

Newton Rediscovered: On Absolute Time and Relative Times.

By Ed Dellian.

I Introduction

1. My work for the last 20 years is devoted to the rediscovery of Isaac Newton's authentic theory of time and space, of force and motion. As I see things, this task is on the agenda since the advent of Einstein's theories 100 years ago, but has not been done by anybody else so far. With respect to the theory of time, already in 1969 the German philosopher Peter Janich asked for a reconsideration of Newton's *Scholium* on time and space, in a book entitled "Die Proto-physik der Zeit" (Mannheim 1969), as follows:

"Auch bei Newton ist die Frage, wie im Rahmen seiner Physik über Zeit zu sprechen sei, nicht allein mit der Verbaldefinition der 'absoluten Zeit' beantwortet. Die ausführlichere Darstellung finden vielmehr die 'relative, die scheinbare und die gewöhnliche Zeit'. Es lohnt daher, erneut die Frage zu stellen, ob nicht der ganze Komplex mit den newtonischen Definitionen des 'absoluten Raumes' und der 'absoluten Zeit' einem neuen Interpretationsversuch unterworfen werden muss. Denn die Lektüre des betreffenden Scholiums bei Newton vermittelt den Eindruck, als widerfahre der Newton'schen Physik (vor allem in der Gegenüberstellung von klassischer und relativistischer Physik in Physiklehrbüchern) Unrecht."

In English:

Even if we look at Newton, the question how to speak about 'time' is not answered with the verbal definition of 'absolute time'. Rather in greater detail he explains 'relative, apparent, and ordinary time'. So to consider a new attempt to interpret the whole complex of Newton's definitions of 'absolute space' and 'absolute time' might be worth while, because when reading the relevant Scholium one feels that Newton's physics is done wrong (especially when classical and relativistic physics are confronted in textbooks).

Janich proposed a new endeavour to understand Newton's theory of space and time not according to *philological-historical*, but according to *methodical principles*. Unfortunately, nobody else has taken up this proposal up to today, not even Janich himself. So the result of

my isolated work will very probably be *a unique one*, and I hope *a convincing one too*. In any case, it is open to every criticism - *from the Newtonian point of view, though*.

2. Actually, Newton's theory of space and time is mostly criticised *not* from the Newtonian, but *from a different point of view*, that is from the philosophical position of Ernst Mach. 120 years ago, this German physicist published a book entitled "Die Mechanik in ihrer Entwicklung, historisch-kritisch dargestellt". The book appeared in 1883 at Prague, and it ran into 9 editions over 50 years, that is until 1933, 17 years after Mach's death. These dates may show how influential Mach's book probably was on the generation of physicists that grew up in the first quarter of the 20th century. It is well known how greatly for instance Albert Einstein admired Mach's work.

What was the essence of that work? The author himself, in his preface of 1883, made clear and emphasized that he had written his treatise for the purpose of *enlightenment*, as he understood it, and in an *antimetaphysical tendency*. Mach: "Vorliegende Schrift ist kein Lehrbuch zur Einübung der Sätze der Mechanik. Ihre Tendenz ist vielmehr eine aufklärende oder, um es noch deutlicher zu sagen, eine antimetaphysische." In English: *The present work is not a textbook of mechanics. Rather its tendency is to enlighten, and, to say it even more outspoken, it is an antimetaphysical one.*

Mach's explicit antimetaphysical prejudice was based on the philosophy of nature of Immanuel Kant, especially on the relational or relativist *anthropocentric* view of space and time, a view that wants to determine variable spaces and times in relation to, or *relatively to* matter, and thus to man. Kant had adopted this view from Isaac Newton's philosophical antipode Gottfried Wilhelm Leibniz, and had introduced it in his "Kritik der reinen Vernunft" of 1781. Consequently, the convinced Kantian Ernst Mach was led *to revitalize Leibniz's criticism* of Newton's foundation of natural philosophy on absolute space, absolute time and absolute motion. The essence of Mach's antimetaphysical engagement, then, was an emphatic *anti-Newtonian*, subjectivist and relativist, indeed *anthropocentric* point of view concerning space, time and motion. Mach's criticism of Newtonianism culminated in rejecting Newton's concepts of "absolute space" and "absolute time" as *scientifically meaningless nonsense*.

(One should note that Mach perhaps meant this verdict as a benevolent one, since he somehow proposed to eliminate these 'nonsensical' concepts in order to maintain the remaining

relativist rest as something that well deserved to be qualified as 'hard science' in the relativist's eyes).

It was the *anthropocentric* background of Mach's book that mainly fascinated not only physicists like Albert Einstein, but all the readers of Mach, and became part of the basis of our modern, anti-Newtonian, and, as I shall show in the following, neo-Aristotelian and in fact *anti-Copernican* philosophical and scientific world view.

2. Ernst Mach's so very influential criticism of Newton - how well-grounded was it?

Sir Isaac Newton laid the foundation of natural philosophy in his "Philosophiae naturalis principia mathematica" of 1687. In this book he proposed and advanced the *quantitative* and *mathematical, geometric* method and spirit of natural philosophy. Surprisingly Ernst Mach, in his just quoted preface of 1883, emphasized not only an *antimetaphysic*, but also an *anti-mathematic* attitude, saying explicitly: "Auch die Mathematik ist in dieser Schrift gänzlich Nebensache" (*even mathematics is subordinate in this book*). This is certainly an illuminating remark. In fact it indicates what the contents of Mach's book corroborates: Mach the philosopher did *not at all* consider the specific *geometric* background, appearance and meaning of Newton's *quantitative* philosophy of nature, which Isaac Newton lays so much stress upon in his preface to the *Principia*, and exhibits it throughout his book. As a consequence, Ernst Mach as well as many other philosophers who ignored the *geometric* spirit of Newton's philosophy, missed Newton's point. I dare say that this judgement meets the whole corpus of *philosophical* discussion and analysis of Newton's teaching, from Leibniz to Kant, from Mach to Heidegger, for instance. The reason is that for generations of philosophers *not mathematics, especially not geometry*, but *Aristotelian logic*, the *semantic* tool of human reason and communication, was, and still is the unquestioned sole basis of academic philosophy. Even though Plato had asked that *only trained geometers* should enter the field of philosophy, academic philosophers up to today still obey the semantic methodology of Plato's antipode Aristotle, the "talkative" philosophy, as Colin Maclaurin once characterized it.

In the following we shall become aware of the unbridgeable abyss, or rift, which, as a consequence of fundamentally different methods, distinguishes and separates the natural

philosophers, Galileo and Newton, the *nuova scienza* of Galileo and the *experimental philosophy* of Newton, from all of *the humane* traditional philosophy.

Now and then scholars who feel this difference even deny that the teaching of Galileo and Newton deserves the label 'philosophy' at all, and propose to call it simply 'physics'. But physics, in the traditional Aristotelian sense, has always been a materialist science concerned with the properties of matter only, far from considering as absolutes such things like immaterial space and time. So to use the term 'physics' as a name for Newton's philosophical science, means a first step to the corruption of Newtonianism by reducing it to materialism. And the same thing happens when one speaks of 'Newtonian Dynamics', since the Aristotelian term *dynamis* expresses an identity of matter and force, say force as a property of matter, contrary to Newton's concept of force as *cause, as cause of motion (or change of motion)*, that is as an immaterial entity in its own right.

