g. Immanuel Kant that meant a guide for German scientists of the 19th century, insofar as some of them engaged in philosophy. Cf. Immanuel Kant, "Metaphysische Anfangsgründe ...", Allgemeine Anmerkung zur Phänomenologie: "... dass alle Bewegung oder Ruhe bloß relativ und keine absolut sein könne, d.i. dass Materie bloß im Verhältnis auf Materie, niemals aber in Ansehung des bloßen Raumes, ohne Materie, als bewegt oder ruhig gedacht werden könne, mithin abso-

lute Bewegung, d.i. eine solche, die ohne alle Beziehung einer Materie auf eine andere gedacht wird, schlechthin unmöglich sei...".

10) Cf. Max Born, "Die Relativitätstheorie Einsteins", Kap. VI I "Die allgemeine Relativitätstheorie Einsteins", Abschn. 1 "Relativität bei beliebigen Bewegungen": "... Demnach werden wir fordern, dass die Gesetze der Mechanik und die der Physik überhaupt nur die relativen Lagen und Bewegungen der Körper enthalten. Es darf kein Bezugssystem a priori bevorzugt sein ...". Cf. also A. Einstein, "Relativitätstheorie", in: Reclam Praktisches Wissen, Leipzig 1930, S. 5: "Jede Bewegung kann ihrem Begriffe nach nur als 'relative' Bewegung verstanden werden, d.h. um die Bewegung eines Körpers zu beschreiben, muss ich fragen, in Bezug auf welchen anderen Körper der erste bewegt ist. Fährt z.B. ein Eisenbahnzug auf dem Bahndamm, so kann ich die beobachtete Bewegung auf den Bahndamm als 'Bezugskörper' beziehen: der Wagen bewegt sich dann relativ zum Bahndamm. Ich kann aber auch den Wagen als Bezugskörper benutzen. Dann bewegt sich der Bahndamm relativ zum Wagen." Einstein clearly expresses his belief in the measuring of motion only with relation to other *material bodies of reference* ("Bezugskörper") corresponding to the anti-Newtonian view of Leibniz, Kant, Mach and other relativists.

11) "Die Stücke von Bertolt Brecht in einem Band", Augsburg 1998, p. 513.

12) I quote Szent-Giörgyi according to Max Jammer, "The Philosophy of Quantum Mechanics" (New York etc. 1974), p. 180.

13) See e.g. Albert Einstein, "Mein Weltbild", Berlin 1955, p. 129: "Jedes allgemeine Naturgesetz, das in Bezug auf ein Koordinatensystem K gilt, muss auch unverändert gelten in Bezug auf ein Koordinatensystem K^1, das relativ zu K in gleichförmiger Translationsbewegung ist". Max Born p. 200 says the same in more detail: "*Das Relativitätsprinzip*: Es gibt unendlich viele, relativ gleichförmig und geradlinig bewegte Bezugssysteme (Inertialsysteme), in denen alle Naturgesetze ihre einfachste (ursprünglich für den absoluten Raum oder ruhenden Äther abgeleitete) Gestalt annehmen." This is: *There exist infinitely many inertial systems, relatively to which all natural laws take on their most elementary shape (as it originally was derived with respect to absolute space, or to the ether at rest)."* Since the relative motions with respect to one another are the same whether their common frame of reference is at rest or moves

uniformly (according to Newton, *Corollary IV* to the laws of motion), it is clear then that the natural laws maintain their "most elementary shape" - as it is developed in relation to absolute space, say according to a *cosmocentric* point of view - even in all these inertial systems, i.e. if referred to their respective inertial system, or frame of reference. A *different* shape only results if motion in the reference frame K is observed from *and referred to* a reference frame K^1 in uniform motion relatively to K. Clearly in this case the law of motion will have to take into consideration the relative velocity between K and K^1, as it is done in the transformation term (the *Lorentz factor)* that is used in Einstein's Special Relativity.

14) On "absolute theory" in this context see e.g. Albrecht Fölsing, Albert Einstein, Frankfurt a. M. 1993, p. 237/8, and Victor F. Weisskopf, Probleme der Popularisierung der modernen Physik, Phys. Bl. 46 (1990) p. 76, where the author explicitly makes use of, and favours the term "Absoluttheorie" in order to avoid many "philosophische Dummheiten" (i.e. *philosophic stupiditie*s). Roberto Torretti also shares this view (personal comm.).

15) Abraham Pais, "Subtle is the Lord…", Oxford 1982, p. 14 quotes Einstein: "Newton, forgive me; you found the only way which in your age was just about possible for a man with the highest powers of thought and creativity. The concepts which you created are guiding our thinking in physics even today, although we know that they will have to be replaced by others farther removed from the sphere of immediate experience, if we aim at a profounder understanding of relationships." - If Einstein was wrong with this judgement, then only insofar as what had "to be replaced" was the Eulerian-Lagrangean "classical mechanics", and that by which it had to be replaced was *the authentic Galileian-Newtonian geometric theory of motion* (unknown to Einstein at his time due to general ignorance concerning the authentic sources of this science); and that is shown in this paper.

16) See e.g. Albert Einstein, Mein Weltbild, Carl Seelig ed., Berlin 1955. B. Kanitscheider, p. 171, quotes from Hilary Putnam the term "metaphysischer Realismus" as to characterize Einstein's point of view. In fact this characterization is quite close to my presentation of realism from Galileo to Einstein as "transcendent realism" in this paper. My term "transcendent", of course, has nothing to do with Kant's term "transcendental" that does *not* refer to (Platonic) transcendent reality (as I do), but rather is meant to characterize some *a priori* principles of mechanics and of science in general as *rooted in pure reason*

only; cf. Brigitte Falkenburg, p. 320 for "Einsteins Tendenz zum metaphysischen Realismus", and p. 337 for Kant's view of the "transcendental" origin of "metaphysical principles" of science.

17) Cf. Ernst Mach's criticism of Newton's "absolute space" and "absolute time" as "Begriffsungetüme" (p. X), i.e. *monstrous notions,* and of "absolute motion" as "physikalisch sinnlos", i.e. *physically nonsense* (p. 271).

