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The scientific definition of *time*

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Abstract

Different cultures around the world have independently discovered time in antiquity and developed calendars and clocks to measure this mysterious unknown. We say 'mysterious' because to this day no one has defined what 'time' is or means. Yet Mathematical Physics, particularly Special and General Relativity, are founded on time; neither can do without this strategic term. Time dilation is one of the three pillars of Special Relativity and the dimension of time is the fourth leg of General Relativity's ubiquitous space-time. What is it that theoreticians are stretching? What are they warping? Is time a dimension? Is it legal to replace height with time on a Cartesian chart and turn it into a Feynman diagram? And if time was born at the Big Bang, what is it that came to life? What does the babe look like? A closer analysis reveals that time is not a dimension. We discover that time cannot do without an observer. More fundamentally, we discover that unless we define this enigmatic word we will never understand what anyone who uses it is talking about.

Keywords - time, motion, distance, location, dilation, paradox, clock, General Relativity, Special Relativity, year, second

I. THE STRATEGIC WORD *TIME* HAS NEVER BEEN DEFINED

The word *time* is perhaps the most important pillar of Mathematical Physics. Without this crucial word, Special Relativity (e.g., *time* dilation) and General Relativity (e.g., space-*time*) would suffer sudden death. Einstein made *time* the cornerstone of both theories. [1] [2] Quantum Mechanics also relies heavily on time, using it as a basis to discuss topics such as Planck time, [3] the arrow of time, [4] and muon life expectancy. [5] In order to follow the line of reasoning in any of these theories, it is indispensable to understand what Mathematical Physics means by *time*. A mathematician would nonetheless impose this task upon himself to toe the party line that *"math is about making definitions."* [6]

We discover to our dismay, however, that no one in the last 10,000 years has managed to define the word *time* scientifically. A short list of ancient and contemporary milestones places this perplexing shortcoming in perspective:

1. St. Augustine was one of the first to attempt to formally define *time*, but eventually conceded:

> *"What, then, is time? If no one ask of me, I know; if I wish to explain to him who asks, I know not.* [7]

2. A few centuries later, Newton did little better, writing in his introduction to the Principia:

> *"I do not define time, space, place, and motion, as being well known to all."* [8]

Of course, if everyone knows what *time* means, why should Newton take the trouble to define the word? One wonders in retrospect how Newton can be credited with discovering the three 'laws' of motion if he had no idea what he meant by *motion* either. However, the fallacy of Newton's logic is exposed with a simple example out of his seminal book. Failure to define *time* at the start of his presentation led Newton to think of and treat this abstract concept as a physical object:

> *"Absolute, true, and mathematical time… flows…"* [8]

3. Einstein follower and relativity popularizer Brian Greene asks, "What then is time?" and after one hour on the subject never answers the question. Much like Newton, he makes unjustified, off-the-cuff remarks about time running slower or faster …or about not running at all. Not surprisingly, Greene ends up blending his dynamic 'entity' with space and proposing that the past, the present, and the future exist simultaneously and blend to form an unfathomable 'structure' known as the Growing Block Universe. [9] [10]

4. Wolf Prize recipient Stephen Hawking writes a popular book titled "*A Brief History of Time*'. The only relevant word that he doesn't define in the entire work is *time*. You certainly won't find it in the glossary. [11]

5. Likewise, Templeton Prize laureate and popularizer Paul Davies writes a book titled '*About Time*'. The only thing he doesn't write about is the definition of time. The entire book is about how mysterious this word still is and about how difficult it is to define *time*. [12]

All popular (as well as mainstream) sources also show their inability to define the word *time*. The Wikipedia provides a semblance of a definition:

> *"the indefinite continued progress of existence and events that occur in apparently irreversible succession from the past through the present to the future.* [13]

However, the word *existence* has never been defined, [14] and the *past*, [15] *present*, [16] and *future* [17] have the definition of *time* as prerequisites. Therefore, it is not surprising that the Wikipedia article follows its definition with a disclaimer:

> *"defining it* [time] *in a manner applicable to all fields without circularity has consistently eluded scholars"*

The Stanford Encyclopedia of Philosophy avoids the issue altogether. [18] The authors of articles dealing with time dive directly into a subject that they never could or bothered to define.

The Catholic Encyclopedia does a slightly better job, yet it also skips defining this cryptic term. Essentially, it summarizes the history of the philosophy of time and argues that there are many definitions and opinions. [19]

The National Institute of Standards and Technology (NIST), the institution that defines and maintains measuring standards in the United States, falls back on a synonym. The NIST defines *time* as:

> *"The designation of an instant on a selected time scale"*

…where a *time scale* is…

> *"An agreed upon system for keeping time"* [20]

In other words, the NIST lives with a circular definition of a word that forms the foundations of what it regulates.

The bottom line is that the mathematical physicists, whom everyone relies on to come up with crisp scientific definitions, and their colleagues, the philosophers, have never defined the bread and butter of Mathematical Physics scientifically. There is not a single textbook of Physics ever published that begins with the definition of *time*, and yet, stunning as it may sound, Mathematical Physics has placed all its eggs in this one basket. Almost all of its equations invoke time in one way or another. Considering that there are sweeping claims of proof, knowledge, evidence, and truth regarding issues such as GPS, time dilation, and the Twin Paradox that are founded on time, it raises an eyebrow to discover that not one scholar can define this basic term. If the theorists are going to introduce the word *time* in Physics and use it to prop up theories in Relativity and Quantum, it is in their best interests to do a much better job. They must etch the definition of *time* in stone and frame it if they expect rational individuals to follow their presentations.