Characteristically, the neoscholastic Gottfried Wilhem Leibniz was the first to introduce the Aristotelian term *dynamis* into the new science, when he composed his "Specimen Dynamicum" of 1695, as a counterpoint to Newton's theory of force and motion in the *Principia* of 1687. As a matter of fact, one may well understand the historical progress from the theory of Galileo and Newton to classical mechanics as a progressive elimination of immaterial contents by reducing space and time, motion and force again to attributes and properties of matter only. One example for this process of materialisation, or materialistic corruption of Newton's teaching, shows the basic equation 'force equals mass times acceleration' of classical mechanics, which identification of force with moving matter has indeed nothing to do with Newton's second law to read "mutationem motus proportionalem esse vi motrici impressae". The example in fact exhibits a reduction of a Newtonian *proportion* to an analytic *equation by eliminating the constant of proportionality*, as I have shown it elsewhere.

Another very significant example of this process can be found in Immanuel Kant's only little known book "Metaphysische Anfangsgründe der Naturwissenschaft" of 1786, where he argues to eliminate from mechanics Newton's concept of "vis inertiae", the force of inertia innate in matter, in favour of "inertia" as merely *a property of matter*. This Kantian claim to transform Newton's immaterial and transcendent 'force of inertia' into a material quality actually brought forth that somewhat mysterious concept of 'inertia', which is a basic one even of modern physics.

A third example of the reduction of Newtonian philosophical concepts to qualities of matter, and certainly the most curious one, reveals the history of Newton's term "quantitas materiae" to denote the quantity of a material body. Newton had proposed the shorter name 'mass' for this quantity. Later philosophers then, musing upon the question what the essence or nature of that 'mass' might be, came to understand it as a certain *quality of matter*. And in fact this view of 'mass' advanced, and is generally accepted in modern science. For this I refer to Max Jammer's "Concepts of Mass in Contemporary Physics and Philosophy", which appeared in the year 2000.

However, besides the *antimetaphysical*, or *materialistic* philosophical corruption of the Galileian-Newtonian philosophy of nature, there was and still is another unphilosophical way to miss Galileo's and Newton's point, and it is the way that is generally taken by scientists, physicists and mathematicians, who at least note the specific *mathematical* approach of the 17th century's new science. A recent example provides the late Chandrasekhar's book "Newton's Principia for the Common Reader" (Oxford 1995). The taken way is to translate Newton's *geometric* demonstrations into the *arithmetic* language of Leibnizian analysis without considering the specific contents of geometric proportion theory.

What is it that might get lost in this process? It is *the specific power of the theory of proportions*. In fact geometric proportion theory has no adequate parallel, or counterpart, in the usual analysis, or elsewhere in the mathematics of today. Geometric *proportions* (which form *the germ* of Galileo's and Newton's mathematics as a tool for natural philosophy), if translated into the language of analysis, become generally reduced to *equations*, and thus *become destroyed*: If, for instance, the variable quantities A and B in geometry are proportional to each other, this is tantamount to stating that their quotient, A over B, results in a constant quantity, C. And this quantity C represents the so-called "constant of proportionality". Leibnizian analysis, however, wants to reduce this proportional relation of variables to an equivalence $A = B$, and as a consequence the constant quantity C gets lost. We shall consider this process in detail in the following.

Reminding myself of the title of my paper, I want to stress at this point that I understand *especially Newton's theory of absolute time and relative times* as a *most remarkable example*

of the explanatory power of geometric proportion theory as a methodical tool of natural philosophy. And this I am trying to radically demonstrate in the following.

II

Geometry, Galileo's and Newton's art to accurately measure quantities of space and time.

1. Sir Isaac Newton, in the preface of 1686 to the first edition of his "Philosophiae naturalis principia mathematica", the so-called *Principia*, challenges a contemporary manner of distinguishing mechanics from geometry, according to which one "called the perfectly accurate 'geometrical', and what is less so, 'mechanical'". Stating that "the errors are not in the art, but in the artificers", he argues that "geometry is founded in mechanical practice", so that the art of geometry *should not* necessarily differ from the art of a "perfect mechanic". Geometry, then, according to Newton, meant "nothing but that part of universal mechanics which *accurately* proposes and demonstrates *the art of measuring*."

2. *The accurate art of measuring*: Newton's view of geometry helps us to immediately understand the difference between geometry and arithmetic, or algebra, which is *the art of calculating*. This difference was well-known in Newton's times, even though René Descartes in his "Géométrie" of 1637 already had initiated the program to abolish it, by reducing geometry to an arithmetic and algebraic art, called "analytic geometry" later on. It was, by the way, Gottfried Wilhelm Leibniz who accomplished the program of Descartes. We should well keep in mind that Newton, who of course knew this program, throughout his long life (from 1642 to 1727) adhered to *Euclidean geometry* as the proper tool for his quantitative mathematical philosophy of nature, even rejecting the Cartesian-Leibnizian method as the "analysis of the bunglers in mathematics" in his later years.

Let me here call back to mind that another famous mathematician of that time, John Wallis, who had made decisive contributions to arithmetic and algebra in his "Arithmetica infinitorum" of 1656, in 1670 published a book *on motion*. Most remarkably, but not to come as a surprise, in this book Wallis chose *geometry* for his proper mathematical tool. The title of the book is: "Mechanica, sive de motu tractatus geometricus" (London 1670). The first definition in part 1, chapter 1, explicitly defines *mechanics as the geometry of motion*.

3. Newton's understanding of geometry as the mechanical theory of exact measurement follows the teaching of Galileo, who laid the foundation of this theory in his "Discorsi e Dimostrazioni Matematiche Intorno a Due Nuove Scienze Attinenti alla Meccanica ed i Movimenti Locali", the so-called *Discorsi*, published in 1638. In this book, written by Galileo as a prisoner of the Inquisition against the explicit ban on writing, the Florentine scholar established something which he called *a brand new science concerning a most ancient subject*. "Motu nil forte antiquius in natura", Galileo begins to explain his subject, which is *motion*, certainly the most elementary part of mechanics. *On motion*, Galileo continues, *many has been written by philosophers, and even the fact that falling heavy bodies perform a continually accelerated motion is known. However - or in Galileo's Latin, "Verum, juxta quam proportionem eius fiat acceleratio, proditum hucusque non est."* That is: *Nobody as yet has shown, according to which proportion this acceleration happens quantitatively.*

4. According to which proportion does the acceleration of falling bodies happen? This simple question reveals two most important insights concerning the program and method of the *nuova scienza*:

First, Galileo aims not at a new semantic, qualitative definition of the essence or nature of motion, but at a *quantitative* theory of motion.

Second: he will make use of the *geometric theory of proportions in his theory of the measurement of motion*.

So let us see what Galileo taught there, in the third chapter of the book, under the headline "De motu locali", that is: *On local motion*.

(By the way I want to point to the fact that the only available German edition of Galileo's book, which is a translation by Arthur von Oettingen that dates from 1890 to 1904, in the title of the book has rendered the term "movimenti locali" (that is: *local motion*) into "Fallgesetze" (that is: *laws of (free) fall*). This corruption of Galileo's true title throws some light on the question of accurateness of that edition, and may have supported the common view of German textbooks as if Galileo was not a philosopher, but only an experimental physicist who invented something like "Fallgesetze" by letting fall things from a tower).

Actually, Galileo begins his treatise on local motion saying that it is divided into three parts: Part 1, "De motu aequabili", concerns what we may call uniform motion. Part 2, "De motu naturaliter accelerato", concerns uniformly accelerated motion. Part 3, then, de motu projectorum, deals with the forced motion of projectiles, and is contained in chapter 4.

I want to concentrate on part 1, Galileo's quantitative explanation of uniform motion. Most surprisingly, Galileo does not at all refer to *experience* or to *experiment*. Rather he starts on his subject *with a mathematical and quantitative definition* as follows: "Aequalem, sive uniformem, motum intelligo eum, cuius partes quibuscunque temporibus aequalibus a mobili peractae, sunt inter se aequales."