18) See Colin Maclaurin, An Account of Sir Isaac Newton's Philosophical Discoveries, London 1748, p. 38, where the author from a Newtonian point of view criticises both "the Platonists" as they in the course of time had become "unintelligible mystics", and "the Peripatetics unwearied disputants", thus implicitly referring to Newton's advice "Amicus Plato, amicus Aristoteles, magis amica veritas" that shows his antiauthoritarian distance to both philosophers. On p. 41 Maclaurin writes on mainly Aristotelian philosophy as "a talkative philosophy that served only to produce endless disputes." Maclaurin's criticism in its somewhat polemic tone reminds one of Roger Cotes' quite similar introduction to the second Principia-edition of 1713. Nevertheless Maclaurin as well as Cotes discloses some very interesting aspects concerning *the philosophy of nature* of Newton and the Newtonians.

19) See "Principia" p. 9: "Die Geometrie ist stolz darauf, dass sie mit so wenigen anderswo hergenommenen Grundlagen so vieles leistet ... und sie ist nichts anderes als jener Teil der *Mechanik insgesamt*, welcher die Kunst des genauen Messens behauptet und beweist." The *few principles brought to geometry from without*, as is shown in this paper will be "space" and "time" as the natural pre-existing scaled standards for the measurement of relative "spaces" and "times"; without some knowledge of which no reasonable orientation and behaviour neither of man nor of other living beings in the world around would ever have been possible.

20) See Nicolai de Cusa, De docta ignorantia - Die belehrte Unwissenheit, E. Hoffmann, P. Wilpert, K. Bormann eds., 4r.th ed. Hamburg 1994, p. 7: "Über eine noch nicht gesicherte Erkenntnis urteilt jede Forschung dadurch, dass sie diese hinsichtlich ihres proportionalen Verhältnisses zu einer vorausgesetzten Gewissheit in vergleichenden Bezug bringt. Alles Forschen geschieht also durch Vergleichen." Cusanus here refers to the

power of proportion theory that will serve us even today as a guide to truth.

21) Cf. e.g. Niccolò Guicciardini, p. 9: "According to Newton, most of the *Principia* was written in a style understandable 'for philosophers steeped in geometry' ". Guicciardini, even though he stresses that one must carefully consider e.g. Newton's *proportions*, fails to do so especially in his representation of Newton's second law. Another scientist, Dana Densmore, who already in 1995 published a "guidebook": "Newton's *Principia* -The Central Argument" (3rd ed. Santa Fe, 2003), imputes to Newton (by ignoring his clear words in several respect) a most restricted geometric proportion theory that would never have really served the way as proportion theory does it in Newton's work. Consequently, even though correctly convinced of the throughout *geometric spirit* of Newton's *principles*, Dana Densmore as well as Guicciardini, unfortunately, fails to understand the full power of Newton's advanced geometry, as it is shown in this essay. There was one more Newton scholar who to the end of his life understood that one has to consider Newton's *geometric* methods: It was the late I. Bernard Cohen, who, accompanied by the also late Anne Whitman, in 1999 published a new English translation of the *Principia* together with an extensive introduction, as "A Guide to Newton's *Principia*" (Berkeley etc., 1999). Cohen already in a paper published in 1966 had stressed that "we must be careful lest we bind Newton's thinking in an intellectual strait-jacket that satisfies our own requirements at the expense of understanding his" ("Newton's Second Law and the Concept of Force in the *Principia*", in: "The *Annus Mirabilis* of Sir Isaac Newton 1666-1966", R. Palter ed., Cambridge/Mass., 1967, pp. 143; 149). But he did not follow this advice in his new Principia-edition, especially not when he wants to understand Newton's second law.

22) The first to see that for instance the classical law "force equals mass-acceleration" cannot be found in the "Principia" perhaps was the Dutch historian E.J. Dijksterhuis, in his book "De mechanisering van het wereldbeeld" (Amsterdam 1950; German: "Die Mechanisierung des Weltbildes", Berlin 1956), where he therefore quoted H.C. Andersen's fairy tail of the emperor's new clothes, feeling himself in the role of the child that pointed to the truth that the emperor had nothing on. Recently the French Newton scholar Michel Blay again has touched upon this problem, as he correctly quotes Newton's second law, and then writes: "This law should not be confused with what is now called 'Newton's law' which is … written $F = ma$, or $F = md^2x/dt^2$ " (Michel Blay, "Force, Continuity, and the Mathematization of Motion", in: Isaac Newton's Natural Philosophy, Jed Z. Buchwald and I. B. Cohen

eds., Cambridge/Mass., 2001, p. 226). For the history of the *F = ma* equation see G. Maltese, La Storia di 'F = ma'. Only recently Max Jammer has adopted (hesitantly, though) the correct view that this law stems from Leonhard Euler (see "Concepts of Mass in Contemporary Physics and Philosophy" pp. 5, 12).

23) E.g. the late S. Chandrasekhar in 1995 published "Newton's *Principia* for the Common Reader" (London) in a radically *non-geometric, analytic, a-historical* (Guicciardini p. 7 fn.) *manner,* which I. B. Cohen judged "an essentially nonhistorical work by one of the world's foremost astrophysicists… Readers should be warned that Chandrasekhar disdainfully and cavalierly dismisses the whole corpus of historical Newtonian scholarship…" (see Cohen's "Guide to the *Principia"*, p. 295).

24) Cf. e.g. Roberto Torretti, "The Philosophy of Physics", p. 47 who, even though he seems to feel that the equation *F = ma* does not fit to Newton's second law as a geometric proportion, holds that one could reconcile both concepts "by a good choice of units" (i.e. begging the question!). See also H.-D. Mutschler, "Naturphilosophie", Stuttgart 2002 p. 93. Oddly enough this author stresses correctly the point that *F = ma* does not at all represent Newton's philosophical view of "force" as "cause" of motion as its "effect" (the "Assymetrie eines lebensweltlich verstandenen Kausalitätsverhältnisses", as the author correctly expresses it) - but does not come to the obvious conclusion that this formula *F = ma* might perhaps not truly represent Newton's causal law!

25) Cf. Samuel Clarke, "A Demonstration of the Being and Attributes of God: More Particularly in Answer to Mr. Hobbs, Spinoza, and their Followers. Wherein the Notion of Liberty is Stated …", London 1705. For this "notion of liberty" Clare here refers explicitly to Newton's philosophy of nature.

26) What I call "transcendent realism" is indeed very close to that "metaphysical realism" e.g. Bernulf Kanitscheider finds in Einstein's (later) philosophical statement; I have already pointed to this correspondence in footnote 16. Once more I want to stress, however, that "transcendent" (not to confuse with "transcendental") for me means "to be out of the reach of immediate sense experience, but nevertheless real". It refers to that reality that, according to Plato's *cave parable,* lies outside the cave, and of which man inside, as he is in chains, his eyes fixed to the wall opposite to the cave's entrance, is

only aware through its shadows thrown by the outside light of the sun against that wall. The parable makes clear that the invisible things outside the cave represent the true and full reality, whilst their shadows man perceives by immediate sense experience are - but shadows. Nevertheless they are shadows *of true reality,* and in a way they participate in the reality of their origins through "methexis".