II. IS *TIME* A MEDIUM?

Mathematical physicists routinely treat time as a physical object in the course of their dissertations. Theorists use phrases such as 'travel *through* time', 'time warp', 'dilate time', 'space-time', and other such expressions in their debates and writings that unambiguously present time as a medium that can flow, accelerate, slow down and stand still, be sliced into units, and interact with matter:

> *"Time dilation induces… the time dilation… a quantum field in curved space-time"* [21]

> *"in curved (and hence even in flat) spacetime"* [22]

> *"time itself can speed up or slow down… time ticks… time could run at different rates… the passage of time… space can shrink and time can dilate… your passage through time… fusion of space and time… think of time as a series of snapshots or moments… all moments lined up… a now slice… think of space-time as a loaf of bread… cut space-time into individual now slices…. past, present, and future… they all exist…"* [23]

The theorists go back and forth, one sentence right after another, talking one moment about how clocks fall out of synchronization, how watches run slower, how 'your' now may not be 'my' now, and the next moment about a substance called 'time' being swift or discrete or bent by gravity. We hear a string of devices, measurements, and human perceptions, on the one hand, clashing against an unrelated analysis of the time as a physical object on the other.

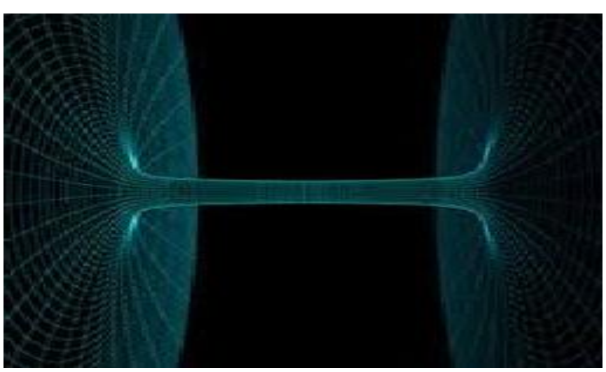
Apologists for four-dimensionalism, [24] B-Theory, [25] or temporal parts [26] might be tempted to argue that popular phrases and catchwords such as 'time dilation', 'time warp', 'space-time', and 'traveling through time' are nothing but poetic figures of speech. We should not take them literally …or at least *that* seriously. Is there anything wrong with using slogans and idioms in the course of a presentation as long as everyone recognizes that they are no more than that?

In Physics, however, in the main segment of the presentation – the phase known as *theory* – figures of speech are strongly discouraged because they interfere with understanding. The explanation has to be precise so that everyone watches the same film and visualizes exactly the same mechanism. Allegories, metaphors, and analogies, where concepts are reified and moved around as if they were objects, leave much to the imagination and interpretation of each listener. Each individual will reach a different conclusion and understanding based on his or her personal biases. Each will have watched a different movie. What is the point of using an analogy if not to simulate the real thing and have everyone understand the same thing? For instance, if a theorist gives a presentation about the DNA molecule, there is no problem if he uses a rope to simulate his theory. He points to an image of the DNA molecule on the screen and does the show and tell with a rope. He is simulating an object with a similar object. In contrast, if a theorist illustrates an adventurer traveling through a wormhole to another universe, it is irrational for him to simulate his wormhole with a plastic tube. Einstein's famous 'bridge' is a mathematical abstraction: an equation. He was not alluding to a physical entity. [27] Therefore, there is no justification to simulate an equation (Mathematics) with a hose (Physics) any more than there is to simulate love with a heart or goodness with an angel. Yet, all contemporary theorists magically morph the Einstein-Rosen equation into a solid cylindrical tunnel (*Fig. 1*). This substitution is illegal because the theorist is filling in the blanks of a set of variables representing motion, time, and distance with a paved road (the tube). It does not follow that because an equation suggests that we can shortcircuit unimaginable distances, this allows the presenter to construct a subway system through the interstitial space between parallel universes.

A theorist would be hard-pressed to dismiss this objection as 'petty semantics' because the literature is filled with articles theorizing about 'traversable' bridges. [28] [29] [30] All papers theorizing about traversable wormholes published in peer-reviewed journals argue that astronauts can and will travel to worlds on opposite sides of the cosmos through a concrete highway that, when inspected up close, is actually 'made' of variables and numbers. Will the spaceships of the future be traveling through a concept? Are these genuine descriptions of the physical world or are they surrealistic thought experiments? If analogies, analogies of what? Are we talking Physics or Math, Philosophy or Literature? Is this a picture of reality or of fantasy?

Fig. 1 The Einstein-Rosen 'Bridge': a wormhole

The theoretician has in effect converted an equation into a cement overpass that connects the shores of different time zones. He has concretized an abstract concept. What are the walls of the cosmic 'bridge' made of? Space and time? Will a NASA spaceship travel through a tunnel comprised of variables?



In order to arrive at a scientific definition of a strategic term such as *time* that makes or breaks many theories of Mathematical Physics, a natural starting point would seem to be the definition of the word *definition* itself. What is a scientific definition?

Let's start with a simple example that places the subject in perspective. Imagine, for instance, that a theorist says "It's white, big, and has wings." What is he talking about? Is he talking about a swan or the White House? This ambiguity can be put to rest by merely adding more restrictions or limitations until the word cannot be confused with anything else…

> *definition: a limitation placed on a word's utility or extent* [31]

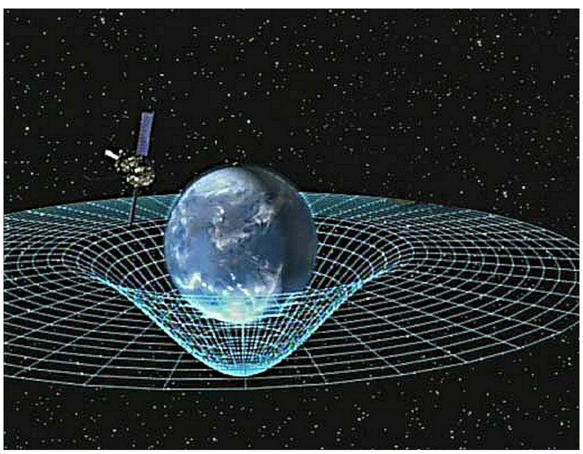
The theorist merely needs to add more properties and attributes until the definition is unambiguous. The more rigorous the definition, the less chance the audience has of confusing the term with one of the many meanings the word may have in ordinary speech and the crisper the message that gets across.