In Aristotelian physics, up to the time of Galileo, motion had mostly been defined as a *quality of matter*. Galileo's *nuova scienza*, with its *quantitative and geometrical* approach to the problems of motion, proposed a radically new view of motion, not only with respect to its definition, but also concerning *its relation to time*. In Aristotelian physics, 'time' meant a matter of experience, a variable phenomenon, related to and depending on the motion of something, basically on the motion of the sun around the earth. Accordingly, the quality 'motion' of matter was *primary*, and time, *depending on* this quality of matter, was *secondary*.

In Galileo's theory, the order is *quite the reverse*: Motion is measured with relation to time. Time, as a standard of measuring, is *primary*, and motion, measured by this standard, is *secondary*. Says Galileo, to quote from his *Discorsi* once again: "Aequalem seu uniformem motum intelligo eum, cuius partes quibuscunque temporibus aequalibus a mobili peractae, sunt inter se equales."

Every moving body moves in time, and successively covers equal periods of time. Now, if the parts of motion which the body performs in covering the successive periods of time, are equal to each other, the body will perform a special kind of motion which Galileo calls "uniformus", that is: *uniform motion*.

Every moving body moves *in time*. Motion is always acquired, produced and changed *not instantaneously*, as it was assumed in Aristotelian physics, but *in time*. We shall see that this fundamental and seemingly trivial insight and presupposition of Galileo *will get lost* about 100 years later, when Jean d'Alembert and Leonhard Euler established mechanics anew, no

longer based on geometry, but on *arithmetic as the art of calculation, namely on principles of the Leibnizian analysis*. Their work will bring forth that foundation of mechanics, which reads 'force equals mass-acceleration', and, as a consequence of this *equivalence* of force - as 'cause' - with its effect 'mass-acceleration', tacitly contends and implies the *instantaneity of change of momentum*, that is: *the comeback of instantaneity*, as a central Aristotelian principle, *at the foundation of the in fact non-Newtonian analytical mechanics of the 18th century*.

It is well known that in the 19th century this very implication of instantaneity in mechanics was found to contradict Maxwell's well-established theory of momentum transfer in the electromagnetic field; that it appeared deficient in Kaufmann's cathode ray experiments at the beginning of the 20th century, and that its elimination means one of the main achievements of modern physics.

In my view, this correction also means a partly return of modern physics to the realistic theory of motion in time and space, as it was conceived by Galileo - and by Isaac Newton, both of whom *of course had known* the space-time appearance of momentum transfer. Actually a look into Newton's *Principia*, especially into his second law of motion, shows that Newton was *not* the creator of the mistaken law to read 'force equals mass-acceleration'. Much to my pleasure this insight is going to spread (I refer to Max Jammer's "Concepts of Mass in Contemporary Physics and Philosophy, pp 5, 12, 17). So the day will certainly come when all textbooks will correctly attribute to Jean D'Alembert and Leonhard Euler the honour of having established that actually effective, but nevertheless *unrealistic* law as a foundation of the imperfect theory of motion of their time.

5. It is quite clear that Galileo, when he determines uniform motion in relation to "tempores aequales", that is in relation to equal periods of time, does *not* consider these periods as *variables*. Successive equal periods of time will form an *infinite succession*, but not a finite *variable* quantity, or phenomenon. So what kind of "time" did Galileo presuppose and use, as a standard in order to measure uniform motion?

Galileo's geometric theory of measurement, as it is expanded in the *Discorsi*, answers this question. We must, however, first recall some basic principles of measurement.

A craftsman who wants to know the unknown length of a table's side will measure it. To measure something means *to learn* a certain quantity. To *measure*, then, means to *learn*. The craftsman learns the wanted unknown quantity of the length of the table's side by *comparing it* with a standard. The standard is represented by a yardstick, or ruler. This known standard somehow *contains* the wanted unknown quantity. The process of measuring the length of the table's side then proceeds by *comparing the unknown length with its known standard*. We learn the unknown by comparing it with the known. At this point we should remember what the Platonist Nikolaus von Kues, whom I see as a precursor of Galileo, taught in the middle of the 15th century: *Knowledge is gained by measurement only, and to measure means to compare* (see Cusanus, "De docta ignorantia", liber primus, capitulum I).

How *exactly* does the process of measurement by comparison work? Our craftsman, when he applies his yardstick to the side of the table in order to measure its length: What exactly does he do? *He examines how many of the yardstick's units correspond to the wanted length*. And this is tantamount to saying that the wanted length X is to the standard's unit L *as the quantity nL of these units (which quantity nL corresponds to the wanted quantity X) is to the same unit L* : The relation of X to L equals the relation of nL to L . Consequently, the wanted X is given as " n times L over L ", which result means that X is found equal to nL . Supposing the standard's unit is centimetre, and the wanted length of X is 50 times this standard, then the wanted length X is found to measure *50 times one centimetre*.

This analysis of the process of measurement sounds quite trivial, but it is not. Its first important point is the *understanding of learning about the unknown*, which learning happens through an *analogy* of the unknown to the known. And the proper tool of this process is the *quaternary proportion*, in our example the proportion $X : L = nL : L$. We should note that a *quaternary* proportion of this kind lies always behind *every* process of measurement, even though in practical craftsmanship one contents with *only two* of its links, namely with the result $X = nL$. Actually most experts who measure the length of a table's side, after having applied the yardstick to find a length of 50 centimetres, will erroneously believe that their measurement process has not required a quaternary proportion, but an equation $X = nL$ of only two links.

The Ancient Greek called the quaternary proportion by the name of 'tetraktys', and they knew about its power as a tool to learn the unknown *by analogy*, or *in proportion* to the known. The

tetraktys actually represents the germ of Greek philosophy of nature, so long as we concentrate on Plato's philosophy, especially on its presentation in the *Timaios* Dialogue.

Aristotelian physics, on the other hand, did not make much use of such a tool. Hastening through the centuries and with a grain of salt we can say that, after the decline of Platonic philosophy and the gradual takeover of Aristotle's teaching in the period of Scholasticism, modern times began when Euclid's *Elements* were restored at the end of the 15th century, and, together with the renaissance of Platonic philosophy, the full explanatory power of the geometric *tetraktys*, that is of the proportion theory of the Ancients, was understood by men like Albrecht Dürer and Leonardo da Vinci, and Niccoló Tartaglia and Geronimo Cardano, and Johannes Kepler, for instance. And so we realize why Galileo in 1638 presented his theory of motion in the language of geometric proportion theory, and why his successor Evangelista Torricelli did the same in his "Opere geometriche" of 1644, and why John Wallis in 1670 and Isaac Newton - who felt called upon to continue Galileo's work - in 1687 did the very same, in his *Principia*. It is *indeed this geometric method* that conveys and exhibits the Platonic spirit of the new science. And as well it is *the destruction* of this geometric method of measurement through the arithmetic art of calculation that exhibits the continuing of scholastic and Aristotelian thinking below the surface of scientific progress.

6. Newton, in the *Principia*, extensively makes use of proportion theory, and he explicitly demonstrates it as the *theory of measuring* on which his work is based. I refer to the little if ever understood section 1 of book 1 of the *Principia*, entitled "De methodo rationum primarum et ultimarum, cujus ope sequentia demonstrantur." Actually, however, Newton's advanced method *presupposes* the achievements of Galileo, which he did not recall in all detail. As a consequence, a full understanding of Newton's teaching requires to first have fully understood that of Galileo, and especially the measuring theory that Galileo introduces, at the beginning of his *Discorsi* of 1638, Third day (or chapter 3). The analysis of this theory of Galileo will answer our above posed question concerning the invariant kind of 'time' that he makes use of in order to measure the 'motion' of a body. And we shall see that this kind of time is identical with the concept that Newton, about 50 years after Galileo, will call 'absolute time'.