27) It is often ignored when the Roman Church's judgement of Galileo's is reported that it was at least part of the reasons that Galileo had failed to prove his assertion. See for this e.g. Walter Brandmüller, Galilei und die Kirche, Aachen 1994, p. 121: "Der ausschlaggebende Punkt (für die Verurteilung, ED) war indes, (dass) Galilei vorgeworfen wurde, das heliozentrische System als zwingend dargestellt zu haben".

28) Already Galileo's subject "De motu locali", as it refers to *local motion*, thus asserting the real existence of *loci,* i.e. *places in space,* and consequently of space itself, indicates that he is going to show the motion of bodies not with respect to other bodies, but in relation to a spacetime frame of reference. This fact has been not only ignored, but much more obscured by e.g. the German translator of Galileo's "Discorsi" who (*traduttore traditore)* rendered Galileo's term "motus localis" most freely into "Fallgesetze". I here refer to the only available poor German edition of the "Discorsi": "Galileo Galilei, Unterredungen und mathematische Demonstrationen über zwei neue Wissenszweige, die Mechanik und die Fallgesetze betreffend", A. von Oettingen ed., Darmstadt 1973. In fact Galileo's work first and foremost is one *on uniform straight-lined motion* (Galileo: "motus aequabilis"); the "Fallgesetz" (*law of free fall*) he finds *as a consequence* of this mostly ignored foundation of his theory.

29) Platon, Timaios, in: Platons Dialoge, transl. and ed. Otto Apelt, Hamburg 1988, Vol VI p. 49: "Körperlich also, sichtbar und fühlbar muss das Gewordene sein. Ohne Feuer aber kann niemals etwas sichtbar werden, und fühlbar nicht ohne etwas Festes. Daher bildete Gott, als er anfing den Weltkörper zusammenzufügen, ihn aus Feuer und Erde. Zwei Dinge aber lassen sich für sich allein nicht haltbar zusammenfügen; es gehört notwendig dazu ein drittes, ein vermittelndes Band nämlich, welches die Vereinigung beider erst zustande bringen kann. Das schönste aller Bänder aber ist dasjenige, welches die engste Vereinheitlichung des Bandes selbst mit den verbundenen Gegenständen darstellt. Dies aber am besten zu bewirken vermag ihrem Wesen nach die Proportion... So stellte denn Gott

Wasser und Luft in die Mitte zwischen Feuer und Erde und stellte unter ihnen die Proportion in möglichster Genauigkeit her, so dass, wie sich Feuer zu Luft, so Luft zu Wasser, und wie Luft zu Wasser, so Wasser zu Erde verhält.... Und eben deshalb ward der Körper der Welt aus diesen so gearteten und quantitativ eine Vierzahl bildenden Elementen nach Maßgabe einer Proportion in sich zusammenstimmend erschaffen....". Plato here explains the *quaternary proportion of fire and earth, water and air* as the constructional feature of the universe.

30) This lattice is present in Galileo's figure 10 to the chapter "Giornata terza - de motu locali" of his "Discorsi" (not numbered originally). I have emphasized this fact as early as 1985 (cf. Ed Dellian, Die Newtonische Konstante, fn. 14).

31) It is certainly one of the most enlightening and far-reaching aspects of the *geometric* foundation of Galileo's and Newton's theory of motion to show *the most elementary quantization of physical quantities such as spaces, times, velocities, and motions.* I have emphasized this fact as early as 1988 (cf. Isaac Newton, Mathematische Grundlagen der Naturphilosophie, Ed Dellian ed., pp. XXVII, 235). See also Ed Dellian, "Newton on Mass and Force", Physics Essays Vol. 16 Nr. 2 (June 2003).

32) Galileo died on Jan. 8 in 1642, Newton was born on Dec. 25, 1642 (Julian chron.).

33) Cf. Isaac Newton, Mathematische Grundlagen der Naturphilosophie, p. 64 (*Scholium* after *Corollary VI*): "Mit Hilfe der beiden ersten Gesetze und der beiden ersten Corollarien fand Galilei heraus, dass der Fall schwerer Körper nach dem Quadrat der Zeit geschieht und dass die Bewegung von Geschossen in einer Parabel abläuft, in Übereinstimmung mit der Erfahrung, sofern nicht jene Bewegungen durch den Widerstand der Luft etwas verzögert werden." Galileo, in the introduction to the "Giornata terza - de motu locali - of the "Discorsi", claims priority for the finding of the spacetime proportion that governs the law of free fall, and also for the finding of the parabolic path of projectiles. As Newton explicitly refers to both findings, this whole paragraph clearly indicates that Newton knew the "Discorsi" of 1638. Some historians nevertheless doubt this Newton's knowledge because it seems that the "Discorsi" were not among the books he left.

34) The most prominent source of this view of "force" as "property of matter" for me is

Immanuel Kant, "Metaphysische Anfangsgründe der Naturwissenschaft", Dynamik, Erklärung 2: "*Anziehungskraft* ist diejenige bewegende Kraft, wodurch eine Materie die Ursache der Annäherung anderer zu ihr sein kann. *Zurückstoßungskraft* ist diejenige, wodurch eine Materie Ursache sein kann, andere von sich zu entfernen. Die letztere werden wir auch zuweilen *treibende*, so wie die erstere *ziehende* Kraft nennen. *Zusatz*: Es lassen sich nur diese zwei bewegenden Kräfte der Materie denken...Also können nur diese zwei Arten von Kräften, als solche, worauf alle Bewegungskräfte in der materiellen Natur zurückgeführt werden müssen, gedacht werden." Kant clearly displays here a philosophical view that is *materialistic* insofar as it incorporates the concept of "force" into his "Materietheorie" (*theory of matter*) as *property of matter* (and consequently "matter" as the general and only "cause of motion"), since this theory does not allow for any non-material entities. At the same time, he shows a *rationalist* belief in "reasoning" to be the ultimate source of existence, insofar as he substantiates his view saying that "forces" cannot be "thought of" otherwise than thus (much in the way of Descartes' idea of creating existence through reason: "Cogito ergo sum").