Following this prescription, it would seem basic to eliminate *time* either as a physical object or as an abstract concept. An object is 'that which has shape' whereas no concept enjoys this property. [31] [32] [33] All words in the dictionary must be placed in one of these two categories; there is no third for the purposes of Physics. A word – any word – alludes either to that which has shape or to that which doesn't. It's a yes or no type of issue. Objects, we illustrate; concepts, we define. If the proponent actually visualizes time as a physical medium that flows, that can be stretched like a rubber band, that can be warped like a hammock, that can be penetrated like a fish slicing through waters, or that blends with space to form a four-dimensional object (Fig. 2), he is in effect treating time as a physical medium. He has, therefore, no alternative but to illustrate this entity for the audience *before* he begins to explain his theory. A simple sketch, a photograph, or a sculpture would adequately satisfy this requirement. A theorist is denied any excuse to bypass this phase of his talk because there is no excuse not to sketch that which has shape and because his presentation amounts to nonsense otherwise. If, instead, a theorist proposes that time is a concept, he has no choice but to define the term. The audience absolutely needs to understand what the word *time* means in order to make sense of his theory. Therefore, the theorist must establish up front and unambiguously whether he will use time as an object or as a concept throughout his theory.

Many readers might be tempted to sweep this entire line of reasoning aside as a waste of time. Just about everyone that is asked will, without giving it a second thought, state that time is a concept. Even the presenter! Who ever suggested otherwise? Why spend time on such an inane issue?

The issue of whether time is an object or a concept needs to be settled because, as just discussed, the conveniently undefined word *time* is widely treated as both a physical object and as an abstract concept in the mainstream literature. If we decide that *time* is a concept, it is strictly forbidden to place an adjective in front of this word (e.g., *dilated* time) or a verb after (e.g., time *passes*)! If time is not an object, it does not qualify as a noun *for the purposes of Physics*. [31 32 33] It cannot serve as the subject of a sentence. Only objects can perform motions and be qualified with adjectives. A rock is a proper object for the purposes of Physics. It can be said to be 'transferred'. Concepts such as energy and information cannot. And a ball may be said to be 'red'. Love cannot be said to be red. We have no paint that can cover love or energy with color. Poetry is off limits. Physics is literal. A theory of Physics is one we can make a movie of. Each frame in the film must have an image of the actors performing the action and this requirement summarily excludes time. Hopefully these issues are straightforward and need no further clarification for a rational human being.

Fig. 2 NASA illustrates time as part of the space-time fishnet on which the Earth rolls. Is this a faithful depiction of 'gravity warping time' or is it a surrealistic representation? Is this Physics or fantasy?



The foregoing arguments actually lead us to the underlying reason that there is no definition of *time* in Mathematical Physics and why one is not forthcoming:

1. Theorists give lip service to the claim of rigorous definitions. They actually regard definitions to be the task of English majors, librarians, and the like. Defining only distracts mathematicians from the more interesting job of theorizing. They routinely dismiss objections that target irrational language as 'semantic' arguments. Therefore, they never have an incentive to fix the jargon or to define rigorously.

2. Mathematical physicists have no use for qualitative terms that they cannot put into symbols in an equation. Theorists also rely heavily on axioms and primitive terms which they take for granted, words that ironically constitute the foundations of their theories and which, for the most part, they simply pluck out of the ordinary dictionary.

3. Rigorous scientific definitions would seriously challenge many of the fantastic physical interpretations and conclusions we see in mainstream physics, specifically the widespread treatment of time as a physical object.

The standard defense raised by mathematical physicists against these arguments is that *time* is 'difficult' to define. The presenter usually runs through a series of excuses for why he cannot define *time*. The most often recited mantra is that definitions rely on other words that in turn also need to be defined and so on *ad infinitum*. Therefore, some words of necessity are and will remain 'primitive'.

It turns out that all the words forming the foundations of Mathematical Physics (point, line, energy, mass, field, time, motion, etc.) still remain primitive after hundreds of years of brainstorming. None of them are defined or will ever be defined. They remain undefined because defining them rigorously would destroy the fantastic theories we read about in the mainstream today. This should make a rational person wonder: "Who is it that is really doing semantics?"

In Rational Science, it is forthright and with no runaround. [33] If the theorist wants to understand what he is talking about and what a strategic word means for the purposes of *his* theory, he simply has to define it. Only then can the audience follow his presentation. If he cannot defend his definitions, what is his theory worth? He needs to dedicate more time to his foundations before publishing.

If we decide that time is not a medium such as the atmosphere that encapsulates the Earth or like an ocean on which a ship floats, if time does not have shape, if we cannot make a portrait or a statue of time and bring it to the conference, then time cannot be anything other than a concept and should at all times be treated as such. Reification is strictly forbidden in Physics. Morphing concepts into objects (concretization) is surrealistic and irrational. It instantly takes the theory right out of Science.

By conceding that time is a concept we have summarily cut out a lot of work for ourselves. We have eliminated half the words in the dictionary with which time should never be confused or simulated (i.e., objects). The first order of the day, then, is to once and for all stop treating this word as a malleable physical entity that is amenable to warping, dilating, flowing, or blending. This deceptive lingo only confuses members of the audience because it jumps back and forth between abstraction and reality. The listener has to guess at every step whether the theorist is talking literally or in parables.