Galileo, in an "admonitio" to immediately follow his definition of uniform motion, informs the reader that in this case a moving body will always cover equal distances, or spaces, in

equal times, which relation between the variable spaces and times of uniform motion leads to four "axiomata":

The following "Theorema", Galileo's first proposition, clearly reveals its foundation in Euclid's said definition, as it reads:

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

The variable times elapsed in a body's motion in the same direction with the same velocity, are to each other as the variable covered spaces are to each other.

So far, the analysis of Galileo's teaching has brought to light relations between *variables* only. But where are the invariant standards, where is the concept of "absolute time" ?

Galileo's demonstration of the just quoted proposition answers the question. It exhibits him to make use of the *tetraktys*, i.e. the quaternary proportion, as follows:

Galileo introduces two straight scaled lines, IK and GH, IK to represent time, and GH to represent space (see next page). He determines the relation between variable spaces covered and variable times elapsed, by measuring these variable quantities in relation to, or relative to the straight lines that evidently serve him as invariable standards of space and of time.

Concentrating on the concept of 'time', at this point we should see as a result of the analysis of the measuring process that, in order to measure all possible finite quantities of time, we must necessarily make use of *an invariant standard* of time that *contains the infinite sum of all these finite quantities*. Obviously this standard, though it *represents* the infinite sum of variable phenomenal times, *is not itself a variable*, rather it is an infinite sequence of equal and invariant *elements, or particles* of time. As a matter of fact, Galileo's straight line to mean the standard for the measurement of variable quantities of time, has no definite beginning and no definite end, rather it extends from infinity to infinity, that is *from eternity to eternity*. Since we have seen that we need measure all measurable things in relation, or relative to their proper standards, and as well we measure finite quantities of time relative to this infinite standard of time, we may call the measurable quantities of time "relative times", and their

invariant standard "absolute time". And this distinction will help us to understand Isaac Newton's conception of absolute time and relative times, or quantities of time, as well as his corresponding conception of absolute space and relative spaces, which he explains in the *Principia*, in the Scholium after *definitio* 8.

7. Historians of science know that the philosopher John Locke, who lived from 1632 to 1704, in the year 1690 studied a compendium of Newton's *Principia* published by James Gregory. Being himself not a mathematician, Locke asked Christiaan Huygens if he could trust Newton's mathematical propositions. Huygens assured him he could, and so Locke made it his business to understand the *Principia* and to meet Newton. The result was an admiring reference to Newton in the preface to Locke's "Essay Concerning Human Understanding" of 1690, but not only this: Moreover, in the second book of the Essay, in chapter 15, "On Duration and Extension", we find an enlightening passage that explains how *duration*, that is *absolute time*, and *extension*, that is *absolute space*, work in the way I have just demonstrated, as infinite standards for the measuring of variable finite segments, or quantities, of time, say *relative times*, and of space, say *relative spaces*.

It is quite obvious that every standard means something "absolute" with respect to which, or "relative" to which, one measures and determines any finite "relative" quantities of the subject to which the standard is adjusted. Consequently, infinite "absolute" time, and infinite "absolute" space, i.e. the two scaled orders introduced in Galileo's theory of motion, mean the absolute standards that are indispensable to determine any finite quantities of covered spaces and elapsed times as the constituents of the velocity of motion.

I may refer here to another Newtonian of the time, John Keill, who, in a lecture held at Oxford University in the year 1700, explained the Newtonian view of space as follows (by your permission, I quote from the German translation to be found in the German edition of Max Jammer's "Concepts of Space", Darmstadt 1980, p. 138):

"Wir fassen Raum als dasjenige, worin alle Körper ihren Ort haben; als unbeweglich feststehend, keiner Tätigkeit, Form oder Qualität zugänglich, als etwas, dessen Teile man nicht voneinander trennen kann. Der Raum selbst bleibt unbeweglich, während er das Nacheinander der bewegten Gegenstände in sich aufnimmt, die Geschwindigkeiten ihrer

Bewegungen bestimmt, *und die Abstände der Gegenstände selbst misst.*" (My italics). In English:

We think of space as that something wherein all bodies have their place, as immoveable, inactive, without form or quality, as something, the parts of which cannot be separated. Space itself remains immoveable, while it contains the successions of moved things, determines their velocities, and measures their very distances.

Returning to Galileo, one should be aware that the standards of space and time *not only* served him as a *system of measuring* of relative spaces and times, but also as a *frame of reference for the motions of bodies*, the velocity of which motions he determined quantitatively by means of geometric proportion theory: It results from comparing the *finite quantity of space*, which a moving body has covered in relation to the immoveable standard of absolute space, with the corresponding *finite quantity of time* elapsed, as it is measured in relation to the absolute standard of time. Motion then, already in Galileo's theory, always happens *in relation*, or *relative to* an absolute space-time frame of reference. Galileo's term "motus localis" clearly denotes the motion of a body as a translation from one "locus" of "place" in immoveable *cosmic space* to another such place.

Isaac Newton, in the *Principia*, *Scholium* after definition 8, will term this kind of motion "absolute motion" about fifty years later, when he defines "place" as a "part of space", and then states: "Absolute (that is: true) motion is the translation of a body from one absolute place into another."

Having just introduced the term "cosmic space", I should here explain that, according to my view, the Galileian-Newtonian theory of motion in fact implies a world picture that should not be called "heliocentric", but far better "cosmocentric", since it does *not* refer for instance the motion of the earth *to the sun*, as it is mostly interpreted, but rather to an immoveable *cosmic space-time system of reference*. It becomes quite obvious, then, that Galileo's *cosmocentric* understanding of motion relative to this immoveable system of reference of motion, was opposed to the Aristotelian concept of motion, *as the real is opposed to the apparent*: In Aristotelian physics, motion resulted from a potential quality of material things to alter their place *relatively to man as the terrestrial observer*, according to their specific nature: going upward from *him*, as light things seem to do (e.g. fire and smoke), or going downward from *him*, as

heavy things seem to do, or surrounding *him*, as heavenly bodies *seem to do*, and also apparently the sun. As this world picture placed *man* in the centre, as the seeming system of reference of everything, it should be called not 'geocentric', but 'anthropocentric'.

The German playwright Bertolt Brecht, in a piece on the life of Galileo, makes a clergyman, as an exponent of the old anthropocentric world view, define this central position as follows:

"Ich bin nicht irgendein Wesen auf irgendeinem Gestirnen, das für kurze Zeit irgendwo kreist. Ich gehe auf einer festen Erde, in sicherem Schritt, sie ruht, sie ist der Mittelpunkt des Alls, ich bin im Mittelpunkt. Und das Auge des Schöpfers ruht auf mir und auf mir allein. Um mich kreisen, fixiert an acht kristallene Schalen, die Fixsterne und die gewaltige Sonne, die geschaffen ist meine Umgebung zu beleuchten." That is in English:

I am not some being living on some little star circulating somewhere for a little while. I walk firmly on a stationary earth that is at rest, and is the centre of the universe, I am at the centre. And the creator's eye looks at me, and at me only. The fixed stars, fixed to eight crystalline spheres,, and the powerful sun, created to shed light on my environment, circulate around me.