35) See Ed Dellian, Neues über die Erkenntnistheorie Isaac Newtons, Zeitschr. f. philos. Forschung 1992 Nr. 1 p. 89.

36) Brigitte Falkenburg correctly reports this fact, in "Kants Kosmologie" pp. 43, 65, 80. A hint to my prior publication just mentioned above (fn. 35) would have been fit there.

37) Cf. footnotes 21, 22, 24. I want to add here a reference to Jürgen Mittelstraß, "Neuzeit und Aufklärung" (Berlin 1970), p. 288, who also wants to eliminate the constant of proportionality between Newton's quantities of "vis motrix impressa" and "quantitas motus" making it "1" (dimensionless!) by means of "Wahl geeigneter Maßeinheiten" (i.e. by *a proper choice of units)* - ignoring the fact that this method at will presupposes to put the said entities *equal in dimensions,* and thus to understand them *not as proportional*, but *equal* (contrary to Newton, and evidently in a circular way of reasoning).

38) Universal constants in theoretical physics work generally as *proportionality constants.* However, this is not the way theoretical physicists look at their formula, since this view requires a *geometric* perspective mathematical physics has abandoned long ago in favour of the arithmetic-algebraic *analysis,* and of the *continuum theory of number.* It was indeed

a part of the philosophy of the Enlightenment to abandon the geometric view of nature, and to adopt arithmetic tools instead: "Das Ideal der Naturerkenntnis wird nicht mehr nach dem Muster der Geometrie, sondern nach dem der Arithmetik bestimmt... Die Lehre von den Zahlen stellt nach Condillac das klarste und einfachste Beispiel für die Lehre von den Beziehungen überhaupt, für die allgemeine Logik der Relationen, dar" (Ernst Cassirer, Die Philosophie der Aufklärung, p. 70/1). See also Max Horkheimer/Theodor Adorno, "Dialektik der Aufklärung" (Frankfurt a.M. 1997), p. 13: "Die formale Logik war die große Schule der Vereinheitlichung. Sie bot den Aufklärern das Schema der Berechenbarkeit der Welt....Die Zahl wurde zum Kanon der Aufklärung. Dieselben Gleichungen beherrschen die bürgerliche Gerechtigkeit und den Warenaustausch... Die bürgerliche Gesellschaft ist beherrscht vom Äquivalent. Sie macht Ungleichnamiges komparabel, indem sie es auf abstrakte Größen reduziert. Der Aufklärung wird zum Schein, was in Zahlen, zuletzt in der Eins, nicht aufgeht. Der moderne Positivismus verweist es in die Dichtung. Einheit bleibt die Losung von Parmenides bis auf Russell. Beharrt wird auf der Zerstörung von Göttern und Qualitäten." I judge the reduction of Newton's (necessarily *quaternate* proportion of "cause", or "force", and "effect", or "motion", to a *binomial equation* of "force" and "mass-acceleration" (according to *Leibniz's* principle "causa a e q u a t effectum"!) by eliminating its roots in "space" and "time" (i.e. the constant of proportionality) a most prominent instance of the arbitrary dismissal of the realist "spacetime" world-view of 17th century philosophers that happened during the French Enlightenment.

Philosophers who understood philosophy as only rationalism and semantics, and reason as the only source of phenomenal things, alleging that *only the reasonable is real* (Hegel), bereft man of the most basic roots of reality that had been "real, or absolute, space" and "real, or absolute time" so long as *geometry* had been the language of philosophy of nature. Once that scientists abandoned this language, they lost the understanding of the geometrically composed "book of nature".

39) This matter concerns the principle of *generation* of uniform straight-lined motion in space and time. Newton here shows that this generation (which he understands as happening really in space and time, contrary to the *instantaneous* appearance of states of motion in classical mechanics) at the very beginning of motion, but at this moment o n l y ("ipso motus initio"), exhibits and requires *special relations* between quantities of relative space and relative time just coming into being, and the causal *force* to produce this effect, and

the *elements of the absolute standards of space and time* relatively to which the just generated quantities are measured. These "special relations" imply an *accelerative term* "space over time squared" - that serves as a proportional (not *equal*!) measure of the generating force *at this very first moment of motion*. I have tried to illustrate this process in a figure to my paper "Inertia, the Innate Force of Matter", p. 232. Indeed such a process is wholly unknown to classical as well as to modern physics up to today, even though it is a most necessary and indispensable part of a realist theory of motion.

40) I. Bernard Cohen and Anne Whitman (eds.), "Isaac Newton - The *Principia*…", Berkeley etc. 1999, p. 92. The phrase reads: "In the centuries following the publication of the *Principia*, the fundamental units of classical dynamics have been mass, length, and time, associated with dimensional analysis (based on M, L, T) . In the *Principia*, however, Newton is generally not concerned with units or with dimensionality….In fact … the *Principia* sets forth a dimensionless physics …". The author of this phrase must never have tried to read, much less to understand e.g. Newton's "Method of first and last ratios" (Book I Sectio I) where he (in the *Lemma X* and its *Corollaries*) could have found the units of Newton's theory to be of course length, and time (not to mention "mass" as a quantity that is present in Newton's first definition), and their relation to each other even to allow for determining the dimensions of "force".

41) See Ed Dellian, "Die Newtonische Konstante", Philos. Nat. 22 Nr. 3 (1985) p. 400.

42) See e.g. Ed Dellian, "Newton on Mass and Force", Physics Essays Vol. 16 Nr. 2 (2003).

43) It is a view that has often been expressed to say that Newton makes us of a reference frame of absolute space and absolute time. So says for instance the German Newton scholar Ivo Schneider, in "die großen Physiker" (Karl von Meyenn ed., München 1997): Newton "betrachtet Körperbewegungen zunächst absolut, bezogen auf das körperunabhängige, stabile Bezugssystem des absoluten Raumes und der absoluten Zeit." The critical point, however, concerns *the absence of this frame of reference* in the classical interpretation of Newton's theory, especially of the second law, due to the elimination of the proportionality constant of dimensions [L/T]. This absence then allowed e.g. Ernst Mach, who believed in the $F = ma$ interpretation of the second law, to assert that Newton *had not made* any use of "absolute space" and "absolute time" as a reference system. Says

Mach, in the preface to the 1912 edition of his "Mechanik": "Bezüglich der Begriffsungetüme des absoluten Raumes und der absoluten Zeit konnte ich nichts zurücknehmen. Ich habe hier nur deutlicher als vorher gezeigt, dass Newton zwar manches über diese Dinge geredet, aber durchaus keine ernste Anwendung von denselben gemacht hat." Of course, to believe this, say to believe that Newton had not made use of a frame of measurement and reference, entails a *conventionalist* view as to measurement, contrary to Newton's explicit glorification of *geometry* to provide this very tool of mechanics (see his preface of 1686 to the "Principia"). - It should be noted here, by the way, that even the very ancient Zenon paradoxies end in smoke if one only refers the motion of Achilles not to the tortoise as "body of reference", but the motion of both Achilles and the tortoise to a common spacetime frame of reference at true rest.