If, as it is clear to just about everyone, time is a concept, we have no choice but to define the term. Objects we draw; concepts we define. We cannot draw concepts. Only objects have shape because that is the definition of the word *object* for the purposes of Physics. In order to zero in on a definition of *time*, it is paramount to start by eliminating concepts with which time can be confused. One obvious candidate that time is often mixed up with is the word *motion*. Is *time* a synonym of *motion*? Before we can answer such questions we need to establish a series of precedents that lead us to the unambiguous definition of both terms.

III. TIME IS NOT A DIMENSION

Is time a dimension?

Cambridge theoretician Stephen Hawking and his colleagues around the world seem to think so. Hawking summarizes the party line:

> *"one can describe the position of a point in space by three numbers, or coordinates. For instance, one can say that a point in a room is seven feet from one wall, three feet from another, and five feet above the floor. Or one could specify that a point was at a certain latitude and longitude and a certain height above sea level. One is free to use any three suitable coordinates… An event is something that happens at a particular point in space and at a particular time. So one can specify it by four numbers or coordinates… It is often helpful to think of the four coordinates of an event as specifying its position in a four-dimensional space called space-time."* [11]

Hawking's description compels us to ask the mandatory question: Is there no difference between a coordinate and a dimension?

Well, perhaps not in Mathematics, but certainly in Physics:

> *dimension: one of the three mutually perpendicular directions in which an object may face or point*

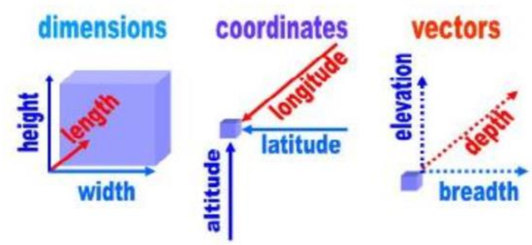
> *coordinate: one of the three mutually perpendicular directions that specify the location of an object within a three-dimensional enclosure*

> *vector: one of the three mutually perpendicular directions in which an object may move*

For the purposes of Physics, dimensions, coordinates, and vectors are strictly *qualitative* parameters. A dimension deals with structure, orientation, and tilt. It is represented by a solid line with an arrowhead at one end indicating direction. The names of the three dimensions are *length*, *width*, and *height* and they point outward from an object. Whether one uses just one or two of the dimensions, the three are tacitly invoked. There is no such thing as *length* all by itself because orthogonality is a key component of the definition. Coordinates have to do with the location of an object. Their function is to be used in a way similar to the technique known in Geometry as *triangulation*. [34] The arrows point in the direction of the object from three distinct reference points. The names of the three coordinates are *longitude*, *latitude*, and *altitude* and should not be confused with the number lines *parallel*, *meridian*, and *radius* which are numerical parameters. Vectors have to do with motion. The names of the three vectors are *depth*, *breadth*, and *elevation* and, like *dimension*, they point outward from an object. The convention is to use dotted lines for vectors and solid lines for dimensions and coordinates. The dimensions, coordinates, and vectors of Physics should never be confused or mixed with each other (*Fig. 2*).

Fig. 2 Dimension, coordinates, and vectors

Because Mathematical Physics deals with quantities and numbers, the mathematicians never realized that there is a difference between a dimension, a coordinate, and a vector. To a mathematician dimensions, coordinates, and vectors are just numbers.

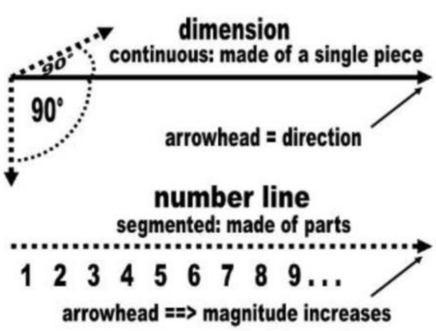


The reason Hawking blends height with longitude and latitude and then talks about specifying 'four-dimensional' space-time with four numbers or 'coordinates' is that he is doing Math and not Physics. Hawking is not dealing with dimensions, coordinates, or vectors, but with *number lines*. A number line differs from a dimension, a coordinate, and a vector in that it enjoys a property that the latter don't have: *magnitude*. A number line is intrinsically partitioned into a series of numbers. Conversely, dimensions, coordinates, and vectors have *orthogonality* and *direction*, two properties that a number line lacks. *Direction* cannot be chopped into parts. The arrowheads also serve different purposes in these irreconcilable concepts. In dimensions, coordinates, and vectors they represent direction. In number lines, they indicate that magnitudes are increasing or decreasing (*Fig. 3*).

We should now recognize Einstein's alleged 'four-dimensional' space-time for what it is: a 'four-number line' space-time. Space-time is a mathematical 'construction' that requires four quantities to specify an 'event'. One of these number lines is time. Therefore, the mathematical physicists see no contradiction if they replace *height* with *time* because they are talking about numbers, distances-traveled, and seconds (quantities) and not about orthogonality or direction (qualities). In their lexicon, the mathematicians refer to these number lines as 'dimensions' or 'coordinates' and mislabel them as 'height' and 'time' to suggest that they are representing the real world of Physics. It gets more confusing when the mathematician casually extrapolates these concepts into Physics in the next sentence and talks about '4D' space-time as a physical object. The Mathematical Physics versions of these terms disorient and confuse laymen because the average person has the ordinary three-dimensional notion of length, width, and height in mind. This is not what the mathematicians are referring to when they say 'dimension' or 'coordinate'. It is this duality of treating the word *dimension* as a physical side of an object one moment and as a number line the next that is outside the bounds of rationality. If a mathematical dimension is defined as '*the number of numbers needed to specify the location of a point*', the theoretician is barred from carrying this notion into Physics and using it as a stick representing *height*. Time is either a solid-line dimension with direction and orthogonality or it is a segmented number line representing seconds. It can't be both.