Nicolaus Copernicus, Galileo Galilei and Isaac Newton have shown the fallacy of the anthropocentric point of view, which the positivist scientist necessarily shares with every other animal living on the earth. Their attempts to obtain a cosmocentric position indicate the *real goal*, and *the power* of the Copernican revolution: *It is the power of truth*, the power to free man from a subjectivist and relativist, *only seemingly* central position, by enabling him, and him alone of all living beings, to adopt the *cosmocentric* point of view that allows him to distinguish between the real and the apparent, say: *to learn the truth about motion*, as a first step of learning the truth about nature.

III

How Newton distinguishes between 'absolute' space and 'absolute' time, and 'relative' spaces and 'relative' times in the *Principia*.

1. I have already pointed to Isaac Newton's preface of may 1686 to the *Principia*, where he exhibits his view of geometry, and highly praises its power. Newton even understands geo-

metry as *a part of theoretical mechanics*, calling it *that part of it*, which *proposes and demonstrates* the art of exact measuring. 'Theoretical mechanics' he terms *the science of motion*, and this science is the subject of the first two books of the *Principia*, both entitled "De motu corporum", *On the motion of bodies*.

It is quite clear that *mechanics presupposes a science of measuring*. Should one not expect, then, that Newton, at the beginning of his work on motion would represent his geometric art of measuring in detail? As a matter of fact, the *Principia* does contain such an introduction, namely the already mentioned "Sectio 1" of "Book 1". However, Newton here presents a quite advanced geometrical method. It refers to the subject of "generation and destruction of motion" in space and time, which certainly means one of Newton's most important developments beyond Galileo's findings. As this advanced theory does not exhibit the most basic foundation of Newton's geometry in the concepts of absolute space and absolute time, this fact may be responsible for some misunderstandings of Newton's laws of motion. For instance, as far as the first law of motion is concerned, scholars often have criticized that Newton did not explicitly introduce the necessary space-time frame of reference with relation to which the state of rest or of uniform straight-lined motion of a body should be determined. As a consequence, Newton has assumed to *only tacitly* presuppose an Euclidean frame of reference without making it explicitly a part of his mathematical laws. Another consequence then is to misunderstand Newton's *Scholium* on time and space as an addendum that only reveals some philosophical or even theological convictions of the author, which must not be considered as elements of his mathematical foundation of mechanics.

From my point of view, Isaac Newton based his theory of motion on Galileo's geometric theory of measuring. As he presupposed this theory, he did not have to repeat it. One should see that Newton did not even define the key term "velocity", but took it over from Galileo. Consequently, Newton's whole theory of motion, and also his *Scholium* on time and space, cannot be fully understood without its foundation in Galileo's teaching.

2. Newton's concepts of "space" and "time" are mostly understood as something "absolute", which something should be absolutely superfluous and nonsense in the science of mechanics, since this science evidently should deal with measurable variable quantities of space and of time only. Ernst Mach was perhaps the first to explicitly criticize Newton in this way, and this

criticism of Newtonianism has indeed made its way into modern textbooks of Einstein's relativity theories.

Had the authors of these textbooks, had Ernst Mach, had even Albert Einstein himself carefully studied Newton's *Scholium*, how could they all have ignored that Newton does not only use a concept of 'absolute' time and of 'absolute' space, but rather *clearly distinguishes* these absolutes from 'relative' counterparts? In fact, scholars have never considered that Newton conceived absolute time and absolute space as immutable orders of finite parts, that is to say: as scaled straight lines in the very sense of Galileo, from which concepts he distinguished 'relative' spaces and 'relative' times as *finite segments, or cuts* of these absolute standards, using the Latin word "mensura" to mean the result of a process of measuring. Had scholars ever considered this theory of time and space, they would not only have understood the space-time foundation of Newton's geometric theory of measurement, but also the intrinsic *quantization* of this foundation in geometry, which inevitably would have led them to understand Galileo's and Newton's theory as a *quantum theory of motion*, in contrast to the *continuum theory* of classical mechanics. The latter only resulted when, after Newton's death, philosophers and scientists on the continent based mechanics no longer on the geometric theory of measuring by means of absolute quantized standards of space and time, but on the art of calculation, the Leibnizian analysis, i.e. on the *arithmetic continuum theory of numbers*. In the year 1749, the French philosopher Etienne Condillac, in his "Traité des Systèmes", expressed the view that nature should no longer be understood according to geometric patterns, *but according to arithmetic*, because the theory of numbers would provide the clearest and simplest example of the theory of relations, or the general logic of relations (I refer to Ernst Cassirer, *Die Philosophie der Aufklärung*, Hamburg 1998, p. 70).

3. Only recently, that is in the year 2001, the theologian and philosopher William Lane Craig, in his book "Time and the Metaphysics of Relativity" (Dordrecht 2001), has presented an investigation of Newton's theory of 'time' that brought forth some valuable insights by taking notice of Newton's so far ignored distinction between absolute time and relative times. Unfortunately, Craig holds that Newton's concepts of 'relative' spaces and 'relative' times should only mean "more or less accurate approximations" to the absolute. This view does not correspond with my understanding of the distinction between finite quantities measured relatively to their absolute standards, and I feel that it contradicts Newton's high appraisal of geometry as the art of *exact* measuring. As I see things, it is quite obvious that relative

quantities of space and time can be measured most exactly by means of their absolute standards, if one refers to the abstract geometrical representation of these standards as scaled straight lines.

In our daily practice, however, as well as in applied science, we use "sensibilia" - as Newton says it - instead of these abstract standards. This means that we use concrete rulers, or yardsticks, as the standards relative to which we determine quantities of space (distances of bodies); and we use technical instruments like clocks, or watches, in order to determine concrete finite quantities of time as segments of the absolute standard of time. These segments are described by a clock's hands *relating to the clock's face, or dial*, as a standard. The problem with these technical instruments is that their dials embody the perfectly ordered abstract scales of absolute space and absolute time only in a more or less approximate manner, and the running of their hands is not perfectly regular. Consequently they allow only for more or less correct results, always depending on the imperfection of any corporeal representation of the perfectly proportionate regularity and harmonious order of the particles of abstract, that is transcendent, absolute time and absolute space. I think that Newton mainly *refers to this problem* when he, in the *Scholium*, repeatedly urges the reader to distinguish between the 'true' and the 'apparent', the 'mathematical' and the 'commonly' determined quantities of space and time.

According to my view, it is clear that for instance an absolutely perfect 'ideal clock' would certainly measure *most accurately* any cuts, or segments of the infinite order of absolute time as finite quantities of time, say as 'relative times'. In general, one should see that Galileo's and Newton's rigorous geometric art of measuring quantities of space and time *without* making use of any corporeal means or traditional standards - which art Newton calls "theoretical mechanics" - yields a most accurate and perfect measuring of quantities that represent cuts or segments of their absolute standards as perfectly as any finite length may represent a perfect cut, or segment, of any infinite straight line. Thus these measured quantities *will share the species of their corresponding absolutes*, as Newton states it with respect to absolute and relative space: "Idem sunt spatium absolutum et relativum, specie et magnitudine." This argument may mirror the Platonic model of μετηξις (*methexis*), which means *participation* - namely the participation of terrestrial relative images in the reality and truth of their transcendent 'absolute' ideas. This participation actually is geometrically represented by the quaternary proportion, the τετρακτυς (*tetraktys*), if seen as a tool that allows to determine

the relation of some unknown variable quantity to the unit of its absolute, transcendent standard as being equal to the relation of a certain segment of this standard to this same unit.