44) See e.g. "Samuel Clarke, Der Briefwechsel mit G.W. Leibniz von 1715/1716", Ed Dellian ed., Einführung pp. XL-XLVI.

45) Cf. e.g. Carolyn Merchant, "Der Tod der Natur", München 1987, p. 272/3, where she ascribes "mechanicism" and the "clockwork-universe" to Newton!

46) This principle is present also in Newton's "Principia", *Scholium generale"*, where Newton at the end writes: "Es mag jetzt gestattet sein, hier noch einiges über ein gewisses äußerst feines immaterielles Prinzip [spiritus] hinzuzufügen, das dichte Körper durchzieht und in ihnen verborgen ist; durch dessen Kraft und Einwirkung ziehen Teilchen der Körper sich auf kleinste Entfernung wechselseitig an und hängen zusammen, nachdem sie in Berührung gebracht sind; durch das elektrische Körper auf größere Entfernungen hin wirken, dadurch dass sie benachbarte Korpuskeln ebenso abstoßen wie anziehen; durch das das Licht ausgesandt, reflektiert, gebrochen, gebeugt wird und das Körper erwärmt; durch das jede Empfindung erregt wird; durch das die Glieder der Lebewesen nach Willen bewegt werden, nämlich durch die Schwingungen dieses immateriellen Prinzips, die sich durch die festen Fasern der Nerven von den äußeren Sinnesorganen zum Gehirn und vom Gehirn in die Muskeln fortgepflanzt haben. Aber diese Dinge können nicht mit wenigen Worten dargelegt werden, und es steht noch keine ausreichende Anzahl von Experimenten zur Verfügung, durch welche die Gesetze der Einwirkungen dieses immateriellen Prinzips genau bestimmt und aufgezeigt werden müssen." There can be no doubt that Newton here *reports the reality of some immaterial agent.* If hard science does not

know anything about that something up to today, this may well be due to its dogmatic limitation to *material phenomena only* (mirroring the rationalist and at the same time materialist philosophy of science taught by Immanuel Kant's "Materielehre" (*matter theory*) in his "Metaphysische Anfangsgründe der Naturwissenschaft". See also Carolyn Merchant, p. 273, where she quotes from an unpublished paper of Newton: "Materie ist ein passives Prinzip und kann sich nicht von selbst bewegen... Sie empfängt Bewegung proportional zu der Kraft, die auf sie wirkt...Wir finden in uns selbst die Macht, den Körper durch den Willen zu bewegen. Leben und Wille sind aktive Prinzipien, durch die wir den Körper bewegen...."

47) In the omnibus volume "Die Großen Physiker" (Karl von Meyenn ed.), München 1997 Vol. I, H.-H. von Borzeszkowski and Renate Wahsner correctly introduce to the chapter on Leonhard Euler and Joseph-Louis Lagrange: "Die heutige analytische Fassung der Physik beruht wesentlich auf den ineinandergreifenden Arbeiten von Leonhard Euler und Joseph Louis Lagrange, die damit nicht nur die Entwicklungen, die zur modernen Mathematik führten, eingeleitet, sondern auch die theoretische Gestaltung der Naturwissenschaft maßgeblich bestimmt haben." And on Euler's work of 1736: "Im Jahre 1736 vollendete Euler ein für die theoretische Physik bedeutendes Werk, die *Mechanica sive motus scientia analytice exposita …*, in dem er die Newtonsche Dynamik des Massenpunktes in die Leibnizsche Schreibweise der Differential- und Integralrechnung transformierte." This is all true except the *explicit* misuse of the terms "Dynamik" and "Massenpunkt" for Newton's theory (*dynamics* is an authentic term of G.W. Leibniz to characterize his own theory of motion of 1695; "Massenpunkt" - referring to *point mechanics* - is exactly what Euler introduced into the theory of motion in 1736 (so says it George E. Smith, "The Methodology of the *Principia*", in "The Cambridge Companion to Newton", I. Bernard Cohen and George E. Smith eds., Cambridge 2002, p. 171), but can never be found in Newton's work; consequently Newton would never have used these terms, and for good reasons). Untrue is also the *implicit* allegation as if Euler had transformed Newton's (geometric) theory into the language of the analysis *without altering it.* For this one must only think of Euler's unquestioned (and unquestionable) justified claim for having *first invented* and introduced the principle "force equals mass-acceleration" as the basis of analytical mechanics.

48) Paolo Casini, "Newton's *Principia* and the Philosophers of the Enlightenment", in:

"Newton's *Principia* and its Legacy", D.G. King-Hele and A. Rupert Hall eds., London 1988, p. 48: "Hume did not invent the positivistic interpretation of the *Principia*, but he probably contributed more than anyone else to the philosophical justification of this view-point."

49) See "G.W. Leibniz, Specimen Dynamicum", H.G. Dosch, G.W. Most, e. Rudolph eds., Hamburg 1982.

50) Jean le Rond d'Alembert composed his treatise "Traité de Dynamique" (Paris 1743) not by chance as an important contribution to the new science of "dynamics" as it had been baptized by Leibniz in 1695. In fact the "Leibnizians" of the 18th century all adhered to Leibniz's *Dynamica* as first presented in 1695, in the "Specimen Dynamicum". D'Alembert for a while around the year 1747 meant Newton disproved in an important respect, and intended to give him (i.e. his science) "le coup de pied de l'âne" - if it is true what is reported by Ilya Prigogine and Isabelle Stengers, in "Dialog mit der Natur", München 1986, p. 72. - At this place it might be convenient to explain the main difference between Leibnizian "dynamis" and Newtonian philosophy of nature as to their contents: "Dynamis" refers to phenomena that can be observed at least on principle, and bans all unobservable and thus "metaphysical" (said in a contemptuous manner) things from science. The Galileian-Newtonian philosophy of nature on the contrary aims at disco-vering the real "transcendent" invisible truth behind the phenomena to be observed by our weak sense experience. Now one may understand why it is a misuse of the term "dynamics" if one uses it as a name of Newton's theory of motion, as it today, unfor-tunately, is mostly done.