Fig. 3 Dimension vs. number line

The dimension of Physics is illustrated with a line conceptually made of a single piece. 'Direction' *is a concept that cannot be chopped into segments. Conversely, a number line is intrinsically segmented. In dimensions, the arrowhead represents direction; in numberlines, that numbers increase or decrease.*



IV. Distance

Mathematical physicists use the word *distance* almost as much as the word *time*. A mathematician needs notions of both time and space to be able to talk about speed, velocity, or acceleration, all of which are the bread and butter of the mathematical guild. All introductory textbooks of Mathematical Physics typically start out with these topics.

Mathematics defines 'distance' as a *quantity*:

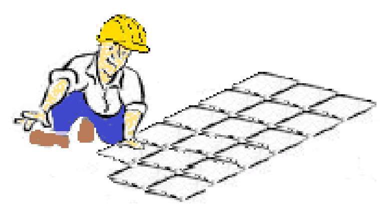
> *"a numerical description of how far apart objects are."* [35]

> *"For a particle with initial position* x_0*, speed v, and acted upon by a constant acceleration a, the position as a function of time t is given by* $x = x_0 + v_0t + ½\,at^2$*. The distance fallen under uniform acceleration a in order to reach a speed v is given by* $x = v^2 / 2a$*."* [36]

For the purposes of Mathematics, distance is an issue of measurement, numbers, and units. Mathematical distance has to do with how many tiles a mason lays from one wall to the other or how fast the tailor unrolled the leading edge of his measuring tape (*Fig. 4*). The 'distance' of Mathematics focuses on a single entity: the one that is moving from A to B.

Fig. 4 Mathematical 'position' = distance = motion

In Mathematics, position, distance and motion are synonyms. Of concern to a mathematician is measurement: how many tiles the mason laid from wall to wall, how many meters per second the horse galloped, or how many steps the pirate is from the treasure chest.



The mathematical notion of *distance* is better understood if we refer to it as '*distance-traveled*'. In Mathematics, distance is both a quantity and dynamic. There is no distance unless there is motion and a number accompanied by a unit of measure associated with it. The *distance-traveled* of Mathematics is a synonym of *displacement*. It has to do with the number of meters or feet that the front end of a measuring tape *traveled* across or the number of seconds on a clock that it took a horse to gallop to the finish line.

As a result of treating every parameter as a quantity that represents motion, the mathematicians ended up regarding *distance* and *length* as synonyms:

> *"In the physical sciences and engineering… the word "length" is synonymous with "distance"."* [37]

Distance and length are synonyms in Mathematics because a mathematician has no use for qualitative parameters. A mathematician is solely interested in 'how long' or 'how fast' or 'how much'.

> *"length is the longest dimension of an object."* [38]

Therefore, whether a mathematician measures objects or lack of them is of little concern to him. A mathematician measures the length of a box and the space between two of them with the same yardstick and arrives at the same units (*Fig. 5*). A measurement is a measurement regardless of what he measures.

It is because mathematical physicists have not distinguished between length and distance that they ended up with the incongruous notion that space is a physical 3D object:

> *"the universe was expanding… there must have been a time in the very early universe when the universe was so small that one could no longer ignore the small-scale effects… Einstein's general theory of relativity, on its own, predicted that space-time began at the big bang singularity… as the universe expands, any matter or radiation in it gets cooler."* [11]

> *"From the equations of the general theory of relativity it can be deduced that this total reduction of inertia to interaction between masses… is possible only if the universe is spatially finite… From such a deviation it could be proved indirectly that the universe is finite. It would even be possible to estimate its spatial dimensions… From the latest results of the theory of relativity it is probable that our three-dimensional space is also approximately spherical."* [39]

They measured the 'distance-traveled' from here to the Moon (i.e., the 'length' of space from here to there) and visualized a photon wading like a fish *through* an ocean. If the mathematicians had invented X units of measure for space and Y units of measure for objects they would have noticed the difference and arrived at a different conclusion. However, Mathematics is a quantitative discipline and never saw the need for this.

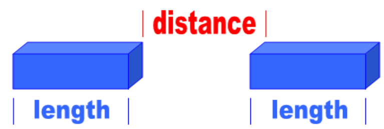
The quantitative versions of *distance* and *length* may be useful for the purposes of Mathematics, but there is no room for them in Physics. There is no use for measurements, for numbers, or for equations because Physics is a science and Science explains. [33] The job of a physicist is to discover causes and mechanisms, specifically, of the invisible world of nature. A physicist needs to rationalize, for instance, why (cause/mechanism) a pen falls to the floor rather than to the ceiling or how (cause/mechanism) a magnet attracts another. For this, a physicist needs to simulate the phenomenon with objects. He has to make the invisible mediators visible. Measurement and numbers serve no purpose in such pursuits. Establishing how many feet away from a reference point cannot help a physicist *explain* any phenomenon of nature. Math is a language that can only *describe*, and then only quantitatively. Therefore, Mathematics is not only *not* the language of Physics (or of Science), but it has nothing to do with Physics (or with Science). Science is strictly qualitative. It was primarily as a result of the beliefs of 17th Century mathematicians such as Galileo, Descartes, Newton, Leibniz, and Huygens that Math unjustifiably surged to be regarded as the language of Physics. Today, the myth persists solely on the basis of tradition and authority.

For the purposes of Physics, *distance* requires two objects. Distance is the word a physicist uses to refer to the qualitative gap between a tree and a rock:

> *distance: the gap or separation between the surfaces of two objects* [31]

Therefore, the *distance* of Physics is irreconcilable with the *distance-traveled* (measurement) of Mathematics (*Fig. 5*).