4. Newton's distinction between absolute time and relative (quantities of) time, after all, should be understood according to the well-known philosophical usage of 'absolute' versus 'relative', not as if it meant to distinguish between *perfect* and *imperfect* measures of time. The latter view should correctly refer to Newton's distinction between the 'mathematical' and the 'common' measures of time. One should see that Newton also terms 'absolute time' 'duration', which term obviously means an *infinite order*. Finite, variable quantities of time, then, as they are measured in relation, or relative to the infinite order of duration as their standard, are 'relative' times *per definitionem*.

These relative quantities of time, unlike the *transcendent* infinite order of duration, present themselves to our senses. As Newton says it, they represent *sensible measures* of time, which may be *true or erroneous*; and I want to add: 'true', if measured *mathematically*, 'erroneous' (more or less), if *determined commonly*, by more or less imperfect technical means. In both cases, however, Newton deals with *finite* and consequently 'relative' quantities. So, if determined *mathematically* by means of theoretical Newtonian mechanics, these quantities will represent true segments of the absolute standard, so they may be called 'true' or 'real' themselves insofar as *they share the species and nature of their corresponding absolutes*, according to the Platonic *methexis* as explained above.

5. If we adopt the view that a quantity of 'physical' relative time, if measured mathematically, truly will represent an accurate cut or segment of its standard 'absolute time', the following consequences should be considered carefully:

5.1. Absolute time, as the infinite standard of physical quantities of time to be measured relatively to it, must not be understood pejoratively as something 'metaphysic' in a sense that would put it beyond the scope of a rational theory of motion, and would expose Newton's theory to all those very well-known (not only Machian) objections against a metaphysical foundation of science. Since we have seen that absolute time means just another name of the standard necessary for every measuring of physical quantities of time, say as a part of Newton's theory of measurement, we may well understand it now as a necessary part of the Newtonian science of mechanics, which science is rooted in daily experience. To be sure,

mechanics measures finite quantities of time by means of clocks. But, whatever a technical device one will use in order to measure finite quantities of time: If it works, it will always *contain a scale* that shows an order of parts of time, as a sensible representation of that indispensable scaled standard 'absolute time' which for instance every clock-face demonstrates to the eye. And finite quantities of time will always be measured relatively, that is in relation to such a scaled standard, as the hands of a clock relatively to the scaled clock-face demonstrate it to the eye.

Scholars have often suspected Newton to introduce the absolute concepts of time and space only on theological grounds. In fact it is true that he, for instance in the *General Scholium* that was added to the second edition of the *Principia* in 1713, exhibits the view that God, as he exists always and everywhere, creates the being and reality of absolute time and space. These absolutes then represent the frame of reference wherein all finite things are contained, but not as being inside of some (necessarily finite, three-dimensional) *container*, but rather in the way how all finite quantities are contained in their infinite standards, and somehow in the way how man is related to God, in whom we act, and live, and have our being.

My purpose beyond theological considerations, however, for the moment is to show that Newton's absolute time and absolute space mean the constituents of that absolute, true *system of measurement* without which no theory of true motion in the sense of Galileo and Newton could ever have been conceived. And moreover, both these scaled standards of space and time spread that indispensable *privileged frame of reference of motion* without which Newton could never have presented a conclusive theory of 'absolute' or 'true' motion, as it was the end to which he explicitly composed the *Principia*.

The theological implications of this theory of space, time and motion are best represented in a treatise written by the Newton scholar James Edward McGuire, "Existence, Actuality and Necessity: Newton on Space and Time", published in *Annals of Science* Nr. 35 (1978), p. 463-508. Recently Prof. McGuire by letter told me that my reading of Newton's theory of time *is his too*. A similar view expressed the late Newton scholar Betty Dobbs some years ago. Dobbs has done pioneer work on Newton's alchemy in relation to other subjects of his interest. Here I refer to her treatise "Newton's Alchemy and his 'Active Principle' of Gravitation" (in P.B. Scheurer and G. Debrock, "Newton's Scientific and Philosophical Legacy",

Dordrecht 1988, p. 55-80), which throws some light on the relations between Newton's view of universal gravitation and the omnipresence of God.

5.2. William Lane Craig, in his just mentioned book, in order to give Einsteinian relativity some credit over Newton, opines Newton might have missed to realize "that the accuracy of physical time in its approximation to metaphysical time depends on the relative motion of one's clocks." In my view, this assertion fails to notice Newton's clear statement that relative time, only if and insofar as it is taken as a "sensible and external measure of duration by means of motion commonly used instead of true time", is always subject to the problem that there perhaps "is no such thing as an equable motion, whereby time may be accurately measured. All motions may be accelerated and retarded...". I feel that Newton's statement on the untrustworthiness of measuring time by motion refers to the already mentioned Aristotelian understanding of time as a quality that depends on the motion of something. And this understanding should include the fact that the motion of a clock might have some influence on its accuracy. When Craig holds that Newton "assumed too readily that an ideal clock would give an accurate measure of ... time independently of its motion", he reveals that he still sticks to the Aristotelian view. Obviously he has not realized how Galileo and as well Newton *abandoned this traditional view of the Schools*, when they made time and its measuring *independent* of the motion of something, by basically introducing that scaled straight lines to represent the standards of time and space, and by showing how motion is *not a primary*, but *a secondary notion, and a relational one* that must needs be determined relative to a pre-existing space-time frame of reference.

All in all, and seen from the Newtonian point of view, Craig's just quoted objection to the accuracy of an ideal clock contradicts the concept of "ideal clock" which clock *by definition* should measure quantities of time *independently* of its motion. Moreover, the authentic Galileian-Newtonian point of view reveals the still Scholastic inner lining of the philosophy of Einstein's Special Relativity, as it will be shown in the following.

IV

On the power of truth, or: Newtonian space-time reappraised.

1. As I see things, William Lane Craig, when he asserts that "relativity corrects Newton's concept of physical time", misunderstands Newton's theory of measuring of physical relative time in relation to its absolute standard, and goes much too easy on Einstein's Special Relativity. And this is somewhat surprising, since Craig has clearly seen that "at the philosophical roots of Einstein's theory lies an epistemic positivism of Machian provenience which issues in a verificationist analysis of the concept of time and space."

Let me put it more simply: Einstein as well as Ernst Mach rejected Newton's notions of absolute space and absolute time because they had no idea of Galileo's and Newton's geometric method to distinguish the absolute and the relative, that is they did not understand the role of absolute time and absolute space as inevitable constituents of the Galileian-Newtonian geometric measuring theory of space and time. It is quite evident that the idea of such pre-existent constituents cannot survive a verificationist analysis, since they are *by definition not subject to measurement themselves*. With a grain of salt we may say that *positivists always must fail to understand* the simple fact that a true, basic standard or scale to measure something *cannot itself be subject to measuring*.

In fact, the positivist philosophy must consequently deny the existence of any such basic standards, since it dogmatically believes only in the real existence of measurable things that through measuring appear to our senses. Entities beyond that materialistic scope, say *transcendent entities* are consequently banned from this philosophy of science. And this is what happened to Newton's concepts of absolute space and absolute time when mechanics after Newton's death, in the course of the 18th century was based on this philosophy, and was based no longer on geometry as the art of measurement by means of absolute standards of space and time, but on the art of calculation by means of numbers, the arithmetical mathematics of Leibniz and his school.