51) Cf. I. Bernard Cohen, "Principia", p. 112: "That an impulse is the primary sense of force in the second law (as stated) is also made clear in the first application of the law in the succeeding corol. 1… (p. 113) The primacy of impulsive forces appears notably in the introduction to sec. 11 (book 1) …".

52) It is certainly a main error of many who have written on Newton's theory of motion to believe that his "central argument" (as Dana Densmore has put it in the title of her book "Newton's *Principia* - The Central Argument", 3rd ed. Santa Fe, 2003; cf. p. 9) must have been the discovery of *centripetal force*, and accordingly the law of gravitation.

This law may well have been a central goal of his "Principia"; but the "central argument" according to Newton's own words was to show the conditions of the possibility of truth concerning the identification and determination of *real, or true, or absolute motion.* To this subject belong Newton's various statements on "impressed (motive) force" (which meant a technical term at that time) defined in "Principia" *definition 4* to be the only real cause of motion, as it comes to light in the first two *laws of motion.* In the explanation to *definition 4* Newton consequently says that centripetal force is but a *source of* impressed forces. Dana Densmore, erroneously, believes in "centripetal force to be an example of impressed force" (p. 13). Consequently she, as many others have also done it, interprets e.g. the second law in order to find the measure of acceleration here, that is as if Newton had stated the "force" of the second law to generate motion "in a given time" (p. 30) - which is not a true rendering of Newton's words. Actually, the "time derivative expression" of a law of force is present in Newton's *definitions 7* and *8* - which, however, clearly refer to *centripetal force*, not to *impressed force.*

53) This can be seen in the figure Newton adds to *section 2, proposition 1 theorem 1* in the "Principia", *book 1.* The figure shows how the repeated actions of "centripetal force" impress "vis motrix impressa" on a body to make it *repeatedly change* the direction of its *always straight-lined* motion, in order to take on a path that "in the limit" ultimately may well be a curved line, e.g. a circle around a centre. Newton's intention, however, here is not to show that "centripetal force" generates curvilinear motion, but rather that, and how, the real impressed forces that step by step *are induced by* centripetal force, perform curvilinear paths of moving bodies *in the limit*. A recent example to show how all this can be confused if one ignores the *priority of impressed force* here gives Herman Erlichson, "Passage to the Limit in Proposition I, Book I of Newton's *Principia",* Historia Mathematica, 2003 Nr. 4, pp. 432-440. Erlichson even wants the reader to believe that Newton had introduced here "instantaneous impulsive forces to produce finite momentum changes in vanishingly small time intervals". Consequently he demonstrates how the "modern form" (as he calls it) of Newton's Second Law $\boldsymbol{F} = m(d\boldsymbol{v}/dt)$ with $\boldsymbol{F}$ allegedly representing "the centripetal force", should coincide with a calculation of repeated impulses "to the limit", ignoring (not only) the fact that Newton would never have accepted the here implied concept of *instantaneous generation of motion*.

54) Cf. footnote 51.

55) The late Newton scholar Betty J.T. Dobbs, in her book "The Foundations of Newton's Alchemy", Cambridge 1975, has stressed correctly Newton's concept of "matter-spirit-interaction" as a central part of his mechanics (pp. 57, 100, 184, 193), stating that, against the "dead mechanism" of Descartes, "the universe lived again" with Newton's discovery of (immaterial) *active principles* such as "force" (pp. XII, 193, 196, 198, 204, 210-212).

56) Newton's *Scholium* after *Lemma X* gives an impressive account of his manner to make use of geometric proportion theory. It shows very clearly that Newton, as he writes "Si quantitates indeterminatae *diversorum generum* conferantur inter se…" (my italics) that is: *If indetermined quantities* of different kinds *are compared with each other,*
(1) applies this method to the relations that quantities *different in kind*, i.e. in dimensions, such a A and B, obey to each other, i.e. A/B, which relation results in C; and
(2) implicitly refers to Cusanus' device "to measure is to compare".
The *Scholium* thus shows that Newton very certainly "boldly" (I.B. Cohen) makes use of "mixed proportions" A **:** B (so says also I.B. Cohen, p. 312), contrary to the view of some scholars who want him to use a most restricted scholastic version of proportion theory which only allowed for proportions such as $A_1 : A_2 = B_1 : B_2$, but not $A_1 : B_1 = A_2 : B_2$ due to some *homogeneity principle* that allowed only for comparing quantities of a *same kind.* For this cf. Guicciardini, p. 125 f., and especially Dana Densmore p. XLIV.
Newton, however, in this *Scholium*, gives an information to the contrary, as he explicitly presents the relation A **:** BC/D to result in a "ratione data", i.e. a *constant quotient* - the factor of proportionality.

57) Leibniz introduces his principle in a phrase which I quote here from Cassirer, "Leibniz' System", p. 310/11: "Au lieu du Principe Cartésien on pourrait établir une autre loi de la nature que je tiens la plus universelle et la plus inviolable, savoir *qu'il y a toujours une parfaite équation entre la cause pleine et l'effet entier.* Elle ne dit pas seulement que les effets sont proportionnels aux causes; mais de plus que chaque effet entier est équivalent à sa cause. Et quoique cet axiome soit tout à fait métaphysique il ne laisse pas d'être des plus utiles qu'on puisse employer en physique, et il donne moyen de réduire les forces à un calcul de géométrie." With respect to "calcul de géométrie" Cassirer refers to another enlightening phrase of Leibniz to read: "Ostendo quodam ut ita dicam

Algebrae Mechanicae genere aequationem latentem inter causam et effectum, nulla arte violabilem." Leibniz' "calcul (! ED) de géométrie" then means *geometry reduced to algebraic arithmetic analysis* as first intended by Descartes.