Fig. 5 Distance vs. Length (Physics)



V. LOCATION

Mathematical physicists rarely use the word *location* and prefer to use what at face value appears to be a synonym: *position*…

> *"In geometry, a* position*… is a Euclidean vector that represents the* position *of a point P in space in relation to an arbitrary reference origin O… it corresponds to the straight-line distances along each axis from O to P.* [40]

The fatal problem with this definition is the use of the word *position* to define *position*. Just as mortal, Mathematical Physics regards *position*, *distance*, and *motion* as synonyms:

> *"Position, velocity, and acceleration all describe the motion of an object; all three are vector quantities. In one dimension, position is given as a function of* x *with respect to time,* x(t)*."* [41]

Like with *distance*, the notion of *position* that the mathematicians have developed is incongruously quantitative and dynamic. Words such as *position*, *location*, *distance*, *above*, *below*, *straight*, *parallel*, *sitting*, *standing*, and *existing* are intrinsically static qualitative concepts. They are quite unlike *running*, *jumping*, *swimming*, *flying*, *breathing*, *wave*, *ionization*, *orbit*, *time*, and *motion* which clearly embody action.

It is as a consequence of brushing aside qualitative parameters that Mathematical Physics has ended up with the incongruous notion that a *static* concept such as *position* is no different than a *dynamic* concept such as *motion*. A mathematician unrolls the end of the measuring tape from a reference to the position in question and measures or counts the number of tiles he laid from wall to wall (*Fig. 4*). He refers to this quantity as a 'position': the number of tiles that he is away from his starting point.

Physics has no use for the term *position* because the discipline has the same notion of *position* that Newton concocted and called *place*:

> *"Place is a part of space which a body takes up… Positions properly have no quantity, nor are they so much the places themselves, as the properties of places."* [8]

Position is the theoretical volume that a 3D object occupies: the object itself without reference to anything else. It is not apparent, therefore, what use Physics would have for such a pointless concept. What could it help a physicist explain?

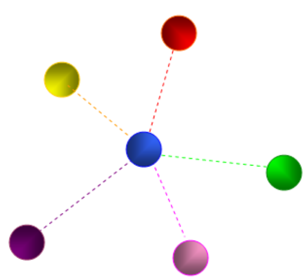
In Physics, it is not *position* which has relevance, but rather *location*:

> *location: the set of distances from every object in the system to the test object* [31]

Location is strictly a qualitative, static concept. There are no amounts or units involved. One is urged to visualize a frozen universe. You are stranded on the twilight of a cross-section of time. There is only distance (separation) between any two units of matter. Motion is outlawed. In the Frozen Universe, every unit simply has *location* (*Fig. 6*). This is a concept that Physics has a use for.

Fig. 6 The Frozen Universe

Location



[As a side note, it is interesting that neither the Mathematics nor the Physics sites of Wolfram, which pride themselves on being "the web's most extensive mathematics resource", have a definition of *position* or of *motion*.]

VI. MOTION

Having failed to define strategic qualitative words such as *object*, *concept*, and *position*, and identifying *distance* as a dynamic, measurable parameter, it is not surprising that Mathematical Physics has made no progress regarding the definition of the word *motion* since the days of Newton. Like Newton, the mathematicians ended up using synonyms in their half-hearted attempts to give meaning to the word:

> *"Absolute motion is the <u>translation</u> of a body"* [2]

> **"***Motion is defined as the <u>action</u> of <u>changing</u> position or location."* [42]

> *"Motion is the <u>process</u> of something <u>moving</u> or <u>changing</u> place, or even just <u>changing</u> position.* [43]

> *"In physics, motion is a <u>change</u> in position of an object over time."* [44]

By merely looking up the definitions of these terms (*translation*, *process*, *change*) it is patently clear that all of them embody motion:

> *"a translation is a geometric transformation that <u>moves</u> every point of a figure or a space by the same amount in a given direction… A translation can be described as a rigid <u>motion</u>"* [45]

> *"A process is a set of <u>activities</u> that <u>interact</u> to achieve a result."* [46]

> *change: to <u>make</u> different from what it would be if left alone… <u>transform</u>, <u>exchange</u>, <u>convert</u>* [47]

Mathematical Physics did nothing but place synonyms in its 'rigorous' definitions of *motion*.

The definitions that underlie the foundations of Mathematical Physics are not only far from rigorous, but entirely unscientific. A scientific definition is one that can be used consistently throughout the guild and doesn't rely on synonyms. And, of course, without a definition of *motion*, it is difficult to understand the difference between *motion* and *time* even assuming that the mathematicians had a scientific definition of *time*.

The objective facts are that you will not find a fundamental word such as *motion* defined scientifically in any textbook of Physics or Mathematics ever published on Earth. The crucial word *motion* doesn't exist in any glossary of physics textbooks. The ultimate reason for this is that the mathematicians have no use for qualitative concepts.

What you will find instead in textbooks is a mathematical definition of the quantitative concept *displacement*:

> *"Distance is a scalar quantity that expresses only the length of an arbitrary path... Displacement is the vector that specifies the position of a point or a particle in reference to a previous position, all with respect to an origin.* [48]

A mathematician unrolls the measuring tape and counts centimeters or uses a yardstick and counts the number of seconds on his clock. In other words, in Mathematical Physics, *displacement* is no different than *position* or *distance*. All three are synonyms. They all deal with quantities. They are all dynamic concepts. They all deal with *how much* an object has *traveled*. Displacement has to do with *how far* something moved, a notion that has no value in Physics because 'how much' is of little use in explaining any phenomenon. Therefore, the mathematicians never found a need to define the qualitative term *motion* scientifically because, like Newton said, we already know intuitively what *motion* is.

How should we define *motion* in the alternative? What do we mean when we say *motion* or *movement*? What is *motion* for the purposes of Physics?