2. I have proposed to understand Galileo's and Newton's scaled orders of absolute space and absolute time as constituents of the privileged *frame of reference* of motion in their authentic theories. The term 'motion' is, and has always been, *a relational one*. Bodies move relatively,

that is *in relation to* something else, say relatively to some *system, or frame of reference*. According to the common positivistic view of things, which is also the view of Special Relativity, this reference system is always a material one: Albert Einstein himself called this foundation of his theory of motion the "principle of relativity", and explained it by stating that for instance the motion of a train relatively to the reference system "railway embankment" could as well be understood as the motion of the embankment in relation to the reference system "train". This example (even though it *erroneously assumes* that the quantity of motion of a train - which is given through the product of the train's mass m times its velocity - could as well be measured as the quantity of motion of the embankment relatively to the train) in the course of time has become the most elementary explanation of Einstein's principle. It has even led science to a sort of *revocation of the Copernican revolution*, since it implies to assert that the question whether the sun moves around the earth or the earth around the sun is only one of the observer's stand, or viewpoint. What results from this principle is a dogmatic materialistic circle - as I call it - , an again *anthropocentric Weltanschauung* based on the idea that every observer should have the same right to state what he, from his stand, observes as motion, were the truth. Physicists call this basic principle of their science *the equality of all (material) systems, or frames of reference*. I call it the most dogmatic part of the foundation of physics.

Galileo had been condemned by the Holy Inquisition for having taught against common 'geocentric' experience the true motion of the earth without proof. So how could this motion be demonstrated? Galileo certainly knew that the 'heliocentric' view to see the earth move around the sun required to prove that the reference system 'sun' was truly at rest, which to demonstrate was as difficult as to prove the motion of the earth. In order to solve this problem, an independent frame of reference was required, a frame of reference which was truly at rest, so that motions relatively to this frame of reference could be understood as real motions. And this frame of reference had to be an immaterial one, since in the whole universe no material object might be found truly at rest. So Galileo, in his "Discorsi", Third Day, introduced two scaled orders, one of space, the other of time, relatively to which standards true motion was to be determined. As it was not the sun, but rather this infinite cosmic space-time frame, which Galileo introduced as the privileged frame of reference of motion, I again propose to call his system not 'heliocentric', but 'cosmocentric'. This term should imply that indeed there exists no privileged *central point at rest* as a cosmic centre of motion, rather *every absolute place, or locus*, in infinite cosmic space-time can serve as such a centre as well as any other such place. The infinite has no centre, of course.

Galileo's view of infinite cosmic space and time is very near to the view of Giordano Bruno, which view had been judged heretic by the church, so that Bruno had suffered an auto-da-fé in the year 1600. Maybe that this is the reason why Galileo, who wrote his *Discorsi* as a prisoner of the Inquisition, did not present a verbal explanation of the exact meaning of his two innocent straight lines to represent infinite space and time. It was Isaac Newton who, about fifty years later, in his *Scholium* on space and time, explained in full detail the true meaning of the cosmic privileged frame of reference that is at the bottom of his theory of motion. For this reason I propose to call it 'Newtonian space-time'.

Let me stress the point once more that the Galileian-Newtonian theory of motion works with standards of space *and of time*, so that the presence of the time-coordinate guarantees motion always to be generated *in time*, and never to happen *instantaneously*, as it (according to Max Jammer, "Masse" 1981, p. 74) was assumed in Aristotelian and Scholastic philosophy, and even by René Descartes. This finding clearly distinguishes the authentic Galileian-Newtonian theory of motion from classical mechanics which, as a consequence of its post-Newtonian non-geometric foundation on the Leibnizian analysis, *implies* this very idea of instantaneous generation of motion, mostly called the *principle of instantaneous action at a distance*, and *erroneously* ascribed to Newton. In fact the comeback of this Scholastic principle in classical mechanics shows the reactionary spirit of this science, which was the spirit of the Neo-Scholastic philosopher G.W. Leibniz. It is well-known that Leibniz did not believe in space and time as absolutes, but defined them as *only physical variables* depending on the order of things. So he accepted no privileged natural space-time frame of measuring and reference of motion, but rather he understood motion as a reversible change of distance between material objects *to be measured by conventional standards only*. Since exactly this view is an implicit part of classical mechanics, Leibniz much more than Galileo or Newton deserves the name "father of classical mechanics". As already Ernst Cassirer has expressed it (see his introduction to the Leibniz-Clarke-Correspondence, in his edition of "G.W. Leibniz, Hauptschriften zur Grundlegung der Philosophie", Hamburg 1904/1966, p. 110), Leibniz' relativism laid the ground for a restoration of the pre-Copernican anthropocentric worldview, which finally prevailed insofar as Einstein made this principle of relativity a cornerstone of his new theory of motion (I refer to von Weizsäcker, *Aufbau der Physik*, München 1985, p.257). I wonder how Johann Wolfgang von Goethe would have judged this progress of science, who in 1831 expressed the following view: "Die größten Wahrheiten widersprechen oft geradezu

den Sinnen, ja fast immer. Die Bewegung der Erde um die Sonne - was kann dem Augenein 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." That is:

The greatest truths are often if not always contrary to sense experience. The motion of the earth around the sun - what could be more absurd to all appearances? But nevertheless it is the greatest, most sublime, most momentous discovery man has ever made, in my view more important than the whole Holy Bible.

3. Contrary to Leibniz's view, Isaac Newton not only believed in the reality of motion relative to an absolute space-time frame of reference and measurement, but explicitly wrote his *Principia* in order to show that man was able to distinguish between true, or absolute, motion, and only apparent motion. Man should be able to understand that for instance the sun *only seemingly* rises and sets, while in fact the earth moves in space and in time. "Hunc enim in finem tractatum sequentem composui" Newton wrote, that is: *To this end I have composed the following treatise.* Newton's project, then, was one to demonstrate the truth of the earth's motion, and, beyond that, the general ability of man to distinguish the real from the apparent, that is to learn the truth.

Supposed Newton succeeded, he should then certainly have brought to light *a mathematical law of true motion* that implied an information on its proper privileged frame of reference. However, none of his three laws of motion reveals such a frame, so long as we rely on their *arithmetical presentation* in textbooks of today all over the world. But if we read carefully what Newton wrote, we must see that especially his second law of motion differs very much from what those textbooks pretend. Newton's law reads "Mutationem motus proportionalem esse vi motrici impressae". It means that the force to generate a change of uniform-straight-lined motion of a body, is always proportional to the produced effect. Newton's law then means a representation of the law of cause and effect. It is evident that Newton's phrase cannot be rendered correctly into "force equals mass-acceleration" as it is generally done in textbooks. Newton's law is *a geometric one* that refers to the theory of quaternary proportions. Its common presentation as an arithmetic equation of only two equivalents obviously falls behind a proportion by two links. In order to show this difference, one may also say that every proportion between two physical entities must needs result in a constant of proportionality, which constant is missing in the force-equals-mass-acceleration law of classical mechanics.

At a closer investigation of Newton's geometric foundation of his theory, especially of his method of first and last ratios, one will find that the complete quaternary representation of Newton's law according to the theory of proportions exhibits two hitherto ignored links, one to mean a finite element of time, Δt , and the second one to mean a finite element of space, Δs . These links represent the most elementary units, or parts of the standards of space and time to lie at the bottom of Newton's as well as of Galileo's theory. Clearly they mean not physical *variable quantities*, but rather *the invariant particles of space and time*, which Newton at various places in the *Principia* explicitly speaks of - equal particles, the infinite order of which constitutes the said standards, or, more generally spoken, the divine cosmic frame in which, as it unfolds together with the presence of God, we live and move and have our being.