58) This intention of the new "dynamics" comes to light e.g. in d'Alembert's preface to his "Traité de Dynamique" of 1743. He writes on the question of "cause" and "effect", as I quote from the edition Paris 1758, p. XI, XII: "Nous verrons bientôt comment on peut déterminer les effets de l'impulsion, & des causes qui peuvent s'y rapporter: pour nous en tenir à celles da la seconde espèce, il est clair que lorsq'il est question des effets produits par de telles causes, ces effets doivent toujours être donnés indépendamment de la connaissance de la cause, puisqu'ils ne peuvent en être déduits: c'est ainsi que sans connaître la cause de la pesanteur, nous apprenons par l'expérience que les espaces décrits par un Corps qui tombe, sont entr'eux comme les quarrés des tems….Pourquoi donc aurions-nous recours à ce principe dont tout le monde fait usage aujourd'hui, que la force accéleratrice ou retardatrice est proportionelle à l'élément de la vitesse? Principe appuyé sur cet unique axiome vague & obscur, que l'effet est proportionel à sa cause. Nous n'examinerons point si ce principe est de vérité nécessaire; nous avouerons seulement que les preuves qu'on en a apportées jusqu'ici, ne nous paroissent pas hors d'atteinte: nous ne l'adopterons pas non plus, avec quelques Géomètres, comme de vérité purement contingente, ce qui ruineroit la certitude de la Méchanique, & la réduiroit à n'être plus q'une Science 'expérimentale: nous nous contenterons d'observer, que vrai ou douteux, clair ou obscur, il est inutile à la Méchanique, & que par conséquent il doit en être banni."
Now we can see clearly that the Newtonian principle of proportionality of cause and effect never was defeated, but rather was *banned* from analytical mechanics due to dogmatic empiricist convictions. Of course rationalists also have always shared these convictions, as one can see it e.g. in Bertrand Russell's enlightening essay "On the Notion of Cause", in "Mysticism and Logic", New York 1917.

59) Contrary to the general belief of those who rely on their textbooks Newton *never* taught something like "instantaneous action at a distance". Max Jammer, "Concepts of Force", Cambridge/Mass., 1957, p. 123 was probably the first to show that Newton already had conceived sort of a gravitational field, to produce *local* actions on bodies. The same view holds Howard Stein, "Newton's Metaphysics", in "The Cambridge Companion to Newton", I. Bernard Cohen and George E. Smith eds., Cambridge 2002, p. 286/7. For

this it should suffice to quote from Newton's letter to Dr. Bentley, Feb. 25, 1692/3: "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 do, if gravitation, in the sense of *Epicurus*, be essential and inherent to 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 any thing 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." Most notably, James Clerk Maxwell referred to this phrase in order to show that his principle of local action in the electromagnetic field agreed very well with Newton's theory of motion; cf. James Clerk Maxwell, Scientific Papers, Vol. II, Cambridge 1890, p. 315-319.

60) Of course e.g. Ernst Mach reflected this rationalist spirit of mechanics when he refuted the term "causal" in favour of "functional", as it is reported in a review of his philosophy in Brockhaus Enzyklopädie, 1970: "Sinnesphysiologische und physikgeschichtliche Studien führten ihn, der von Kant ausgegangen war, zu D. Humes verwandten Anschauungen. Er verwarf Atomistik und Kausalität zugunsten einer rein funktionalen Anschauung." This remark is correct and elucidating, as it mirrors the rationalist recoining of "cause" to "reason" and "effect" to "consequence", and to the *functionalist* (and instantaneous!) relation between the latter, as it happened according to the philosophy of Leibniz (the principle of *sufficient reason* to replace *natural causation)* in the philosophy of Kant and his school. Cf. Leibniz, d'Alembert, and Russell as quoted in footnotes 57 and 58.

61) See J.H. Poynting, "On the Transfer of Energy in the Electromagnetic Field", Philos. Trans., 1885, Vol. 175 part II, p. 343-361, esp. eq. (5) on p. 359 which is equivalent to $E/p = c$ (Poynting's "*v*" means the constant *c*, and his *"mH*" means *momentum* $p = mv$, as can be seen on p. 344). Cf. Max Born, "Die Relativitätstheorie Einsteins", p. 244: "Dass eine Lichtwelle, die auf einen absorbierenden Körper auftrifft, auf diesen einen Druck ausübt, folgt aus den Maxwellschen Feldgleichungen mit Hilfe eines von *Poynting* (1884) zuerst abgeleiteten Satzes; und zwar ergibt sich, dass der Impuls, der von einem kurzen Lichtblitz oder Lichtstoß von der Energie *E* auf die absorbierende Fläche ausgeübt wird, gleich E/c ist."

62) In the formula $E = p^2/2m$ which is used in wave mechanics, the proportionality of energy E not "linearly" to p, but rather to the square of p comes best to light. Inevitably serious mathematical and conceptual problems will arise of one wants to treat both energy terms as *equivalents*. It seems that some still existing problems of the foundation of quantum mechanics arise from this wrong choice: Werner Heisenberg e.g. put his formalism on the "linear" energy concept $E = c \times p$ (see "Physikalische Prinzipien der Quantentheorie", Stuttgart 1958, p. 93), while Schrödinger's wave mechanics rests entirely on the "squared" term $E = p^2/2m$ (cf. e.g. John von Neumann, "Mathematische Grundlagen der Quantenmechanik", Berlin etc. 1996, pp. 5-18). Erwin Schrödinger must have felt this discrepancy when he, in a letter of 31 May, 1926, wrote to Max Planck: *I do not believe that the (macroscopic concept of kinetic) energy can be taken over into micro-mechanics just like that … the energy property of the individual particle oscillation is its frequency.* "Frequency", however, as a part of wave mechanics that represents "momentum", is proportional to "energy" here, and is not in a squared relation to E. Says Schrödinger: "Dem Quantentheoretiker sagt 'sein Gefühl', dass die Energie der Frequenz selbst und nicht ihrem Quadrat proportional sein muss" ("Quantisierung als Eigenwertproblem", Ann. d. Phys. IV. Folge 1926 p. 373). A seemingly sophisticated method to unite the different energy terms one finds in H. Haken/H.C. Wolf, "Atom- und Quantenphysik", Berlin etc. 1983 p. 117 (in "9.2 Die Schrödinger-Gleichung"). At closer inspection, however, it comes to solve the problem enlarging an equation by multiplying its both sides with different terms. Cf. with respect to the whole problem Ed Dellian, "Does Quantum Mechanics Imply the Concept of Impetus?", Physics Essays 1990, Vol. 3 Nr. 4 (p. 365).

63) Einstein's transformation rule in this paper, p. 920, reads in modern terms $a =$ $= (1/\sqrt{1 - v^2/c^2}) - 1$. Clearly with $v = 0$, $E = mc^2 \times a$ results in $E = mc^2 \times 0$, that is $E_{vo} = 0$.

64) Albert Einstein, "Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig?", Ann d. Phys. 18 (1905), p. 639-41.