In Physics, we cannot do without objects. We must have an object in order to do Physics. What would there be to study? What phenomenon would we see? What would we handle in the lab? The Golden Principle is inviolable! [33]

Likewise, in Physics we cannot do without motion. The entire matter in the Universe is in motion. If we are to make sense of the *workings* of the Universe we absolutely must begin by defining the word *motion*.

The first thing we must do to define *motion* is to get rid of what Mathematics needs the most and can't do without: *an observer*. We do not need a witness in the definition of *motion*. The Moon and the planets of the Solar System move even when there's no one around to film the scene. The Moon moved before life arose on Earth. Indeed, in order for the definition of this crucial term to be objective, it must dispense altogether with testimony.

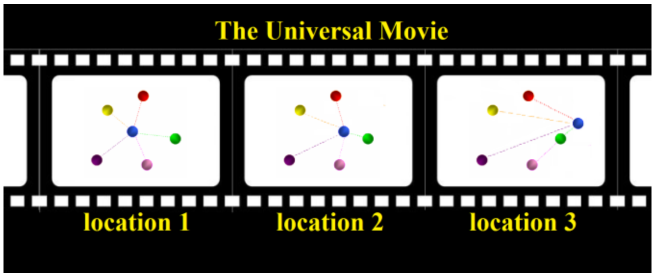
For the purposes of Physics, motion demands an object and involves two of its locations. If we had omniscient eyes and could see every bit of matter in the Universe, the movement of any discrete entity would consist of a minimum of two locations with respect to all the rest (*Fig. 7*).

motion: two or more locations of an object [31]

Since *location* requires other objects to be present, there is no need to clarify that the word *motion* is likewise a relation with respect to other objects.

Fig. 7 Motion

A blue atom moving with respect to other atoms: two or more locations



VII. TIME

The philosophers have struggled with keywords such as *object* and *exist* for centuries. To this day atheists, agnostics, and theists argue in circles because these two strategic terms have never been defined rigorously by any of the debating parties.

Kant was one who famously could not tell the difference between *object* and *exist*:

> *"when I think a thing… not the least bit gets added to the thing when I posit in addition that this thing is… the missing reality does not get added when I say the thing exists"* [49]

Kant thought of the two words as synonyms.

In Physics, however, we must be able to and can tell the difference between a standalone object and whether it exists. They are two separate issues. It all boils down to a matter of definitions:

object: that which has shape [31 32 33]

exist: physical presence (object + location) [31 32]

What the word *exist* adds to or has in addition to *object* is *location*. Objects that don't exist (e.g., Superman, Pegasus, Little Red Riding Hood, tribar, circle, the entire set of imagined objects) lack location. The paper and the ink have locations, not the circle.

Are *motion* and *time* synonyms or are they like *object* and *exist*? If there is a difference, what does *time* add to *motion* if time invariably involves motion?

Time and motion are obviously not synonyms from the point of view of Physics. Motion *objectively* requires two locations. Time refers, instead, to *subjective* before and after, early and late. Time clearly demands an observer, one that makes a call. What time adds to motion is *memory*. Time cannot do without recording the previous or subsequent *set* of reference points:

Time: a comparison of two motions [31 50]

Motion occurs without an observer. When our hypothetical Frozen Universe melts and becomes the Universal Movie, a single object is all that is required to move. Instantly, all others change their location with respect to it. You can make God move this way and that at your pleasure by just moving your pinky. There can be no motion of one object alone. If one object moves, they all move.

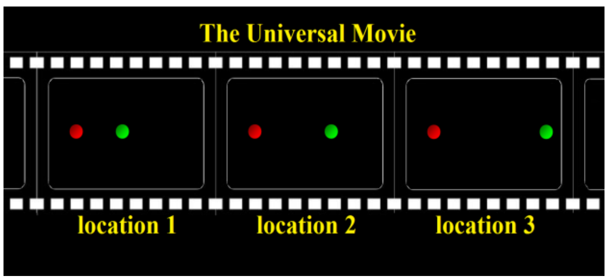
In this scenario, we have motion, but not time. For instance, let's remove God and assume a world with nothing but atoms. One atom moves back and forth between two locations. What does this oscillation tell us about time? Let us now introduce memory in this 'tictoc' universe. Our witness has the ability to compare two or more locations of the atom against two or more locations of another object (e.g., his hand). This is the rudimentary conception of time. In order to make this comparison, the observer must record the previous locations of each object in memory or in a device (*Fig. 8*).

Memory is a *sine qua non* element of time and not required at all for motion. Without memory, there can be no such conception as time. Memory makes the observer aware of before and after, early and late, yesterday and tomorrow. We absolutely need some kind of recording device.

Fig. 8 Motion vs. Time

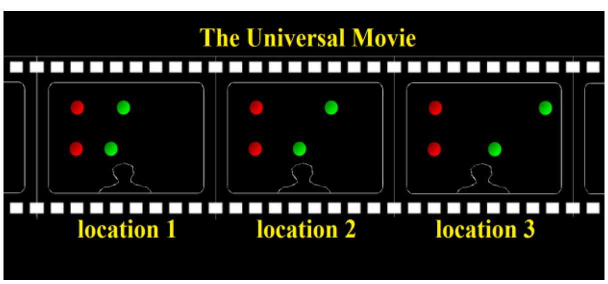
Motion is simply two or more locations of an object. No observer is necessary. An object moves by definition.

Motion



Time is the comparison of two motions. Time requires memory. An observer must record the previous locations of the two objects that he will compare.

Time



Having said this, we throw a bucket of ice on the entire matter. Physics has no use for time. Rational physicists dispense with this parameter altogether because time does not help a scientist explain any phenomenon of nature. This should also follow from the fact that time requires an observer. Science has no use for witnesses or testimonials. Science is objective. The audience simply needs to understand the mechanism being proposed.