4. The quotient of the said elements of space and time then will appear as a the constant factor of proportionality so evidently required by Newton's second law. And it will play the role of a *grating constant* to determine the said space-time frame of measuring and reference of motion. This constant factor of proportionality between the proportional quantities of "force" and "change of motion" is as indispensable for a true mathematical representation of Newton's second law, as for example Hubble's constant is an indispensable part of the proportionality between red-shift and distance, or as Planck's constant of proportionality is indispensable between energy and frequency, or as the constant vacuum velocity of light is indispensable in order to show the proportionality between energy and the momentum of light according to Einstein's famous formula $E = mc^2$. Accordingly, I have baptized the said constant of proportionality that shows the full power of Newton's second law "Newtonian constant" some years ago (see Ed Dellian, "Die Newtonische Konstante", *Philos.Nat.* 22(3) 1985, p. 400.

5. Amicus Plato, amicus Aristoteles, magis amica Veritas., or: Some final remarks on the relation between the theory of motion and truth.

Aristotle aimed to establish philosophy as a *semantic and discursive* science of truth. This foundation prevailed. It still determines the way philosophy sees itself today, as part of the humanities. Consequently, the philosophical understanding of truth is generally also a semantic and discursive one. Its most elementary methodical tool is Aristotelian logic.

Plato, contrary to Aristotle, aimed to establish philosophy on geometry. Accordingly, it was meant as a part of natural science, or rather, Plato did *not* distinguish science from philosophy, as Aristotle did it. The most elementary methodical tool of Plato's holistic philosophy was the geometric theory of proportions.

Galileo and Isaac Newton established the theory of motion as a philosophical touchstone of truth. It was conceived as a quantitative, mathematical, *geometric theory* in the spirit of Plato.

It is quite obvious that the question of the meaning of 'truth' will be answered differently from the Aristotelian *semantic*, and from the Platonic *geometric* point of view. To state that something truly moves, *semantically* means that a body in an observable way changes its distance from some other observable thing. From the *geometric point of view*, true motion means that a body changes its spatio-temporal local state relative to a frame of reference at true rest, which frame is not observable itself. The semantic philosopher expresses what Newton calls the 'common' view, and what Newton confronts with the geometer's 'mathematical' view. The question of truth, then, in Newton's philosophy is not a problem of language and discursive logic, but *a question of geometric demonstration*.

I think that the idea to base philosophy on geometry was widely present in Newton's time, and for instance Spinoza's attempt of 1662 to base moral philosophy immediately on geometry meant a consequence of this view. If Spinoza failed, by the way, this should not be taken as a proof of the inadequacy of geometry as a philosophical tool, but rather it might show that one cannot derive moral laws *immediately* from geometry. But there may well exist an *indirect* connection between geometry and moral philosophy, if Newton was right, who held that moral philosophy *presupposes* geometric natural philosophy, that it *depends on it*, and *arises from it* in a way he describes as follows, at the end of Query 31 in his "Opticks":

"And if Natural Philosophy in all its parts, by pursuing this method, shall at length be perfected; the bounds of Moral Philosophy will also be enlarged. For so far as we can know by Natural Philosophy what is the First Cause, what power he has over us, and what benefits we receive from him; so far our duty towards him, as well as towards one another, will appear to us by the light of Nature."

APPENDIX

One question above all remains: It concerns the reality, and consequently the truth of Galileo's and Newton's space-time frame of measurement and reference. For this I call modern physics as a witness, which science, as I see things, brings to light this truth in some principles of Quantum Mechanics and Special Relativity.

My tool in proving this statement will be the geometric theory of proportions, of course, applied to basic mathematical relations of modern physics, namely to the Heisenberg relations of Quantum Mechanics, and to Einstein's most famous achievement of Special Relativity, the equation $E = mc^2$.

5.1. Isaac Newton's true theory of absolute time and relative times is of course a part of his most basic proportion, which appears in his second law of motion. As we have just learned, the law reads "mutationem motus proportionalem esse vi motrici impressae", to express a proportionality between *mutatio motus*, the change of motion, and *vis motrix impressa*, the force to produce this change. With your permission I use the symbol Δp for "mutatio motus", and the symbol " ΔE " for the said 'force'. Newton's second law then can be written $\Delta E / \Delta p = \text{constant}$. The constant, which I have baptized "Newtonian constant" in 1985, is a quotient of elements of *absolute* space and *absolute* time, $\Delta s / \Delta t$, so that Newton's law forms a correct quaternary proportion $\Delta E : \Delta p = \Delta s : \Delta t$. The concept of *relative* time, and the concept of *relative* space, of course is implied in the variable Δp , which symbolizes Newton's term "change of motion", that is $\Delta(mv)$, where v stands for a quotient of variable quantities of space and time, s/t .

5.2. The very same quaternary proportion lies behind the Heisenberg relations, $\Delta E \times \Delta t \geq h$; $\Delta p \times \Delta s \geq h$ as follows. Taken that we can write these relations as an equation of products, $\Delta E \times \Delta t = \Delta p \times \Delta s$, *the corresponding quaternary proportion*, or *tetraktys*, then is $\Delta E : \Delta p = \Delta s : \Delta t$. Please note that this proportion exactly harmonizes with Newton's second law, as I have shown it above.

5.3. Turning now to the main achievement of Einstein's Special Relativity, the equation $E = mc^2$, I concentrate on the meaning of this equation in the photon theory, where the product mc stands for the momentum p of the photon, so that Einstein's equation reads $E = pc$. This

equation can be transformed into $E : p = c = \text{constant}$, and, since the constant c is a quotient of constant elements of space, Δs , and of time, Δt , Einstein's equation reads $E : p = \Delta s : \Delta t$, which without substantial alteration can be written as $\Delta E : \Delta p = \Delta s : \Delta t$ in order to show that Einstein's equation also implies the geometric structure of a quaternary proportion, which structure harmonizes with the just developed geometric structure of Newton's authentic second law, and of the Heisenberg equations.

As we are dealing here with the subject matter of 'absolute time' and 'relative times' I want to stress that both concepts are present in all three relations with exactly the same meaning: absolute time represented by the Δt which is part of the constant of proportionality, relative times represented by the " t " which is part of the *variable velocity* that is present as part of the term "momentum p " in all three relations.

The revealed harmony and correspondence between the geometric representation of most elementary achievements of Newton, Einstein and Heisenberg is certainly not a meaningless result, obtained by means of an arbitrary handling of symbols. In fact it concerns *not the symbols*, but *the structural identity* between mathematical relations. Let me here quote, please, a paragraph from Max Jammer's "Philosophy of Quantum Mechanics" (New York 1974). Says Jammer:

"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 Greeks (Plato), has reached its logical conclusion."

The question, however, still remains, if the just revealed harmony and correspondence of the structure of basic mathematical relations says anything about the 'truth' of these relations, and especially about the truth of Newton's theory of time. For this I want to refer for the moment to an argument that is generally accepted at least by physicists: it is the argument of successful application. If we agree that a scientific theory is true if it can be successfully used

in applied physics, the certainly overwhelming success of applications of Einstein's $E = mc^2$ then provides as well an argument for Newton's theory of absolute and relative time.

So far for the moment on the question of truth. Of course I do not believe in the absolute power of the argument that a scientific theory is true if it is successful. One must only call back to mind that the unrealistic Ptolemaic system of the world was quite successful in astronomy for over 1500 years. With Galileo's dictum concerning the motion of the earth - "Eppur' si muove" (si non e vero, ben trovato) - I would insist on an *ontic*, or *realist* concept of truth. As I see things, the appearance of identical principles of motion, from Galileo and Newton to the theories of modern physics, is a strong indication of their truth *especially because* these appearance of identical principles happened *unconsciously*, that is to say it did *not* happen as a result of *conscious rational decisions of physicists*. So these principles should not be seen as constructs of the human brain, but as *true laws of nature* in the very Galileian-Newtonian sense.

To expand this argument, however, would be a subject matter for another essay.