65) Ibid. P. 640: "Es befinde sich nun im System (x, y, z) ein ruhender Körper, dessen Energie - auf das System (x, y, z) bezogen - E_o *sei*." Evidently Einstein here presents a hypo-

thesis at will in absolute contradiction to the contents of the concept of "kinetic energy" to which he refers. It is still true today that "ein ruhender Körper", i.e. *a body at rest,* does not, with respect to the reference system wherein it is at rest, represent any other quantity of *kinetic energy* than "zero".

66) See Max Born, "Die Relativitätstheorie Einsteins", 6th ed., Jürgen Ehlers and Markus Pössel eds., Berlin etc., 2001, p. 454 Nr. 18. I cannot help pointing to the fact that these distinguished editors reveal their limited skill on p. 447 ibid. where they attribute the dimension of "time" to the *measuring unit* "light year" (*l.y.*), ignoring that this unit according to its general definition represents *not time*, but *distance,* or "length" of course. And they do *definitely* so, i.e. not by misprint or any other excusable error, as they draw far-reaching wrong conclusions from their wrong idea.

67) The transformation term $a = 1/\sqrt{1 - v^2/c^2}$, different from that of the paper "Zur Elektrodynamik bewegter Körper" by a lacking "minus 1" (cf. footnote 63), now becomes no longer "zero", but "1", if $v = 0$. Accordingly, the meaning of velocity v, which was "velocity of motion of the electron" first (cf. "Zur Elektrodynamik bewegter Körper" p. 920), tacitly shifted to "relative velocity of reference frames" here, that is between June and September 1905, in order to support the hypothesis of "rest energy" on which the paper concerning the idea of an interconvertibility, or *equivalence,* of energy and mass is based. Since that time, the v in the transformation term is always meant to express the relative velocity of inertial frames; cf. H. Goenner, Spezielle Relativitätstheorie, München 2004, p. 21.

68) Max Jammer correctly there criticizes also the allegation of textbooks around the world that $E = mc^2$ should represent an *interconvertible mass-energy equivalence* (p. 88/89), saying: "In short, E and m, having different physical dimensions, cannot be interconvertible." In fact, it is a basic truth of physics that physical dimensions define *the kind* of physical entities (Robert A. Carman, "Zahlen und Einheiten in der Physik", Berlin 1972, p.179A : "Die Dimension irgendeiner physikalischen Variable ist eine Aussage über ihr innerstes Wesen"). Since entities of *different kinds* cannot be equivalent (by definition of "equivalent"), it is clear then that E and m are n o t equivalent, and that $E = mc^2$ does n o t represent a "mass-energy equivalence". This is also clear if one only looks at the equation itself, which puts equal *not E* and m, but rather E and the term (mc^2)

as "equivalents". Those who want to solve the problem by putting $c = 1$ simply ignore the dimensions of c, which to do certainly means a most elementary error in mathematical physics. Clearly this method reminds one of those who wanted to reduce Newton's second-law proportion to a force-matter equation $\boldsymbol{F} = m\boldsymbol{a}$ (i.e. "force equals matter in accelerated motion") by putting the factor of proportionality equal to a dimensionless "1", and it has a similar materialist goal: which is to allege an *identity of force (energy) and matter* in order to *dogmatically ban* non-material entities from physics as a theory of matter only. - The ongoing struggle of theoretical physicists with the problem of the "true meaning" of $E = mc^2$ mirrors a lack of understanding what a *true proportion* looks like, since mathematical physics has lost knowledge of geometric proportion theory due to the choice of arithmetic-algebraic analysis as the mathematical tool of physics, a choice that happened long ago. Nevertheless, the geometric, or philosophic spirit is still present at the bottom even of modern physics, as it is shown in this essay, and it helps to *understand* what to the analyst appears as an enigma. By the way, the fact that *geometric proportions*, arranged around *universal constants* as factors of proportionality, govern the most elementary formula of modern physics even though the formulation of such proportions was not intended by the inventors (Planck, Einstein, Heisenberg), may indicate their truth.

69) See Max Born, "Die Relativitätstheorie Einsteins", 5th ed. p. 322: "Die klassische Physik führt auf Differentialgleichungen, die den Charakter deterministischer Gesetze haben, indem sie erlauben, die Zukunft streng aus gegenwärtigen Beobachtungen vorherzusagen." That is: *Classical physics is based on differential equations which, due to their characterization as deterministic laws, should allow to strictly predict the future from present observations.*

70) Cf. footnote 46 above; and additionally see Alan Gabbey, "Newton, active powers, and the mechanical philosophy", in: "The Cambridge Companion to Newton" p. 344: "There is abundant textual evidence of Newton's belief in the motive powers of the will. For example, in a draft variant (c. 1705) of Query 23 of the 1706 Latin edition of the *Opticks*, that is, of Query 31 of the later English editions, Newton stipulates that: '*the first thing to be done in Philosophy is to find out all the general laws of motion (so far as they can be discovered) on which the frame of nature depends…in this search metaphysical arguments are very slippery …We find in ourselves a power of moving our bodies by our thoughts (but the laws of this power we do not know)*

& see the same power in other living creatures but how this is done & by what laws we do not know. And by this instance and that of gravity it appears that there are other laws of motion (unknown to us) than those which arise from Vis inertiae (unknown to us) which is enough to justify & encourage our search after them. We cannot say that all nature is not alive."

70a) See Betty J. T. Dobbs, "The Foundations of Newton's Alchemy", p. 109.

71) See Bernulf Kanitscheider, "Das Weltbild Albert Einsteins", p. 27, 38, where he correctly criticizes Peter Janich, "Die erkenntnistheoretischen Quellen Einsteins", in: H. Nelkowski et al. (eds.), Einstein Symposion Berlin, Lecture Notes in Physics, Vol. 100, Berlin 1979, p. 425, stating (p. 38) "dass Janichs These von der Trivialität der Einsteinschen erkenntnistheoretischen Annahmen falsch ist" (i.e. *that Janich's thesis of the* triviality of Einstein's epistemological conceptions *is wrong).* Peter Janich, however, shows a dogmatic sophisticated philosophical attitude that has for a long time abandoned the allegedly "trivial" and naïve" search for reality and truth (cf. his booklet "Was ist Wahrheit?", München 1996). In order to emphasize his position (which of course is shared by many distinguished philosophers of today), once he said to me: *He who today still believes in "reality" must have a problem either of understanding or of intelligence.* This philosophical conviction, however, can be traced back to Immanuel Kant, who very effectively destroyed for a long time the foundation of a realist world view, which is the reality of space and time and motion, as it has truly been taught by Galileo Galilei and Isaac Newton.