VIII. QUANTITATIVE *TIME*

The mathematician may object to the qualitative definition of time because it does not make provisions for what has typically been regarded as time by the entire planet, to wit: seconds, minutes, hours, days, etc. He has no use for qualitative time (early, late, yesterday, tomorrow, etc.)

Physics counters that it has no use for measurements, numbers, equations, or units of time invented solely for the purpose of *describing*. Physics is theoretical. In Physics, we must *explain* the causes or mechanisms that underlie events and phenomena. It is technology which has a use for measurement, but technology is not science. [33]

Einstein's famous Twin Paradox underscores the differences between Mathematics and Physics and shows how quantities and measurements lead to irrational qualitative conclusions. The equations 'predict' that an astronaut who travels at near the speed of light to the stars and back finds that he has aged only 1 year while his twin brother who remained behind aged 50 years. Time, say the theorists, went faster for one twin than for the other. This fantasy is so loved by Hollywood that it has been reproduced in countless movies and documentaries purporting to be based on science.

Physics doesn't arrive at such surrealistic conclusions such as the Twin Paradox because to debunk this amusing claim it counts revolutions of the Earth rather than measure time with a clock. The *year* is not defined as 12 months or 365 days or 31.5 million seconds. The word *year* is still officially defined as a complete revolution or orbit of the Earth around the Sun. [51] Each ring on a tree represents one orbit that the plant physically experiences: winter, spring, summer, and fall. Therefore, the Earth either went 1 time around the Sun or 50 times; it can't be both.

The source of the problem with the Twin Paradox is that Mathematics wishes to tell you how old you are by *measuring* the 'length' of seconds on a clock rather than by *counting* the objective number of revolutions of the Earth. Clocks are subjective because they are dependent on their distance from the nearest center of gravity and the speed at which they are traveling. Gravity Probe A and the Hafele-Keating Experiment reinforce that *all* clocks are inaccurate when traveling at different speeds or are taken different distances from the center of Earth. [52] [53] [54] As a result, the Global Positioning System (GPS) clocks are routinely adjusted. [55] In contrast, a periodic phenomenon such as any celestial revolution around the Sun is a natural clock and quite a reliable one for lengthy periods of thousands of years. Therefore, even if we change the standard and count blips on a cesium wave rather chop up the orbit of Earth in 30 km segments, we still have an inaccurate clock once we take it for a ride into outer space. If we make the *second* artificially longer by measuring it with the number of blips on a cesium wave rather than as a segment of the year, the year becomes longer because an Earth year is comprised of 31.5 million seconds. [56] For instance, one revolution of Mars around the Sun is 687 Earth days, almost 60 million Earth seconds. Mars takes almost twice as long as the Earth to make one revolution around the Sun. This means that if you lived on Mars and specified your age in Mars years, you would be almost half as old as your twin here on Earth. There would be no need for you to invoke General Relativity or travel at the speed of light. But we would be comparing apples and oranges. In terms of earthly years, you would both have the same age. Likewise, if you are the traveling twin and count your age in terms of seconds on a clock that is running at a slower rate, this clock will show that you aged half as much or even less than your twin here on Earth. But we don't use clocks to celebrate birthdays of people or of trees. We use Earth orbits. Therefore, if we're going to talk about whether two twins have the same number of Earth years, we are not going to use atomic clocks or do fancy calculations. We simply need to count how many times the Earth went around the Sun. That number should be the same for anyone in the Universe regardless of distance or speed.

Having failed to introduce the Twin Paradox into rationality, relativists raise another issue that concerns Physics just as much. They claim that the fact that the traveling twin's clock counted fewer seconds implies that he *physically* aged less. He returns to find that his brother looks like his grandfather.

It suffices to introduce a genetic disorder known as progeria into the discussion to debunk the surrealistic 'twin' theory. Progeria is an ailment that makes an individual age much faster than his brother without either of them having to leave the Earth. Should we conclude that the unfortunate twin is caught in an exotic time warp? Or does this have more to do with internal biological processes?

Whether a person physically ages faster or slower than people born on the same day has little to do with how fast they were traveling or what their clocks say. Relativists should simply learn once and for all that they cannot extrapolate their equations involving time directly into Physics and claim that their irrational conclusions are supported by scientific calculations… especially if they don't have a definition of the word *time* to start out with.

> Corollary: Whenever someone invokes the word *time* in a scientific context, we merely need to replace this term with its definition: *a comparison of two motions*. For example, if someone says "*dilated time*", he is saying "*dilated a comparison between two motions*". If the proponent does not like *time* to be used like that in his theory, he has the burden of defining *time* in the alternative.

IX. Conclusions

Mathematical physicists use the word *time* to prop practically every theory of Relativity and Quantum despite that they have never defined this strategic term scientifically. Theorists take advantage of this shortcoming and use time as both a physical medium and as an abstract concept at their convenience. This duality enables them to blend time with space into an enormous block in one scenario and to treat it as discrete drum beats marking the pace of intervals on a number line in another. These notions lead mathematical physicists to paradoxes that don't trouble them in the least.

Rational Science requires, instead, that theorists define the terms that make or break their theories unambiguously. Once we define the word *time* in a way that it can be used consistently throughout the dissertation, the surrealistic theories we read about in mainstream journals suffer sudden death. It is the rigorous definition of *time* that destroys the physical interpretations of Special and General Relativity in particular and of Mathematical Physics in general.

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"In accordance with definition the two clocks synchronize if $t_B - t_A = t'_A - t_B$."

"velocity = light path/time interval"

"the time marked by the clock (viewed in the stationary system) is slow by $1 - \sqrt{1 - v^2/c^2}$ seconds per second"

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